DEPT. COMM. NO. 475

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GOVERNOR OF HAWAIʻI
KE KIAʻĀINA O KA MOKUʻĀINA ʻO HAWAIʻI

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In reply, please refer to:
File:

December 15, 2022

The Honorable Ronald D. Kouchi,
President and Members of the Senate
Thirty-second State Legislature
State Capitol, Room 409
Honolulu, Hawaii 96813

The Honorable Scott K. Saiki, Speaker
and Members of the House of
Representatives
Thirty-second State Legislature
State Capitol, Room 431
Honolulu, Hawaii 96813

Dear President Kouchi, Speaker Saiki, and Members of the Legislature:

For your information and consideration, I am transmitting a copy of the "Cesspool Conversion Working Group Final Report to the Regular Session Legislature pursuant to Act 170 Session Laws Hawaii of 2019." In accordance with Section 93-16, Hawaii Revised Statutes, I am also informing you that the report may be viewed electronically at:

https://health.hawaii.gov/opppd/department-of-health-reports-to-2023-legislature/

Sincerely,

Elizabeth A. Char, M.D.
Director of Health

Enclosures
c: Legislative Reference Bureau
Hawaii State Library System (2)
Hamilton Library

Cesspool Conversion Working Group

Final Report to the 2023 Regular Session Legislature

Prepared by the
State of Hawai'i Department of Health
In response to Act 170 Session Laws of 2019
November 2022

Hawaiʻi Cesspool Conversion Plan Considerations

Final Report to Legislature 2023

Executive Summary

Hawaiʻi has approximately 83,000 cesspools that discharge an estimated 50 million gallons of raw sewage into the State's groundwater and surface waters every day. Cesspools are an antiquated technology for the disposal of untreated sewage that can pollute groundwater, drinking waters, and surface waters. Cesspools present a risk of human illness and significant harm to streams and coastal resources, including coral reefs.

The Legislature has recognized the serious health and environmental concerns of cesspool pollution and established in 2018 the cesspool conversion working group to develop a long-range, comprehensive plan for cesspool conversion statewide of all cesspools by 2050. That law also commissioned; a statewide study of sewage contamination in nearshore marine areas to further supplement the studies and reports conducted by the Department of Health (Department) related to cesspools.

This report updates the status of findings of the Cesspool Conversion Working Group and makes recommendations for potential next steps. Key highlights of this report include:

- All cesspools are substandard sewage disposal systems and pose some level of threat to their surroundings.
- Some cesspools present more significant immediate risk for human health and environmental harm and should be upgraded well before 2050.
- Cesspools may be upgraded by connecting a central or localized sewer system, or installing an individual wastewater on-site.
- Cesspool upgrades can be quite expensive. Significant federal and State funding will likely be needed to help homeowners with the costs of cesspool upgrades.

For administrative purposes, the Cesspool Conversion Working Group was established within the Department. The Department convened the first Cesspool Conversion Working Group meeting in September 2018 and submitted a progress report to the Legislature in 2020 and 2021. To support the development of this plan, consultants were hired to assist in technical research and three subgroups were developed: finance, technology, and data and prioritization.

Cesspool Conversion Working Group Recommendations

The Cesspool Conversion Working Group reviewed internal and external reports, scientific and policy data, in addition to consulting with various wastewater experts to develop a thorough set of recommendations to promote a successful and actionable plan to convert cesspools across Hawaiʻi by 2050. Recommendations include actions that can be taken by the State, County, non-governmental organizations, and the private sector since it will take interdisciplinary collaboration to successfully fulfil this state-wide goal. The list of recommendations provided is extensive, however, the group recognizes that more may be needed as the situation evolves. The recommendations provided below represent a majority opinion of the working group but where appropriate, narratives are included from members who dissent on specific positions.

A. Recommendations for Cesspool Conversion Prioritization and Timeline

The working group recommends, based on greater understanding of impacts cesspools have on nearshore water quality and human health, that the deadline by which cesspools in the State must be converted should be adjusted to a staggered timeline that would accelerate the mandatory conversion date for cesspools that pose the highest risk of harming human or environmental health, as determined by the Hawai'i Cesspool Prioritization Tool and supporting water quality data. The working group further recommends the adoption of policies and mechanisms that will facilitate this acceleration and the need for an iterative process as new findings are established.

A1. Replace the 2050 deadline, from Act 125 Session Laws of Hawaii (SLH) 2017, for cesspool conversion as follows:

- Priority 1 zones (13,821 cesspools) converted by 2030
- Priority 2 zones (12,367 cesspools) converted by 2035
- Priority 3 zones (55,237 cesspools) converted by 2050

Approximately 35%, 7%, 21%, and 37% of cesspools in the Priority Level 1 group are located on Oʻahu, Maui, Kauaʻi, and Hawai'i Island, respectively. Refer to Section 2.3 for priority zone definitions.

A2. Adopt and implement policies and mechanisms to accelerate cesspool conversions statewide, prioritizing the highest risk areas. Recommendations include:

- Point-of-sale conversion requirements
- Require a seller's disclosure form for any property sold that has a cesspool
- Financial incentives including grants, tax credits, and loans to offset the cost of conversion

A3. Priority areas and/or timelines of cesspool conversion should be updated/evaluated when significant information, policy, and/or data changes arise. For example, use a higher resolution map (census blocks or block-groups, rather than larger census tracks) to better assist managers in identifying urgent problem areas.

B. Recommendations for Cesspool Conversion Financing

The high upfront costs associated with onsite wastewater system replacement are not affordable for many Hawaii residents and are the biggest obstacle to cesspool conversion among all income levels. The working group recommends developing robust funding and financing options to assist low- and moderate-income homeowners to finance conversions, as well as incentives for cesspool conversion for all homeowners. The working group further recommends maximizing the use of available federal funding, which has been a missed opportunity in the past. There will be a need for a corresponding increase in capacity at both the state and county levels to effectively access and spend more federal dollars. Additionally, both the state and counties will need to consider options for either reallocating resources or generating new revenue to supplement other financing programs and homeowners' dollars.

B1. Maximize use of available Federal funds such as the Infrastructure Investment and Jobs Act funds, Inflation Reduction Act and American Rescue Plan Act for State and Counties to implement cesspool conversion. Conversion solutions may include, but are not limited to, options for onsite replacement, connections to sewers, and local cluster wastewater treatment systems. Where appropriate, State, County and local governments should pursue congressionally designated spending requests for cesspool conversions.

B2. The State and Counties should develop a long-term, low-interest loan program for low- and moderate-income homeowners.

B3. Partner with private lending institutions to integrate financing for cesspool conversions into private lending applications. Explore the feasibility of financing cesspool conversions within existing loan programs such as the Department of Veterans Affairs, the US Department of Housing and Urban Development, and Fannie Mae.

B4. Maximize use of all available federal, State and local funding, including grant, rebate, and revolving loan programs. Analyze existing models set up by places like Suffolk County, New York. Even with federal funding, it is likely that local financing will still be needed to achieve cesspool conversions by 2050. Another option is to consider fees for homeowners with cesspools to generate funds to finance or fund cesspool conversions. Special Assessment Districts (Chapter 12) or Improvement Districts (Chapter 32) could allocate property tax to finance improvements.

B5. Provide tax credits and rebates for upgrades or connection costs and allow these incentives to be claimed by a third party on behalf of the homeowner.

B6. Increase personnel capacity at the State and County level to apply for and manage Federal loans, grants, and other financial assistance programs.

B7. Enact policies to enable nonprofits and community development financial institutions to help cesspool owners access available funding through the Clean Water State Revolving Funds.

B8. Create an entity within the State to help administer and provide federal funding to Counties, nonprofits, and community development financial institutions for cesspool conversions.

C. Recommendations for Public Outreach for Cesspool Conversions

Public outreach and education are essential components of a cesspool conversion program. Wastewater upgrade programs in other jurisdictions found that robust public outreach was necessary for the success of their efforts.

C1. Establish paid public outreach personnel for cesspool conversion at State and/or County levels and work with non-profits to educate homeowners about why cesspools need to be converted, what the due dates are, options and resources available to help with conversions, and other relevant information.

C2. Fund the development of a comprehensive outreach strategy for cesspool conversions that educates homeowners on conversion options and resources. Work with existing non-profits and institutions that support conversions.

C3. Support the development of a web page to serve as an informational clearinghouse with resources needed for homeowners and wastewater industry professionals. Include information about priority zones, cesspool impacts, links to priority zone web maps, and other relevant information.

D. Recommendations for Cesspool Conversion Technology Considerations

Supporting access to certified technology that addresses nutrient pollution reduction and public
health protection is essential for Hawai'i's unique geology, climate, and land use practices. The working group seeks to promote the certification and adoption of novel wastewater treatment and disposal technologies and policies to allow tailored solution.

D1. The Hawaii Department of Health should develop and maintain an online comprehensive resource of approved technology options, including advantages and disadvantages of approved technology options for given locations and site conditions (including onsite systems, sewering systems, and cluster systems).

D2. Collaborate with national onsite wastewater testing centers (like Stony Brook University Center for Clean Water Technology and Massachusetts Alternative Septic System Test Center) for onsite wastewater testing, training, and education to test and approve new alternative wastewater treatment solutions.

D3. The Hawaii Department of Health should update minimum treatment standards (i.e., reduction of nutrients) for onsite wastewater technology for ecologically sensitive areas (high water table, proximity to ocean/streams, prone to sea level rise).

D4. Establish a pilot program to provide matching funding for trialing wastewater technologies in coordination with the Department of Health.

D5. The Hawaii Department of Health should develop an online map and database inventory of all onsite wastewater treatment systems within the state for management and maintenance tracking.

E. Recommendations for Cesspool Conversion Planning/Program Administration

Undertaking a massive infrastructure project such as converting 80,000 or more cesspools requires proper planning and administration across stakeholders and governmental institutions. The working group seeks to set up the State and Counties for successful implementation of its conversion plan through the following recommendations.

E1. Require each County to develop a comprehensive integrated wastewater management plan to include where connections to centralized (public and private) treatment systems are planned, where individual treatment systems will continue to be needed, and where smaller-scale "cluster" treatment systems might be utilized. Include financial strategies.

E2. Establish a cesspool section within the Hawaii Department of Health's Wastewater Branch to include at least three to four staff to work on cesspool conversions planning, implementation, permitting, and regulatory framework.

E3. Increase administrative capacity as needed for cesspool conversion on State lands. Include Department of Hawaiian Home Lands, Department of Land and Natural Resources, Department of Agriculture, Hawaii Community Development Authority, and Hawaii House Finance and Development Corporation.

E4. Prioritize environmental justice principles for disadvantaged community needs (i.e. Department of Hawaiian Homelands), including identifying funding and position(s) to promote equitable outcomes related to the entire cesspool conversion process.

F. Recommendations for Cesspool Conversion Workforce Development

Converting 80,000+ cesspools will require many professionals in the wastewater field. By investing in education and workforce development targeted at residents of Hawai'i, it may enable the State's economy to grow by offering well-paying jobs while meeting its environmental goals.

F1. Assess and identify the workforce needs for upgrading all cesspools, including but not limited to State and County workers, contractors, engineering, permitting and public engagement. Include research and work already in progress with the community colleges.

F2. Re-evaluate current public sector salaries and whether they are sufficient to attract the needed workforce. Streamline the hiring process to facilitate filling needed positions.

F3. Allocate funding to support existing (i.e. the Workforce-4-Water program) and/or the creation of new workforce training program(s) such as education, certification, on the job training, partnerships with other agencies, the University of Hawaii system, labor unions, non-profits, or other entities as appropriate.

1. Act 132 and Working Group Formation

1.1 Working Group Objectives

The following sections outline progress made to date in the Cesspool Conversion Working Group's subgroups (finance, technology, and data and prioritization), and updates on outreach and collaboration along with long range planning. Each of these sections relate directly to the fifteen objectives outlined in Act 132, which can also be found on the Department's website: https://health.hawaii.gov/wastewater/files/2018/09/objectives.pdf.

1.2 Working Group Formation

Act 132 authorized the establishment of the Cesspool Conversion Working Group and requested the following representatives be included:

1) The director of health or the director's designee, who shall serve as chairperson
2) The branch chief of the wastewater branch of the Department of Health or the branch chief's designee
3) Four members representing the appropriate wastewater agency from each county appointed by the mayor of the county in which the agency is located
4) A member representing the wastewater industry, appointed by the president of the senate
5) A member representing the financial and banking sectors, appointed by the speaker of the house of representatives
6) A member of the University of Hawaiʻi, Hawaiʻi institute of marine biology appointed by the director of the Hawaiʻi institute of marine biology
7) A member of the University of Hawaiʻi water resources research center appointed by the director of the water resources research center
8) A member of the Hawai'i REALTORS® appointed by the speaker of the house of representatives
9) A member of the Surfrider Foundation appointed by the president of the senate
10) One representative appointed by the speaker of the house of representatives
11) One senator appointed by the president of the senate

Act 132 also gave the authority to the Director of Hawaii Department of Health to approve of additional working group members. In addition to the list above, representatives from the Coral Reef Alliance, United States Environmental Protection Agency, State of Hawaiʻi, Department of the Attorney General, and the University of Hawaiʻi Sea College Grant Program were approved by the Director to be on the working group. Below is a list of the current members who served on the Cesspool Conversion Working Group. Past members include Bruce Anderson, Senator Kalani English, Lori Kahikina, Wesley Yokoyama, William Kucharski, Jason Kagimoto, David Albright and David Smith.

1	Dr. Elizabeth Char, Chair	Director, Department of Health
2	Edward (Ted) Bohlen	Member of the Public
3	Stuart Coleman	Formerly Surfrider Foundation, WAI
5	Charlene Lani Fernandez	Bank of Hawaiʻi
6	Ken Hiraki	Hawai'i REALTORS®
7	Troy Tanigawa	Wastewater Division, County of Kauaʻi
8	Dr. Roger Babcock	Director, City and County of Honolulu, Department of Environmental Services
9	Ramzi Mansour	Director, County of Hawaiʻi, Department of Environmental Management
10	Dr. Darren T. Lerner	Director, University of Hawaiʻi Sea Grant College Program and the Pacific Islands Climate Science Center
11	Representative Nicole Lowen	State of Hawaiʻi House of Representatives
12	Kenneth Wysocki	USEPA Region 9
13	Eric Nakagawa	Director, County of Maui, Department of Environmental Management
14	Erica Perez	Coral Reef Alliance
15	Sina Pruder	Wastewater Branch, Department of Health
16	Dr. Kawika Winter	Manager, Heʻeia National Estuarine Research Reserve, Hawaiʻi Institute for Marine Biology
17	Michael Mezzacapo	University of Hawaiʻi Water Resources Research Center

Table 1: CCWG Member List

1.3 Meeting Overviews

The Cesspool Conversion Working Group has met fourteen times between September 2018 and June 2022 to discuss updates from subgroups and contractors and progress on the 15 objectives. The Cesspool Conversion Working Group has helped inform the scopes and research objectives of each subgroup. Further details on the duties of each subgroup are outlined in the following sections.

Minutes and agendas from all meetings can be found on the Department's website: https://health.hawaii.gov/wastewater/ccwg/. Highlights from each meeting are as follows:

- September 13, 2018:
  - Decision to hire a facilitator to help organize working group structure and organize meetings.
  - Discussion on potential subgroups to examine the objectives outlined in Act 132.

- October 9, 2018:
    - Three established subgroups developed, Finance, Technology, and Data and Prioritization.
    - Discussed potential University of Hawaiʻi expertise for research objectives. Reviewed the need for additional expertise.
- November 15, 2018
    - Scope and budget agreed for facilitating contractor, One World One Water, LLC.
    - Confirmed working group members for each subgroup.
    - Assigned objectives to each subgroup for discussion and vetting.
    - Agreement on the use of Permitted Interaction Groups for each subgroup meeting.
- January 18, 2019
    - Approval of Finance, Technology, and Data and Prioritization scopes.
    - Evaluation criteria and process for vetting proposals identified.
- March 28, 2019
    - Approval of Department moving forward with One World One Water, LLC contract for facilitation, reflecting that Water Resource Research Center will assist with key research.
    - Update on procurement process for Technology and Finance consultants.
    - Overview by University of Hawaiʻi on cesspool regulations in other states and an overview on the state funded sewage contamination study.
    - Agreement that previous research demonstrates indications of cesspool pollution in groundwater and nearshore waters, but degree of harm or risk is not currently well quantified.
- June 21, 2019
    - Technology and Finance contractor Request For Proposal reviewal in progress, the Department to make final decision.
    - University of Hawaiʻi to review case studies from other states and share with Data and Prioritization subgroup, key insights shared with main Working Group.
    - Legislative Bill HB551 update.
- October 2, 2019
    - Carollo Engineering awarded contracts for both Finance and Technology research scopes. Suggestions to create a matrix of technology options for on-site treatment and to engage with homeowners to understand what information they need for guidelines on conversion technologies.
    - University of Hawaiʻi presentation on cesspool conversion approaches of other states.
    - Suggestion to invite University of Hawaiʻi to share insights on near-shore water study funded by state legislature.

- December 3, 2019
    - University of Hawai'i research update including overview of relevant case studies.
- April 3, 2020
    - Reviewed and approved Data Collection and Prioritization subgroup goals including five key objectives.
    - University of Hawai'i research updates.
    - 2020 legislative session update.
- June 19, 2020
    - Scope updates for Finance, Technology, and Data and Prioritization approved.
    - Lessons learned from Stony Brook and Suffolk County cesspool conversion program shared.
- October 29, 2020
    - Reviewed financial estimates of cesspool conversions and statewide affordability mechanisms.
    - Update on complementary initiative Work-4-Water.
- March 30, 2021
    - Overview of progress on data and prioritization including discussions on exemptions and federal financing opportunities.
    - Legislative bill SB369 update.
    - Update on future sewer expansions through 2050.
- April 20, 2021
    - Discussion on federal funding options and the opportunity of climate change as a driver of different wastewater models.
- May 18, 2021
    - Update on final Hawai'i Cesspool Conversion Plan draft scheduled for end of 2021 and discussion on recommended inclusions. Final report is due by end of 2022.
- July 29, 2021
    - Presentation on University of Hawai'i research, discussion and comments on report draft. Update on final Hawai'i Cesspool Conversion Plan
- October 19, 2021
    - Discussion on the content of the Hawai'i Cesspool Conversion Plan, specifically the revised prioritization data.
- November 16, 2021
    - Outreach group shared Legislative initiatives.
    - Overview of the Interim Report to the Legislature.
    - Discussion of Clean Water State Revolving Fund pass-through program.
- December 14, 2021
    - Discussion of the Data & Prioritization report results.
- February 18, 2022
    - Overview of the outline of the Cesspool Conversion Plan

- Cesspool related legislative bill updates.

- March 14, 2022
  - Initial discussion on recommendations for the Cesspool Conversion Plan, requested more input on suggested recommendations from all working group members.
- April 19, 2022
  - Review proposed recommendations and determine method for prioritizing recommendations to be included in the final Hawai'i Cesspool Conversion Plan
- May 17, 2022
  - Determine recommendations for Hawai'i Cesspool Conversion Plan
- June 21, 2022
  - Determine recommendations for Hawai'i Cesspool Conversion Plan
- July 12, 2022
  - Determine recommendations for Hawai'i Cesspool Conversion Plan
- August 16, 2022
  - Determine recommendations for Hawai'i Cesspool Conversion Plan
- September 20, 2022
  - Vote to approve recommendations for Hawai'i Cesspool Conversion Plan
- October 18, 2022
  - Review final report with recommendations.

1.4 Current Status of Cesspools and Onsite Wastewater Pollution in Hawai'i

There are approximately 83,000 known cesspools in the State. Table 1 estimates the number of cesspools by island and the estimated total effluent discharge represented by those cesspools. These data were generated in 2009 and 2014 through a joint effort between the University of Hawaiʻi at Mānoa, Department of Health, and the U.S. Environmental Protection Agency. In 2021, the number of cesspools were updated during the University of Hawaiʻi cesspool prioritization project. Housing data is estimated from the United States Census Bureau.

Island	Housing Units	Estimated Number of Cesspools	Cesspool Effluent Discharges (million gallons per day)
Hawaiʻi	82,000	48,596	29.27
Kauaʻi	29,800	14,300	8.61
Maui	65,200	11,038	6.64
Oʻahu	336,900	7,491	4.51
Molokaʻi	3,700	1,400	0.84
Total		**82,825**	**49.87**

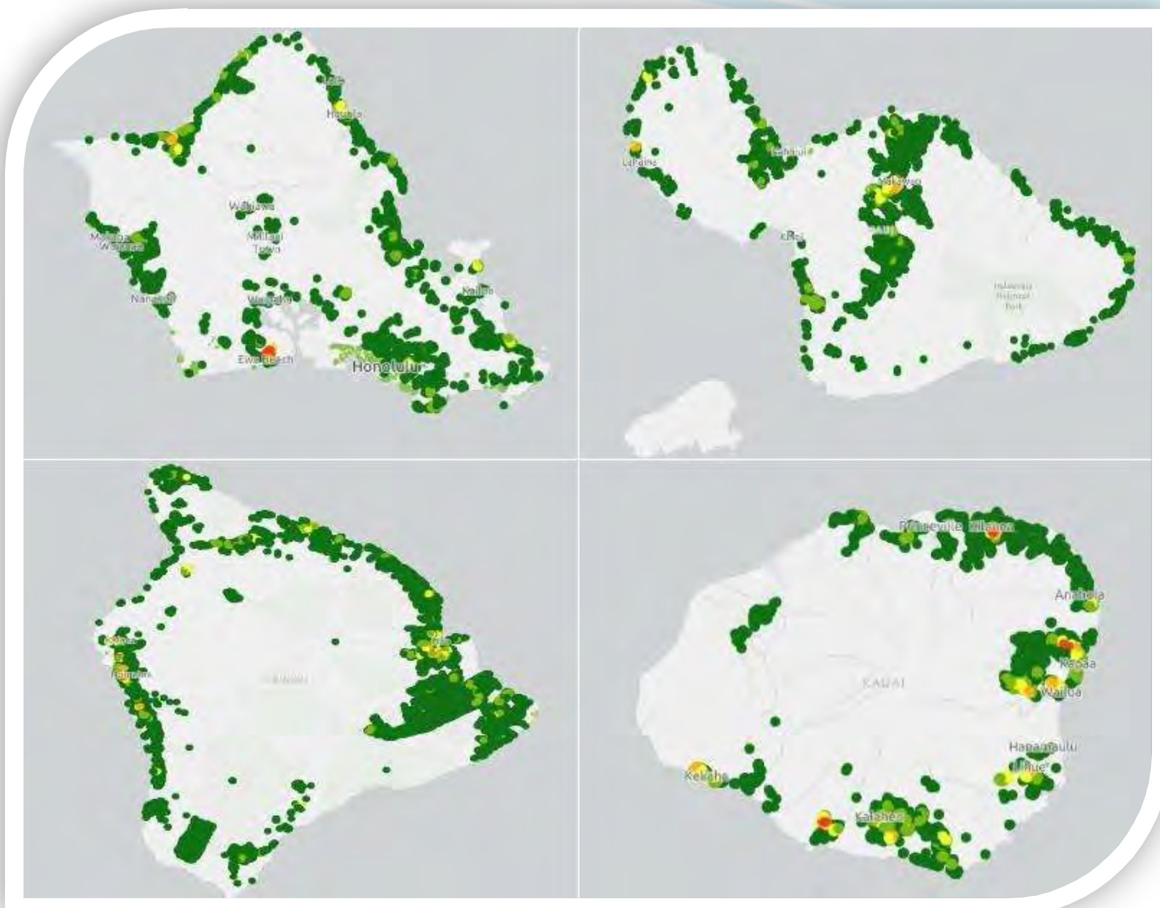

Figure 1. Example map of cesspool density. Red locations indicate the highest density areas, with orange, yellow, and green indicating lower density per acre, in that order.

Although the State has a rough estimate of the number of cesspools and a generalized idea of their locations, an up-to-date georeferenced database of all cesspools and Onsite Wastewater Treatment Systems in Hawaiʻi is needed for diagnosing pollution threats, community outreach/education, watershed planning support, and to ensure proper Onsite Wastewater Treatment Systems maintenance. To achieve the highest database accuracy, a robust ground-truthing effort is needed to verify cesspool/ Onsite Wastewater Treatment Systems locations and conditions. This effort would require significant human and financial resources. More research is needed to determine costs and timelines for accomplishing such a project. It is highly recommended that this effort be initiated and completed prior to finalizing a long-term cesspool conversion plan. Additionally, previous research by University of Hawai'i recommends the State develop a comprehensive and robust statewide Onsite Wastewater Treatment System management tracking program that is part of an updated database to address current failures and future Onsite Wastewater Treatment System maintenance and inspections[1]. States like Oregon and Vermont track Onsite

[1] *1: Babcock et al. 2014.*

Wastewater Treatment System information through an online system with a public accessibility component, simplifying the permitting and maintenance tracking process.

Cesspools pose a serious threat to the health of humans and the environment. Future challenges such as sea level rise complicate cesspool conversion efforts. Sea level rise will worsen cesspool pollution and solutions require long term planning and strategies to mitigate future risks. The entire State of Hawai'i is considered part of the "coastal zone", meaning activities on land have an impact on inland water quality and coastal water quality. Rising sea levels will impact infrastructure along the coast, including cesspools and Onsite Wastewater Treatment Systems. Hawaiian models have detailed how sea level rise reduces the soil treatment zone between Onsite Wastewater Treatment Systems and groundwater, making their treatment less effective and providing a pathway to contaminate groundwater. Dye tracer studies along Puakō shoreline have shown that sewage can reach the shoreline between three hours and ten days due to Hawai'i's porous geology and high groundwater[2]. Results conclude that the underlying geology, rather than OSDS type, primarily controls the speed at which sewage reaches the shoreline. Other coastal states such as Florida are also facing similar challenges. In a recent report, researchers found that Miami-Dade County will experience groundwater levels within a half-foot of the surface for more than 25% of the year by 2040[3]. The 2022 Hawai'i Cesspool Prioritization Tool identifies which cesspools are vulnerable to sea level rise. Future sea level rise conditions must be considered when developing a long-term cesspool conversion plan to ensure longevity and resilient solutions for those impacted.

There are several examples of areas in Hawai'i that have seen decreases in coral cover near locations with high nitrogen levels. Elevated nutrient concentrations from sewage pollution can stimulate benthic macroalgae resulting in phase shifts from coral to macroalgal-dominated reefs[4]. A 2014 report to the Hawai'i Division of Aquatic Resources found coral coverage decreased nearly fifty percent at various sites around Puakō, an area with high levels of nitrogen, short groundwater travel time, and high levels of bacteria in nearby waters. Many other studies have connected wastewater discharges with decreased species diversity, excessive algae growth, human illness, and substantially altered ecosystems. The recently completed Act 132 report, titled: State-Wide Assessment of Wastewater Pollution Intrusion into Coastal Regions of the Hawaiian Islands, provides an understanding of the sources of nearshore sewage pollution, including verifying estimated sewage discharge amounts and the distribution using nitrogen analysis of algae.

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[2] *Tracy N. Wiegner et. al., 2021, Identifying locations of sewage pollution within a Hawaiian watershed for coastal water quality management actions.*

[3] *Miami-Dade County Department of Regulatory & Economic Resources, Miami-Dade County Water and Sewer Department, & Florida Department of Health in Miami-Dade County, 2018.*

[4] *Hawai'i Division of Aquatic Resources, 2014, Understanding the consequences of land-based pollutants on coral health in South Kohala.*

The study compared the impact of sewage pollution between areas with high Onsite Wastewater Treatment System density and nearby areas impacted by agriculture only or with little land-based pollution impact.

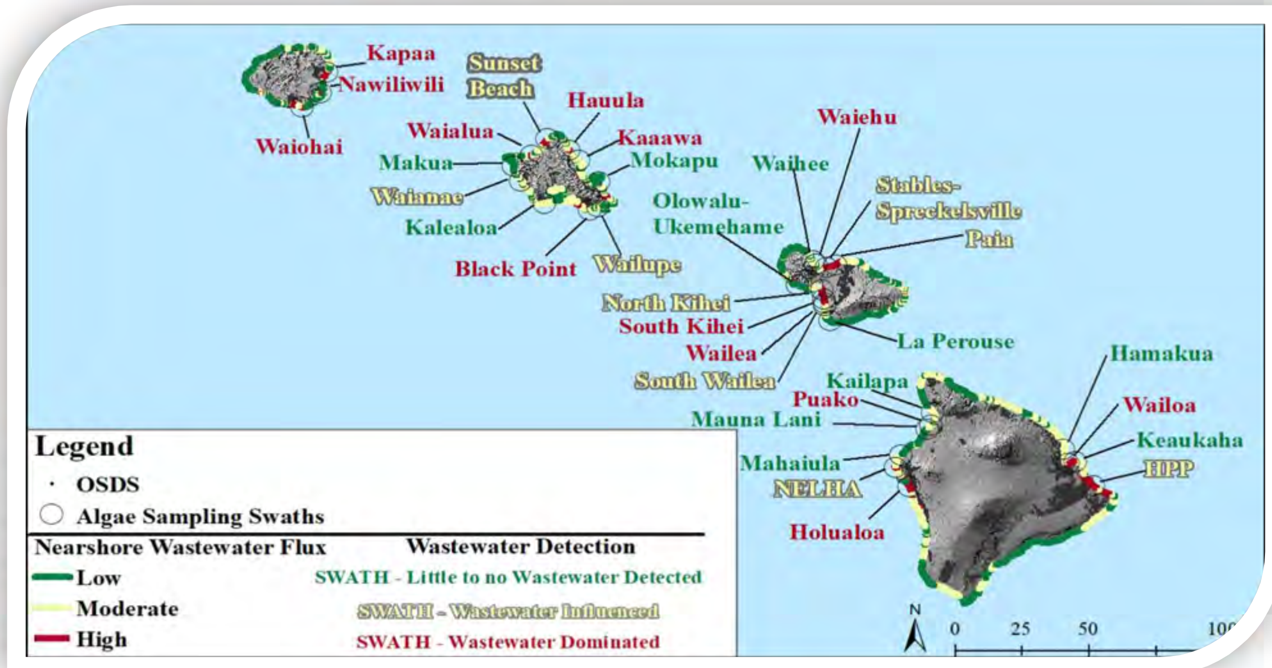


Figure 2. Modeled nitrogen flux shown in three color ranges with low amounts of nitrogen shown in green, moderate amounts in yellow and high amounts in red. **Source:** Act 132 Report: State-Wide Assessment of Wastewater Pollution Intrusion Into Coastal Regions of the Hawaiian Islands.

To date, there have been limited educational/outreach campaigns to inform the public about cesspool pollution and actions being taken by government organizations and the private sector regarding cesspool conversion. The Cesspool Conversion Working Group recommends identifying funding and organizing a coordinated effort between stakeholders to perform outreach and education throughout the various stages of cesspool conversion plan development.

Since Act 125 passed in 2017, and prioritizing areas for cesspool conversion, there have been only 194 cesspools converted. The State's current method to track onsite wastewater system maintenance and permitting lacks mechanisms to keep track of the number and location of cesspools converted each year.

2. Cesspool Prioritizations, Impediments, and Exemptions

Objective 3: Identify areas where data is insufficient to determine a priority classification of cesspools for conversion and determine methods and resources needed to collect that data and conduct analysis of those areas.

Objective 4: Modify, amend, and develop definitions and criteria for priority upgrade areas, as identified in the Department's report conducted pursuant to Act 125; Session Laws of Hawaiʻi 2017, identify the preferred alternative waste treatment systems or sewerage connections for these priority areas, and consider and make recommendations on whether cesspools in these priority areas should be required to convert sooner than 2050.

Objective 8: Identify physical, practical, and financial impediments that may be encountered by land owners who are required to connect pre-existing cesspools to a sewer system or convert cesspools to individual waste treatment system and recommend solutions to those impediments.

Objective 14: Consider whether exemptions should be granted for some mandatory conversions based upon geology, topography, soil type, availability of land, or other relevant factors and make recommendations to the department relating to establishing rules for those exemptions.

2.1 Areas of Insufficient Data

Prioritizing which cesspools pose the greatest hazard to human and ecosystem health can help organize and create a more efficient conversion process from which upgrade timelines and sound policies can be created. Prioritization of which cesspools pose the greatest risk is essential due to the large number of cesspools across Hawaiʻi and limited resources and materials for conversion. In 2017, Department of Health developed an early prioritization method to help identify high-priority cesspools across the State. This effort was unable to classify all cesspools. The 2017 effort was preliminary, however, at the time it still provided valuable methods to evaluate cesspool hazards.

In 2021, Department of Health contracted researchers at University of Hawaiʻi to review the 2017 prioritization methods and develop a more complete and objective prioritization process. The University of Hawaiʻi team created the Hawaiʻi Cesspool Prioritization Tool and produced the 2022 Hawaiʻi Cesspool Hazard Assessment & Prioritization Tool Report, which prioritizes all cesspools in the state and includes an interactive web based map and accessible website allowing for quick visualization of the priority areas, and improved education and outreach with the associated data. The full report is provided in Appendix G.

The Hawaiʻi Cesspool Prioritization Tool uses statewide datasets with at least 90% geographic coverage of the four major Hawaiian Islands (Molokai lacked the necessary data and could not be included in the tool at this point in time. Further analysis could be performed to integrate those data in the future). The careful, comprehensive selection of the datasets that feed into the tool means that every cesspool was able to be evaluated in the process.

While updating the prioritization method, the Hawaiʻi Cesspool Prioritization Tool authors were asked to make recommendations to identify potential exemption criteria for groups of cesspools that are unlikely to severely impact the environment and human health. All cesspools are substandard sewage disposal systems and pose some threat to their surroundings. Therefore, each cesspool in the inventory was assigned a priority ranking, and none are considered by this analysis to be exempt from conversion. Future exemption criteria could be developed, however, they should be done in a manner that is consistent with Act 125 principals and methods that continue to provide protection to human and environmental health.

The Hawai'i Cesspool Prioritization Tool is structured in such a way that it is open source. The code and data used in the tool are publicly available for use and scrutiny by scientists, policy makers, or others. The platform's flexible design allows future data to be incorporated as it becomes available or as policy changes are made. For example, comprehensive nearshore ocean circulation data was limited, however, as new data becomes available it can be reviewed and incorporated into the tool as appropriate.

Finally, because the impacts of wastewater effluent are cumulative, the tool aggregates cesspools into census-based geographic areas (e.g. blocks, block groups, and tracts). There are approximately 320 census tracts within the state of Hawai'i, and of these, just over 100 have a sufficient number of cesspools (i.e. greater than 25) to be ranked by the Hawai'i Cesspool Prioritization Tool. This structure allows the Hawai'i Cesspool Prioritization Tool results to be combined with census data, or data which is similarly structured for additional analysis by internal or external stakeholders. This type of configuration can help outreach and education efforts by tailoring specific needs based upon data and the results, such as household income and persons per house, among others. As the conversion plan is refined, the Hawai'i Cesspool Prioritization Tool can continually be used with new data for consistency, while still providing accurate results and a solid basis on which to prioritize cesspools.

2.2 Conversion Impediments

Successful conversion of cesspools begins with proper planning, identification of impediments, and inclusion of the various participants in the process, including homeowners, businesses, manufacturers, academia, wastewater industry experts, and government officials. Because a conversion process involves interdependence on various stakeholders, any breakdown from one link in the chain can cause challenges for all. Based on the various research provided to the Cesspool Conversion Working Group, several key areas have been identified as conversion impediments. These may involve stakeholders at multiple levels, and careful consideration should be given when developing conversion plan objectives to address these challenges.

The first major impediment to successful cesspool conversion is physical limitations like land area, geology, and sea-level rise. Cesspool conversion requires adequate land area to build most Onsite Wastewater Treatment Systems. Home lots in Hawai'i, on average, are smaller than some of the mainland counterparts identified in this report, presenting unique engineering challenges when siting and installing equipment. Hawai'i also has a varied and unique climate, topography, and geology. Proper soil and underlying geology are important to how an onsite wastewater treatment system treats wastewater and discharge. Hawai'i's young, fractured volcanic geology presents many difficult challenges and must be properly considered when engineering an Onsite Wastewater Treatment System. Home lots with extremely steep slopes also present challenges in wastewater treatment and installation; ideal lots have gradual or no slope. Finally, a very important physical impediment to properly functioning Onsite Wastewater Treatment System is the depth to groundwater under a system. This issue is increasingly important because most development in Hawaiʻi occurs on the coastal plain. Research indicates that sea level rise in Hawai'i is to continue at a rate of one to four inches per year[5]. This rise can, and does, push groundwater levels higher, which can flood onsite wastewater treatment systems and cause pollution to enter the groundwater and ocean. Ensuring that new systems are properly installed and designed to handle future physical conditions like sea-level rise, flooding, and extreme weather events is vitally important. In many difficult situations, the landowner will have the additional requirement of applying for a variance to allow for the construction of an individual wastewater system that may not be designed and constructed to meet existing Chapter 11-62, Hawaii Administrative Rules (HAR) requirements under U.S. Environmental Protection Agency guidelines.

The second major impediment to a successful cesspool conversion involves limitations in the availability of resources, including financial assistance, Onsite Wastewater Treatment System workforce capacity, and administrative processes like Onsite Wastewater Treatment System design, permitting, and planning. Perhaps the most pressing impediment is the availability of financial assistance to convert cesspools. Research has shown that paying for cesspool upgrades is a top consideration among homeowners and is an extreme financial burden for 92% of Hawaiʻi's homeowners. Finding long-term sustainable sources of funding is paramount to a successful conversion program. Additionally, because many cesspools will need to be converted each year, planning and coordination needs to occur between agencies tasked with administering the plan and those involved in training, installing, and manufacturing to ensure an adequate supply of materials, workers, and equipment as demand increases.

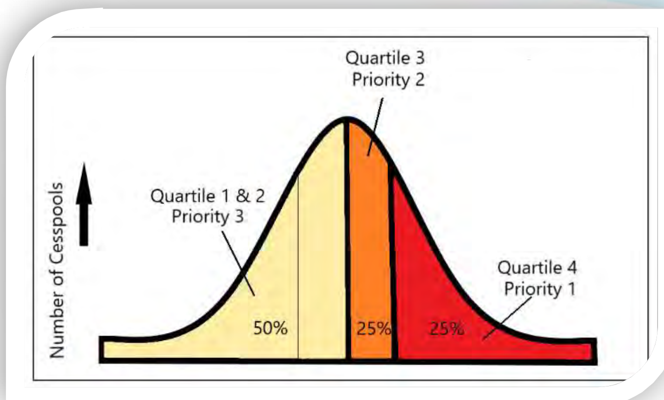
Finally, the third major impediment is technological, including items such as supply chain or manufacturing issues, appropriate nitrogen removal, and methods to track and monitor Onsite Wastewater Treatment System performance. Prior to demand being created for cesspool conversion through the creation of new regulations or financial assistance, a plan should identify proper technologies for nitrogen removal and collaborate with local industry to help reduce barriers to production or shipping of equipment.

2.3 Defining Priority Upgrade Areas

The Hawaiʻi Cesspool Prioritization Tool uses data with a geographical (i.e. map-based component) to integrate multiple types of risk factors posed by cesspools to visualize, assign, and rank each factor at the individual cesspool level and at the community level. The data used within the tool includes physical drivers (e.g. things that impact the movement of pollution and water quality, including proximity to environmentally sensitive areas) and impacts on social and ecological assets (e.g. damage to reefs, impacts to tourism, etc.). The

[5] *State of Hawaii, 2022, Rising Sea Level: What is Happening Now.*

Hawaiʻi Cesspool Prioritization Tool did not evaluate existing infrastructure elements such as nearby sewer mains, injection wells, or future sewer plans. However, these are essential elements that should be included in an overall conversion scheme and further discussed in this report. The Hawaiʻi Cesspool Prioritization Tool authors were asked to continue the previous numerical categories as done in the 2017 process to maintain continuity among homeowners and others who were used to the previous titles.



The new prioritization method utilized in the Hawaiʻi Cesspool Prioritization Tool organizes each geographic area (i.e. census tract) into three categories, and now categorizes all cesspools, unlike the 2017 efforts. The three categories include:

Priority 1: Greatest contamination hazard (map color of red)
Priority 2: Significant contamination hazard (map color of orange)
Priority 3: Pronounced contamination hazard (map color of yellow)

Hawaiʻi Cesspool Prioritization Tool categories are defined by the mathematical quartiles of 25% and 50%:

- The top 25% highest scoring areas designated with the Priority Level 1 ranking
- The next lower 75% to 50% with Priority Level 2
- The bottom 50% as Priority Level 3

The breakpoint categories can be revised based on management strategies, policy needs, or updated research and data.

The total number of cesspools in the state categorized as Priority Level 1 was 13,821, with 12,367 and 55,237 as Priority Level 2 and Priority Level 3, respectively. Approximately 35%, 7%, 21%, and 37% of cesspools in the Priority Level 1 group are located on Oʻahu, Maui, Kauaʻi, and Hawaiʻi Island, respectively.

A full overview of the Hawaiʻi Cesspool Prioritization Tool methods and limitations can be found in Appendix G. As of 2022, the Hawaiʻi Cesspool Prioritization Tool is the most objective, comprehensive, data-driven prioritization method provided to the Cesspool Conversion Working Group and Department of Health that can assist with the conversion process. The Hawaiʻi Cesspool Prioritization Tool prioritization process, similar to other methodologies in North America, involves some subjectivity and policy decisions for resource managers.

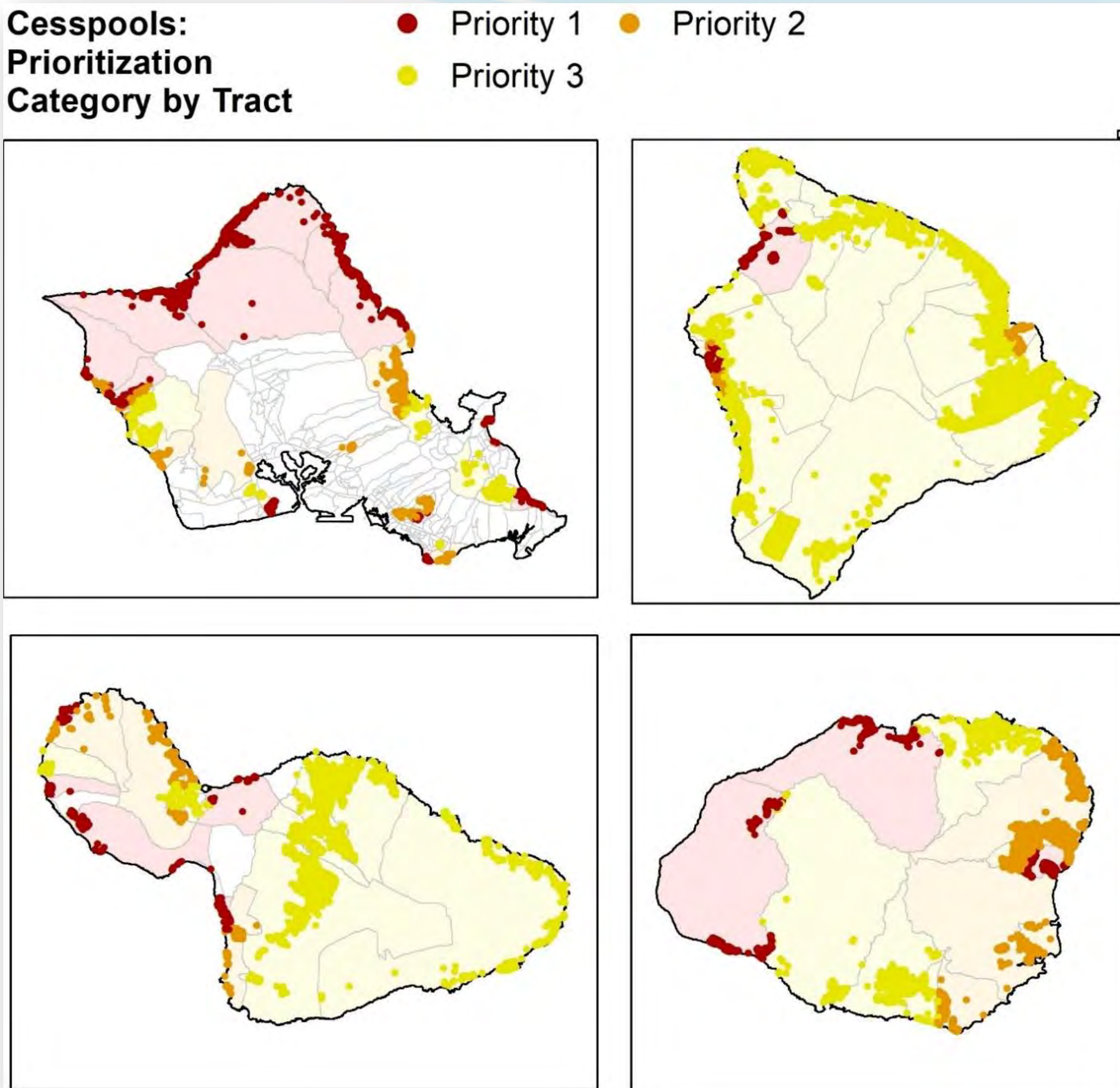


Figure 3. 2021 Statewide map highlighting the simplistic design of the three-tiered categories, census tracts, and their respective colors to signify a priority score. Each dot represents a cesspool and its corresponding color represents its prioritization category.

Though not explicitly touted in the Hawaiʻi Cesspool Prioritization Tool, the tool can help agencies decide on which onsite wastewater technologies match well in certain priority areas based on the detailed data layers. The Hawaiʻi Cesspool Prioritization Tool assesses several physical drivers, which are elements that control the movement, reduce capacity, or otherwise affect the overall level of impact a cesspool has on the land and also the water quality nearby. Much of the data used in the Hawaiʻi Cesspool Prioritization Tool is also used by agencies like Department of Health or county water supply departments for source water protection and public health.

The impact an individual cesspool has on its surroundings depends on many factors. Even with readily available data, it is difficult to fully assess impacts due to various environmental factors and complex site-specific interactions that occur. It is important to acknowledge that no tool can completely predict or assess all environmental variables. Primary factors that contribute to the Hawai'i Cesspool Prioritization Tool include physical factors such as soil suitability and surrounding geology, location, and proximity to environmentally sensitive areas like wetlands and coastlines. Additional factors include ecological assets affected through the coastal discharge point of effluent and cumulative impacts of other nearby cesspools. Importantly, the tool's concept is based on the hypothesis that the more cesspools in an area, the less effective natural soil and subsurface systems will be at degrading cesspool effluent. The Hawai'i Cesspool Prioritization Tool can be used to help inform critical policy decisions such as timelines of conversions.

Key Concepts: All cesspools are substandard sewage disposal systems and pose some threat to their surroundings. Therefore, each cesspool in the inventory was assigned a priority ranking, and this analysis considers none to be exempt from conversion. A shift in priority ranking from the 2017 effort is to be expected due to the amount of available data and the use of census tract areas to frame the overall cumulative scores. The few areas with previous scientific data supporting the presence of wastewater pollution should be treated accordingly and factored in separately when developing conversion schemes.

3. Cesspool Alternatives

Objective 2: Consider and recommend means by which the department of health can ensure that cesspools are converted to more environmentally-responsible waste treatment systems or connected to sewer systems.

Objective 11: Consider alternative wastewater equipment and technologies appropriate to the various areas where cesspools are located that may better protect the environment at lower or comparable cost and how the equipment or technologies can be incorporated as part of the long-term solution to wastewater treatment issues. These alternatives may include, without limitation, graywater systems, constructed wetlands, and other available technologies.

3.1 Conversion Options

There are generally three options for cesspool conversions, including: collection, treatment, and disposal.

- **Connection to existing or new centralized sewer systems.** In the large municipal areas of Hawaiʻi, homes and businesses are connected to county or privately owned, sewer collection and treatment systems, where the wastewater flows to a large centralized treatment facility for treatment and disposal. Centralized sewer collection and treatment systems are cost effective because of economies of scale, treating the water either for discharge to the Pacific Ocean or for water reuse applications (e.g., golf course irrigation). However, there are significant capital investments required by counties or private developers, and connections to centralized systems may not be feasible for many cesspool conversions.
- **Connection to decentralized sewer systems.** Decentralized sewer systems (also "cluster" wastewater systems) are similar to centralized sewer systems, but typically have a smaller collection system service area and wastewater treatment facility. Decentralized treatment can range from passive treatment with soil dispersal to more sophisticated, mechanical treatment, such as membrane bioreactors. Within the rural areas of Hawaiʻi, which are extensive, the costs to dig and construct long sewer systems from remote locations to a centralized treatment facility are substantial.
- **Conversion of cesspools to new** Onsite Wastewater Treatment System **and disposal systems.** A 2004 survey conducted by Department of Health Clean Water Branch showed that approximately 38% of the households in Hawaiʻi had onsite decentralized wastewater treatment system, including cesspools. Since many of the cesspools are in rural areas without centralized wastewater systems, conversion to Onsite Wastewater Treatment System and disposal may still be the most cost-effective option for some homeowners, as long as permitted engineering for disposal is possible.

3.1 Onsite Wastewater Treatment Technologies, Disposal, and Solutions

Most Onsite Wastewater Treatment System can be broken into two main phases of treatment: the initial treatment phase and the final treatment/disposal phase. Some treatment includes an extra step where the wastewater is disinfected. The initial treatment phase of an Onsite Wastewater Treatment System is where the settling/sorting of wastewater occurs and bacteria begin to breakdown waste. The final treatment/disposal phase is where most of the "cleaning" happens in an onsite wastewater treatment system treatment train. It is also the stage when effluent is returned to the environment. Many of the systems described in this section are described in greater detail, including a technology decision making matrix, in the Cesspool Conversion Technologies Research Summary Report prepared by Carollo Engineers, located in Appendix B.

On the surface, wastewater treatment is fairly simple. Aerobic (oxygen loving) and anaerobic (non-oxygen loving) bacteria, which exist in our excrement and the environment, breakdown waste into chemical elements that can be utilized by the environment. However, certain elements like excessive amounts of nitrogen can cause problems such as excess algae growth on coral reefs. Therefore, it is important to further treat waste to breakdown elements into forms that reduce damage to the environment. All Onsite Wastewater Treatment System release some forms of these elements into the environment. However, improperly functioning systems can introduce higher levels of nitrogen, phosphorus, organic matter, and bacterial and viral pathogens into surrounding groundwater and coastal waters. The next section will briefly summarize wastewater equipment and technologies appropriate to Hawaiʻi to protect the environment and human health.

3.1.1 Initial Treatment Phase Options

Type	Cost	Overview	Maintenance	Challenges
Septic Tanks and Leach Fields (Approved by HAR 11-62) 	Lowest initial treatment technology costs. Pumping costs ~$300. Typically no electricity costs.	The most common conversion treatment technology that is approved for use in Hawaiʻi. In a tank, solids, fats, oils and grease are settled out and anaerobic bacteria break down the waste. When paired with a disposal field the two systems can properly treat wastewater and remove dangerous pathogens while returning water safely to the ecosystem.	Septic tanks are recommended to be pumped to remove scum layers of fats, oils and grease every three to five years depending on treatment and household size. Mostly passive, however, some systems may need pumping stations to have the waste reach the disposal field.	Can be large and difficult to install in certain geographies. Not adequate at removing large amounts of nutrients in human waste, i.e. nitrogen. Vulnerable to sea-level rise, floods, earthquakes.

				Small lot sizes without a substantial soil layer will prevent proper installation.
Aerobic Treatment Units and Leach Fields (Approved by HAR 11-62)	Highest initial treatment technology costs. Pumping/annual maintenance costs ~$600. Requires electricity.	Using aerobic (oxygen loving) bacteria to treat the wastewater more than a typical septic tank. Removes more nitrogen than a septic tank but should be paired with a denitrifying final disposal system for maximal nitrogen removal. More efficient at removing nutrients in human waste, i.e. nitrogen, than a septic tank.	ATUs are recommended to be pumped to remove scum layers of fats, oils and grease every three to five years depending on treatment and household size. Requires electricity and regular semi-annual inspections (per HAR 11-62.33.1(b)(4)(A)) by qualified service providers. Requires special alarms to alert homeowners of failures.	Can be large and difficult to install in certain geographies. Many moving parts and greater homeowner involvement. Vulnerable to sea-level rise, floods, earthquakes. Sensitive to high and low temperatures, toxic chemicals, power failures, and large flow variability. Small lot sizes without a sufficient soil layer prohibit proper installation of disposal methods. Supply chain concerns for operation and maintenance.
Fixed Media Treatment and Disposal	Higher costs than a septic tank and typically is paired with a septic tank. Typically, does not require electricity. Pumping/annual maintenance costs ~$300.	Uses aerobic (oxygen loving) bacteria that live on a special type of media surface and treats the wastewater as it moves through the media. More efficient at removing nutrients in human waste, i.e., nitrogen, than a septic tank.	Systems can be passive and do not require electricity which reduces annual costs. However, there are moving parts which would require periodic inspection. Requires special alarms to alert homeowners of failures.	Can be large and difficult to install in certain geographies. Many moving parts and greater homeowner involvement. Vulnerable to sea-level rise, floods, earthquakes. Small lot sizes without a sufficient soil layer prohibit proper installation of disposal methods.
Ultraviolet Disinfection Lamps	Requires electricity. Extra cost for difficult areas	Ultraviolet disinfection is a polishing step that follows other treatment, such as	Ultraviolet systems require periodic replacement/cleaning	Disinfection may be required near sensitive waters and

(Approved by HAR 11-62) 	located near sensitive waterbodies.	septic tanks; disinfected effluent then flows to the disposal system. Ultraviolet systems use lamps emitting ultraviolet light that acts as a physical disinfection agent to destroy bacteria, viruses, and pathogens. Ultraviolet systems do not use chemicals and are not space intensive.	of the quartz sleeves to ensure transmission of the Ultraviolet radiation into the wastewater. Ultraviolet bulbs must be replaced annually, and regular inspections are needed to ensure the correct operation of the system. Requires special alarms to alert homeowners of failures.	drinking water sources.
Chlorine disinfection (Approved by HAR 11-62) 	Requires electricity. Extra cost for difficult areas located near sensitive waterbodies.	Chlorine disinfection is a polishing step that follows other treatment, such as septic tanks or ATUs; disinfected effluent then flows to the disposal system. Chlorine systems use elements of chlorine to destroy bacteria, viruses, and pathogens.	Chlorine systems require periodic inspections to ensure the correct operation of the system and chemical application. Requires special alarms to alert homeowners of failures.	Disinfection may be required near sensitive waters and drinking water sources. Uses chemicals requiring proper usage and storage. Residual chemicals may enter the environment. Not appropriate for homes connected to shoreline areas.

Table 2. Initial Treatment Options.

There are many types of Onsite Wastewater Treatment System and disposal methods approved for use in Hawai‘i (see Table 2). More advanced or new initial treatment technology must undergo testing, often done in conjunction with the National Science Foundation standards to confirm a systems feasibility. Department of Health requires NSF245 and/or NSF40 certification in order to install advanced treatment technologies in Hawai‘i under HAR 11-62.

Similar to other locations, Onsite Wastewater Treatment System installed in Hawai‘i can be impacted by events like sea-level rise, flooding, and earthquakes. More advanced units use electricity to run pumps or aerators, adding costs to the operation of the unit and typically require annual maintenance to ensure it is treating wastewater to the desired level. Hawai‘i’s high electricity costs and limited distribution lines may limit where certain technology can be installed. Performance can be impacted by high and low temperatures, heavy loading of solids, toxic chemicals (like chemical cleansers), power failures, and flow variability. A septic tank may be required prior to advanced treatment technology, increasing the amount of space needed. However, advanced systems may reduce the size of the final disposal system needed. Advanced units are often installed in areas with poor soil conditions or adjacent to sensitive water bodies. Occasionally advanced units will be paired with a disinfection system when very poor conditions exist for a final disposal area, such as extremely high-water tables or being adjacent to a river, ocean, or lake. The most common types of onsite disinfection units use chlorine tablets or ultraviolet radiation to destroy harmful pathogens.

3.1.2 Final Treatment/ Disposal Options

After the wastewater undergoes a type of initial treatment, the effluent heads to the final treatment and disposal phase. This stage often uses a series of pipes with perforations and aerobic bacteria residing in the soil to break down the waste products. These bacteria (in combination with the physical characteristics of the gravel and soil) further treat, filter, and dispose of the remaining wastewater. Commonly referred to as a soil absorption system or leach field, these areas contain a significant portion of the entire treatment process (where bacteria and pathogens die and nitrogen can be converted to less harmful forms). Final disposal systems are carefully engineered to ensure proper treatment and timing. Some newer soil absorption system technology uses additional media like wood chips to further treat wastewater and remove significant amounts of nutrients like nitrogen. The next section will discuss final disposal systems and other technologies that treat wastewater to help Hawaiʻi meet its cesspool conversion goals. Options of final treatment and disposals include:

3.1.2 Final Treatment/ Disposal Options

Type	Cost	Overview	Maintenance	Challenges
Inground/Mound Soil Absorption System (Approved by HAR 11-62) TREAT & DISPOSE	Least expensive, however can become costly depending on site requirements.	Most common/ proven technology. Most common form of final treatment/disposal, however not the best option for environmental protection.	Mostly passive operation, limited maintenance. Sensitive to misuse, including excessive grease, oil, and fat use.	Requires a significant amount of space and not all sizes can accommodate. Requires specific sand/gravel types. Susceptible to damage from roots, cannot place structures on top of the area. Extremely susceptible to sea level rise.
Nitrogen Reducing Biofilters (Approval under review) TREAT & DISPOSE	Moderately expensive, typically more than an inground/mound system. Cost can fluctuate based on the cost of the carbon materials.	Combines elements of an inground/mound system with a carbon source to significantly reduce nitrogen. Research is being conducted at University of Hawaiʻi to develop a non-proprietary system for use in Hawaiʻi.	Mostly passive, can be difficult to replace carbon source for nitrogen reduction. Sensitive to misuse, including excessive grease, oil, and fat use.	Requires a significant amount of space not all lot sizes can accommodate. Requires specific sand/gravel types. Susceptible to sea level rise, damage from roots, cannot place structures on top of the area.

Recirculating Sand Filters (Approval under review) TREAT & DISPOSE	Moderately to extremely expensive.	Raised and boxed area with special sand and lines to disperse effluent in a timed manner. Very useful in areas with difficult site conditions (such as high-water table) or where there is limited space. Once effluent reaches the bottom it can be recirculated and run through the treatment process again or head to a paired soil absorption system or seepage pit.	Needs frequent maintenance of pump and piping to maintain proper treatment.	Structural components made of wood can be prone to rot. Care must be given to ensure plant roots do not destroy elements of the system. Can require a significant amount of space depending on system combinations.
Drip Dispersal System (Approved by HAR 11-62) TREAT & DISPOSE	Can be expensive depending on site conditions and the size of the system. However, typically excavations costs are less.	Small-diameter pressurized pipes deliver, precise, even doses of effluent to the surrounding soil for treatment. Can be used to irrigate landscaping.	Because of the small pipe size, these systems use tanks, filters, and pumps which require annual maintenance and electricity.	Can require a significant amount of space to place piping. Can require unclogging or descaling of emitters depending on effluent and filter quality.
Bioreactor Gardens or Constructed Wetlands (Approval under review) TREAT & DISPOSE	Costs are difficult to determine due to the limited number of systems designed and installed. However, by using locally sourced materials and as the number of systems increase, costs will likely decrease.	Mimic the process of treatment that occurs in natural wetlands. Wastewater enters a lined area with sand, gravel, soil and other special media in which plant roots and microbes live in and take up and treat the waste.	Though the systems are mostly passive, preventative maintenance is required. Additionally, special care must be given to the plants performing the work. This can be an additional cost if a professional is hired.	May use gravity distribution or have pumps that evenly distribute the effluent, complicating the system. Additional, but much smaller, conventional soil absorption system may be downstream to treat waste further. Use special plants that must have optimal growing conditions. Vulnerable to flooding.
Evapotranspiration Systems (Approved	Cost can fluctuate significantly depending on size, location, and materials.	Watertight lined pits or open-air tanks (with vents) where the wastewater flows into them and evaporates into the atmosphere. The effluent never touches soil	Typically, limited maintenance is needed for these types of system.	Require special climate conditions, with ample amounts of sunshine and limited to no precipitation.

by HAR 11-62)  		or groundwater, making it especially useful for difficult sites.		

Table 3. Treatment and Disposal Options.

Inground/mound soil absorption systems are the most common form of final treatment/disposal used in onsite wastewater treatments. If soil conditions are appropriate for wastewater treatment/disposal a series of shallow trenches are dug and lined with gravel. Perforated pipes or plastic chambers are then laid out parallel to each other and connected to a distribution box located after the initial treatment technology. The piping or chambers are then covered with soil and grass. Systems are often close to the surface to allow for the constant exchange of oxygen to help the bacteria break down the waste. When soil conditions are suboptimal, but still semi suitable, a mound system can be built. These systems often exist when there is a high-water table. The mound uses engineered sand/soil designs to build up enough space between the groundwater table, allowing adequate treatment through unsaturated soil. Mound and inground systems can require pumps if the treatment area is higher than the septic tank or other initial treatment unit. These systems require a significant amount of space but can be made smaller if an appropriate initial treatment unit is used. Mound/inground soil absorption systems require limited maintenance and are often the least expensive final treatment/disposal mechanism.

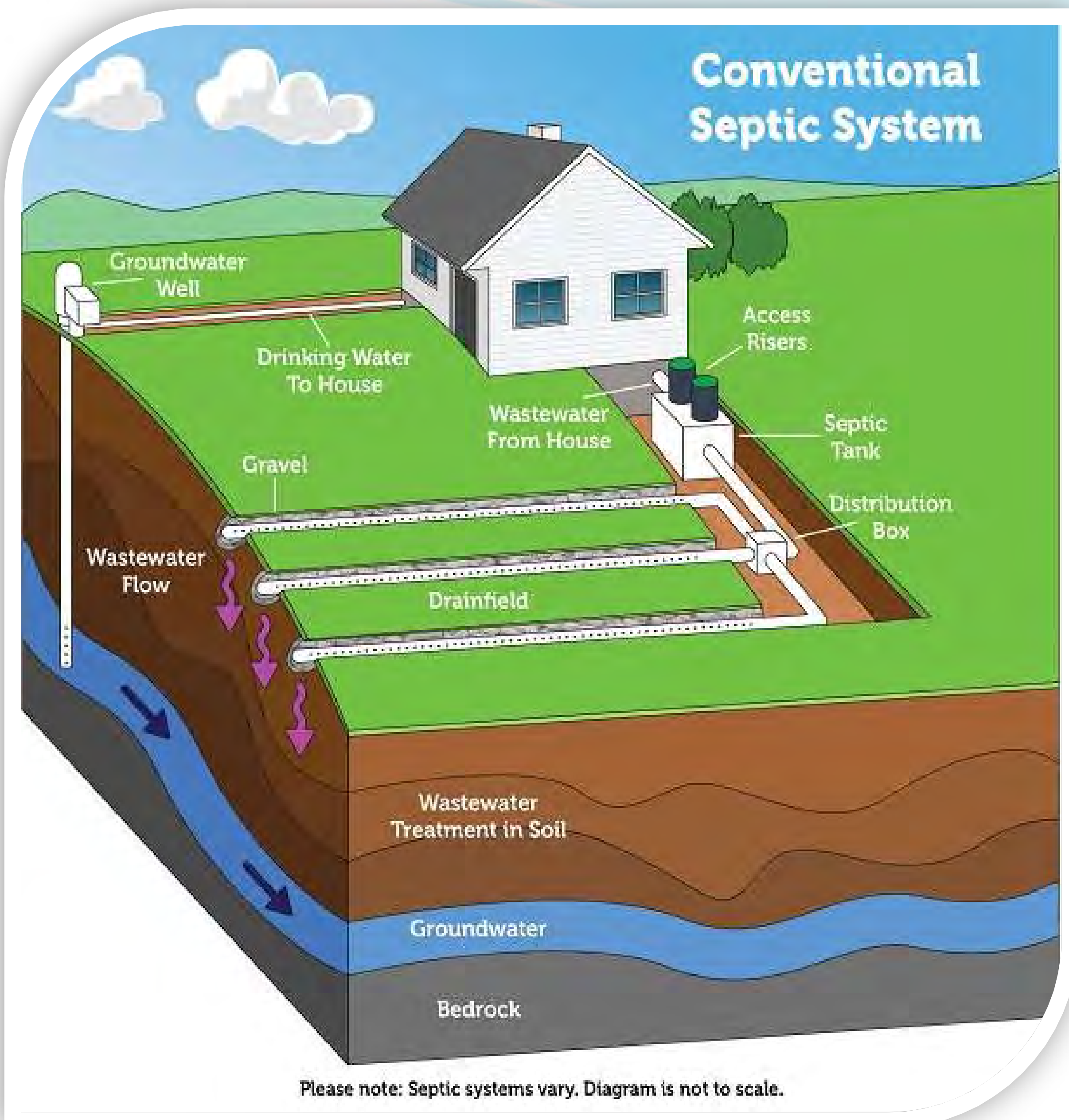


Figure 4. Conventional Inground Septic System. **Source:** U.S. Environmental Protection Agency.

Figure 5. Mound Septic System. **Source:** U.S. Environmental Protection Agency.

Though there is some nitrogen removal in an inground or mound soil absorption systems, it is limited. By adding an anaerobic layer under a soil absorption system and a source of carbon, bacteria can significantly reduce the amount of nitrate released into the environment. These final treatment/disposal systems are often known as nitrogen reducing biofilters. Nitrogen reducing biofilters are typically passive and do not require electricity. Nitrogen reducing biofilters are usually greater in depth than a conventional mound or inground soil absorption system, which may mean more space is needed between the water table to install them. Some nitrogen reducing biofilters are lined and could potentially be placed in areas with a shallower groundwater table. Research is occurring at the University of Hawaiʻi at Manoa to develop nitrogen reducing biofilters specific to Hawaiʻi's geological and hydrological needs.

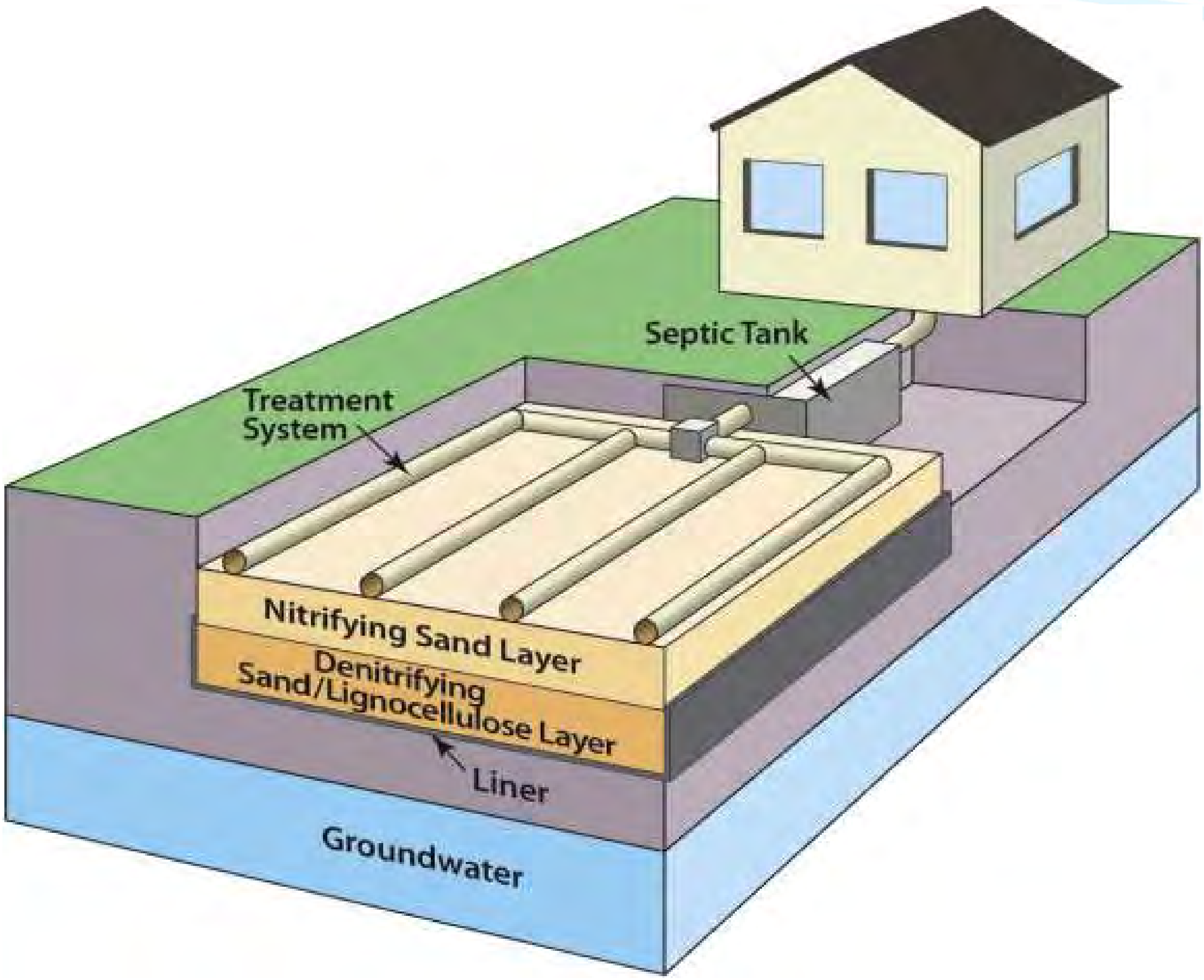


Figure 6. Nitrogen Reducing Biofilter. **Source:** EPA.

Recirculating sand filters are another form of final treatment/disposal. Recirculating sand filters are approved for use in Hawaiʻi and are NSF40 and NSF245 certified. A recirculating sand filter is a lined box filled with sand that uses pressurizing effluent distributed (by spray nozzles) to the top of the bed of sand. The wastewater is treated as it percolates through the sand. As it reaches the bottom, a portion of the water is pumped back to the pump chamber or the treatment process, and another portion passes on to a final disposal such as a soil absorption system, drip irrigation, or a seepage pit. The nitrate in the recirculated water undergoes denitrification under anaerobic conditions. The greatest benefit of recirculating sand filters is that they can remove up to 50% of total nitrogen. Recirculating sand filters require annual maintenance, proper protection of the filters, and electricity is needed to run alarms, pumps, and filters to recirculate the wastewater. Recirculating sand filters are good choices for areas that may be impacted by rising groundwater levels.

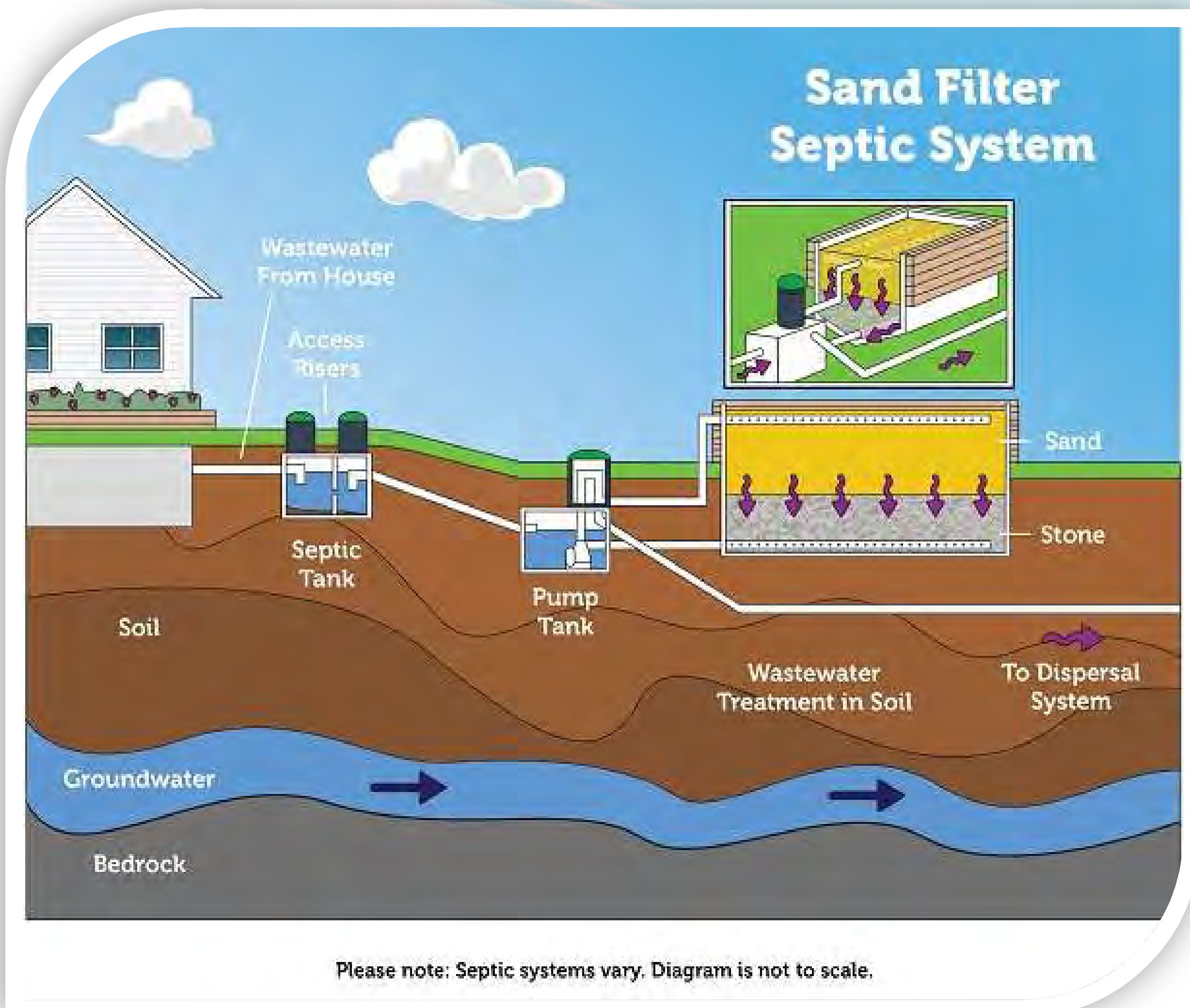


Figure 7. Sand Filter Septic System. **Source:** U.S. Environmental Protection Agency.

A drip dispersal system uses small-diameter pressurized pipes to deliver small, precise, even doses of effluent to the surrounding soil. Drip dispersal systems are very similar to a conventional inground soil absorption system through filtering and bacterial decomposition of the effluent. Drip dispersal systems utilize consistent dosing by using a special pump/ holding tank. Most drip dispersal systems also use filters prior to being distributed into the piping to prevent clogging. Pipes are typically installed six to twelve inches deep and spaced around two feet apart. Pipes are often laid out with the lines running parallel, but there is flexibility to accommodate irregularly shaped sites or contoured slopes. Drip dispersal systems require electricity to run the pumps, filters, and alarms. Due to their complexity, drip dispersal systems require annual maintenance to clean filters, flush lines, and check electrical components.

Figure 8. Drip Distribution Septic System. **Source:** U.S. Environmental Protection Agency.

Bioreactor gardens or constructed wetlands mimic the process of treatment that occurs in natural wetlands. Effluent enters a lined area with sand, gravel, soil and other special media in which plant roots and microbes live in and take up and treat the waste. Sometimes these systems use gravity distribution or have pumps that evenly distribute the effluent. Additional, but much smaller, conventional soil absorption systems may be downstream of a constructed wetland to treat waste further. These use special plants that must have optimal growing conditions. Many bioreactor gardens or constructed wetlands do a good job at removing nutrients from wastewater, making them good choices when dwellings are near sensitive water bodies.

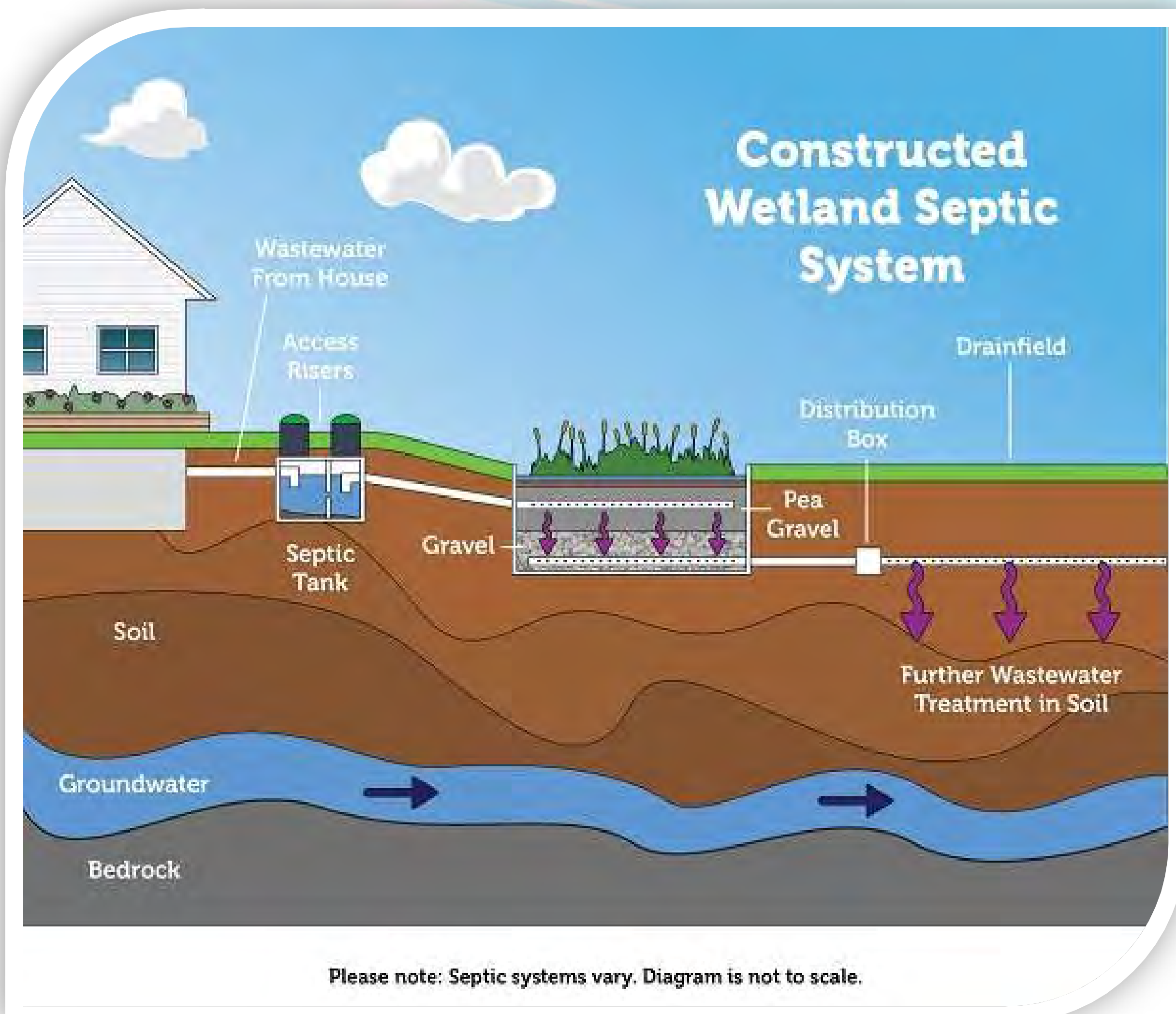


Figure 9. Constructed Wetland Septic System. **Source:** U.S. Environmental Protection Agency.

Evapotranspiration systems are watertight lined pits or open-air tanks (with vents) where the effluent flows into them and evaporates into the atmosphere. The effluent never touches soil or groundwater, making it especially useful for difficult sites. However, evapotranspiration systems require special climate conditions, with ample amounts of sunshine and limited to no precipitation.

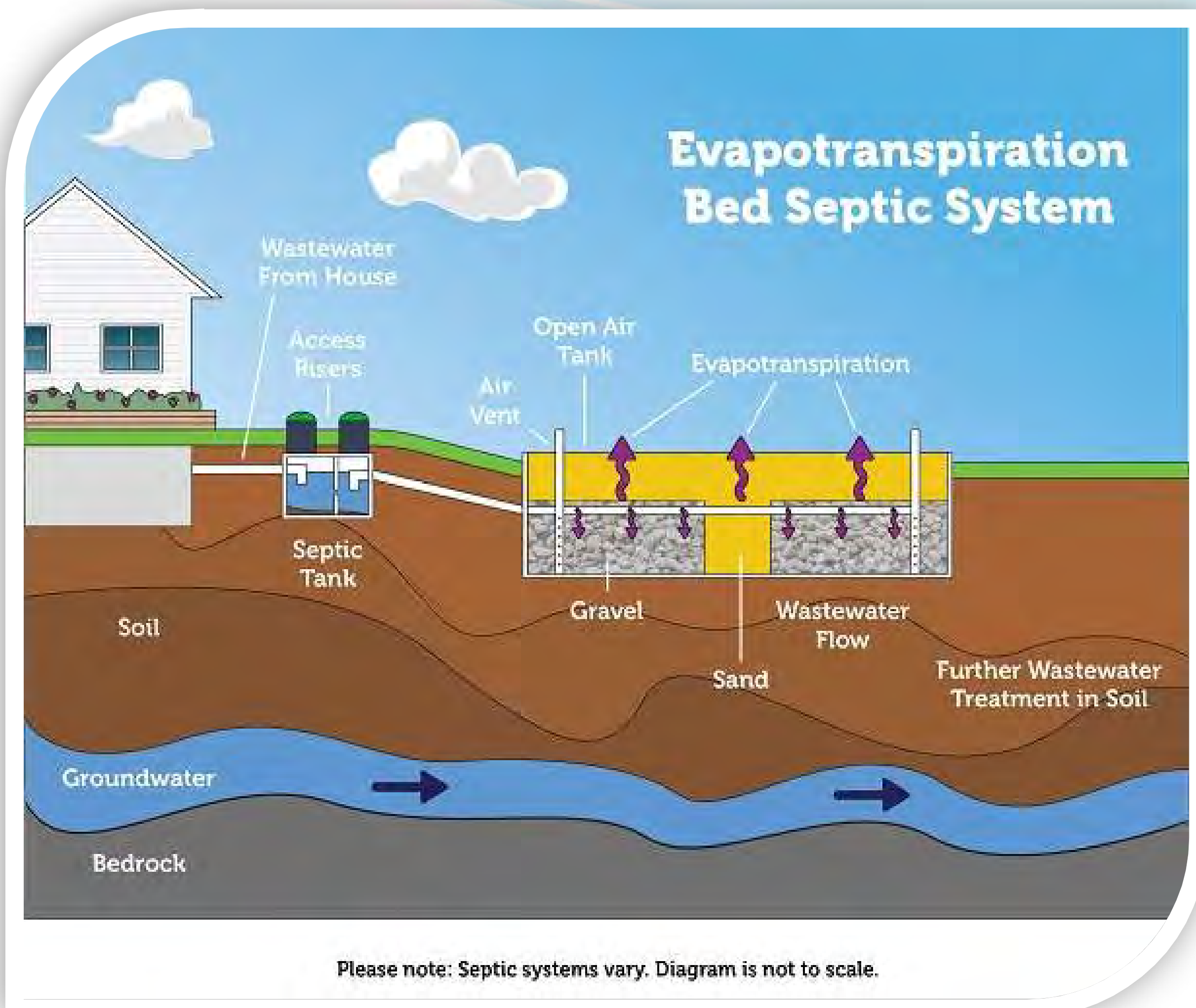


Figure 10. Evapotranspiration Bed Septic System. **Source:** U.S. Environmental Protection Agency.

3.2 Alternative Technologies

The science of wastewater treatment is expanding rapidly. There are new technologies/solutions being engineered rapidly that can help solve major hurdles in the onsite wastewater treatment industry, such as space requirements or nitrogen removal. Many of these technologies are not a panacea and may require site adaptations. However, adopting policies that encourage innovation in wastewater technology can benefit all by reducing costs, decreasing regulatory hurdles, and increasing availability. This section will briefly explain some technologies that do not fit into the typical two phase onsite wastewater treatment systems described above and are either available or being piloted for use in Hawaiʻi.

Composting toilets are a self-contained or centralized system that uses little to no water and the biological process called composting to break down human waste to basic elements and humus. Composting toilets often separate solid and liquid wastes to simplify the composting process. The composting process is often labor intensive and requires considerable maintenance and upkeep. Capacity is limited by the size of the composting tank and the systems can occupy significant space inside the dwelling. Composting systems perform best under appropriate moisture and temperature conditions, along with the proper ratio of carbon and nitrogen, which requires frequent monitoring. Composting systems also need to be properly vented and use electricity to run special ventilation fans or augers to mix the material. Because composting toilets involve owner maintenance and treatment, there are pathways for improperly treated waste to contaminate the environment. Though modern composting toilets have been in use for many years, they may only be beneficial for the most remote rural areas or restrictive sites.

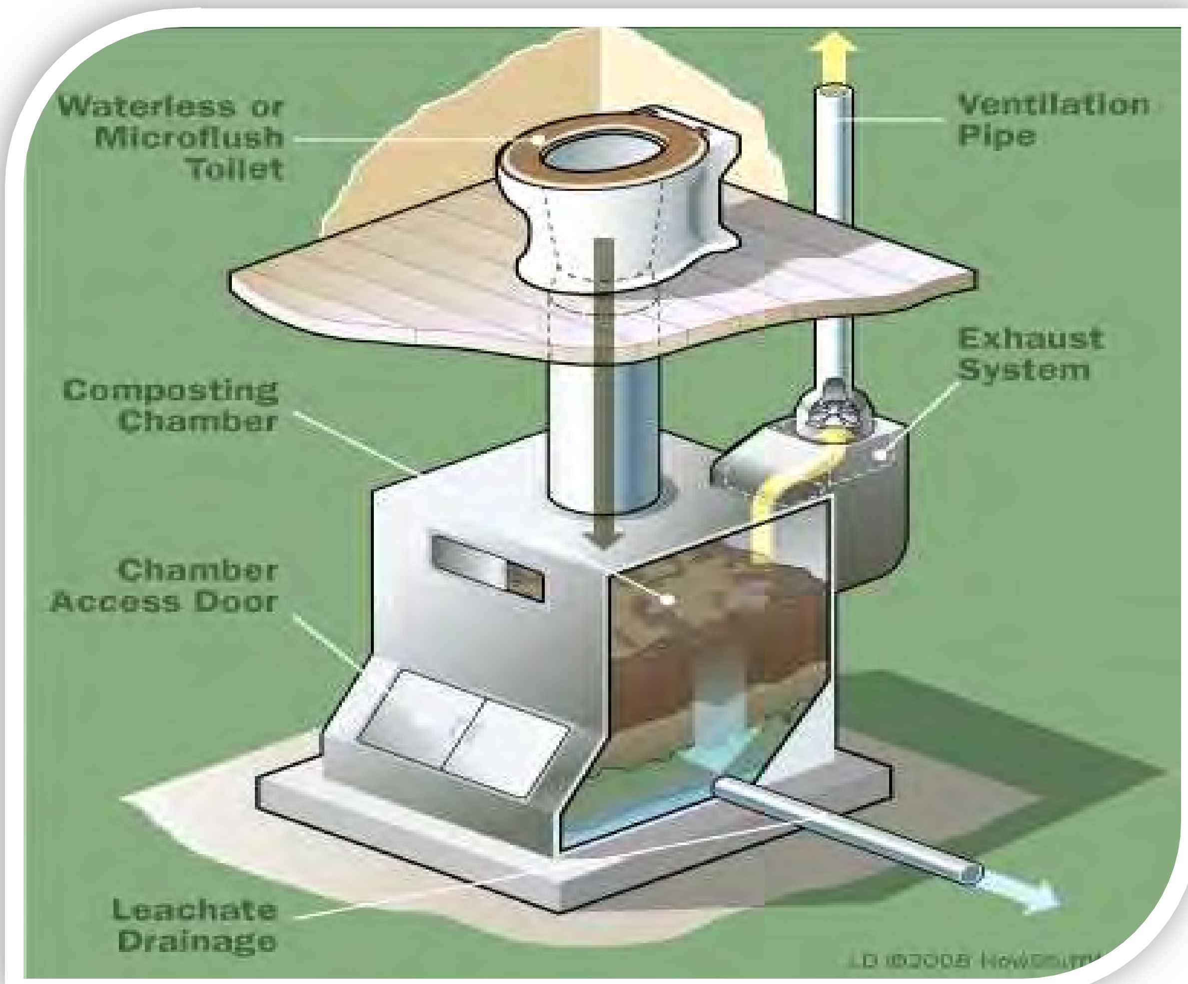


Image 11. Composting toilet diagram. **Source:** www.howstuffworks.com

Incinerating toilets are similar to composting toilets in that they are often waterless and self-contained. However, instead of using the biological process of composting, the solid and liquid waste is burned at extremely high temperatures using gas or electricity. Incinerating toilets do not require a plumbing system and produce no harmful byproducts. When the toilet has finished burning the waste, an inert ash is left over for disposal in household refuse or in a garden. Incinerating toilets require the use of a paper liner and must be emptied every few days depending on use by the operator. Incinerating toilets may be useful for areas with frequent natural disasters, remote rural locations, or smaller dwelling units. Limited professional maintenance is required to service electrical or gas parts on the units.

Vermicomposting systems use earthworms housed in a tank with other organic materials like coarse wood shavings, chopped prunings, dead leaves, dead ferns, straw, and kitchen scraps to break down and treat human waste. Often these systems are accompanied by a small rudimentary soil absorption bed covered with certain plants to further treat the liquid waste and remove nitrogen. Vermicomposting systems can be completely passive (require no electricity) and are built with common construction materials, very similar to a traditional septic tank. Vermicomposting systems may be subject to extreme temperature swings and changes in use. These living systems require some maintenance and monitoring from the homeowner which may be a challenge for homeowners unable to perform maintenance or if the home is occupied part-time. However, the simple design and low cost of construction may make these systems ideal for rural or off grid homeowners. Because there are several non-proprietary and proprietary systems, the Department of Health should study and approve a specific system design or require testing to ensure waste treatment is adequate. Finally, due to necessary maintenance, a workforce could be created to offer services to homeowners.

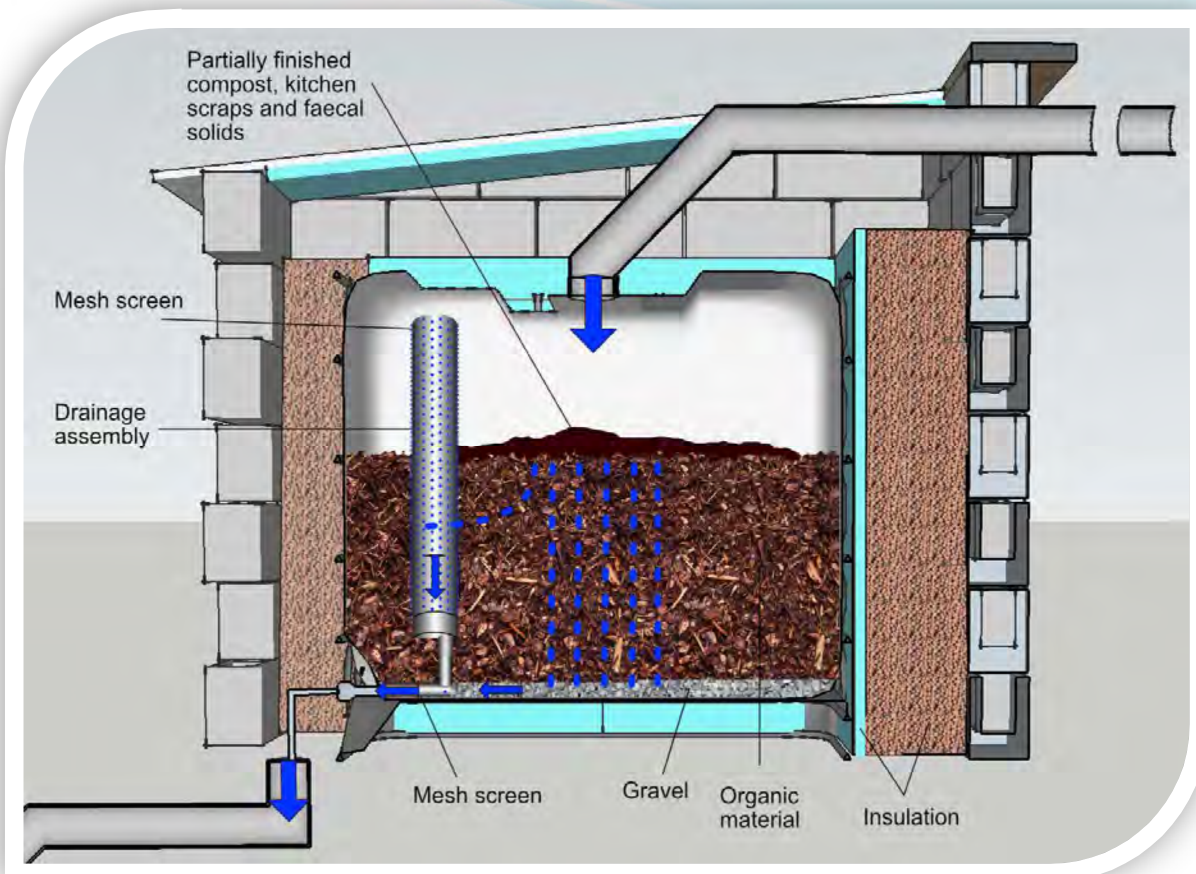


Figure 13. Vermiculture composting system. **Source**: www.vermiculturecompostingtoilets.net

Combination projects which use both existing technology (including systems already in the ground) and new technology may also be part of the solution for cesspool conversion. For example, the use of a septic tank, aerobic treatment unit, ultraviolet disinfection, and a seepage pit for final disposal may be an option for sites very limited in size or poor geology. Projects such as these may require site specific research and monitoring. However, we recommend that Department of Health standardize certain practices of proven system design for faster permitting in certain areas.

3.3 New/Innovative Technology Approval Process

Reducing barriers to onsite wastewater treatment systems technology approval and testing, while simultaneously protecting the environment and outlining a clear structured process is important and needed for Hawaiʻi. Section 11-62-35 of Hawaiʻi Administrative Rules allows the Department of Health Wastewater Branch to review and approve of new and innovative technologies on a case-by-case basis. The new and innovative technologies are approved by the Director of Health based on appropriate testing procedures and standards set forth by the National Sanitation Foundation Testing Laboratory. The performance data shall be obtained by an agency such as a university or an independent research laboratory acceptable to the Director of Health or from National Sanitation Foundation. Additional capacity will be needed as conversion efforts ramp up. Hawaii Department of Health may wish to include more specific and adaptable language in HAR 11-62 which clearly identifies a pilot project/ new technology's pathway for approval and testing, especially for advanced onsite wastewater treatment systems. Section 8 of this report details information regarding the creation of an in-state onsite wastewater training and testing center.

4. Financing Cesspool Conversions

Objective 5: Examine financing issues and the feasibility of various mechanisms, including grants, loans, tax credits, fees, special assessment districts, requirements for conversion at point of sale, and any other appropriate mechanisms for accomplishing and funding cesspool conversion, or any combination of these mechanisms.

Objective 6: Consider owners' ability to pay for cesspool conversions, and, especially how assistance can be provided for lower-income homeowners.

Objective 7: Consider the most cost-effective approach to cesspool conversion.

4.1 Financing Options

Based on the average cost of cesspool conversions, it is estimated that the total cost of the conversions within the State of Hawaiʻi is approximately $2 billion, but the actual number may range from $880 million to more than $5.3 billion. The magnitude of the potential amount of funding that the program requires is significant and poses a substantial challenge to identifying viable funding mechanisms for Hawai'i's cesspool conversion program. While there are low-interest loan and grant funding opportunities from federal, state, and local financing sources, these still fall short of the amount needed to fund all conversions. In addition, most of the financing programs are available only to government entities such as the state or counties, or non-profit organizations, and are not targeted at private, residential property owners. This is further complicated by the fact that the State and the Counties do not currently have the staff or the administrative capabilities to receive grant or loan funds, review, and process individual applications, disperse the funds to homeowners, and conduct follow-up payment collection in the case of loans.

The State will need to invest significant capital and human resources to meet its goal of converting all cesspools. Hawaiʻi isn't charting new territory when it comes to funding upgrade programs. Places like Suffolk County, New York or Washington State offer models of how to approach this crucial element of an upgrade program. Potential funding options, recommendations, and benefits and limitations are included in the following table, and further information on funding opportunities can be found in the Financing Cesspool Conversions in Hawaiʻi report.

Option	Overview	Recommendations	Pros and Cons
Grants and Loans	Federal, state, and local grant and loan funding sources. Grants do not need to be repaid, while loans are borrowed funds that require repayment, typically with interest.	The state should convene a group of local finance experts, federal partners and other relevant stakeholder to create financial timeline plans.	These sources do not provide a reliable long-term solution for financing cesspool upgrades but can help with the implementation of portions of the program. It is likely infeasible for financial support in the form of grants or low interest loans

			to be provided to all cesspool owners for the conversions.
Federal Funding	The Water Quality and Job Creation Act of 2021 provides $50 million to Hawaiʻi over the next five years to help address the wastewater infrastructure and water quality challenges. Other federal funding opportunities include the American Rescue Plan Act, Clean Water State Revolving Funds, the Water Infrastructure Finance and Innovation Act, and Non-Point Source Section 319 grants.		Funding requirements/limitations.
Private/ Mortgage Loans	There are several private financing options available to homeowners including: personal loans, home equity loans, or the use of personal savings. Given the economic turmoil caused by the global COVID-19 pandemic in 2020, the current, low interest rates provided by private lending options may be an economical option for some residents. There are a variety of private lending options, with interest rates ranging from 2.7 to 14%.		A necessary option for homeowners, given that grants and loans will not likely be enough.
State Tax Credits or Rebate Program	The State of Hawaiʻi's temporary tax credit program (Act 120), which provides up to $10,000 in incentives for individual homeowners to convert cesspools to septic systems or aerobic treatment units, expired on December 31, 2020.	Legislation to continue Act 120. Given that less than 100 applicants filled out this credit to date, work is needed to appeal to a larger audience and encourage more applications. Consider separate rebate program, which might be more appealing for conversions.	Credit program has not been taken full advantage of in the past, consider a rebate program.
On-bill Financing Programs	On-bill financing programs are generally loans that are paid back over time through additional charges on a utility bill.	Assistance from county or local agencies (such as water or wastewater utilities) on the billing administration similar to on-bill financing of electric utilities.	Can be adapted to finance cesspool conversions.
Property Assessments	A mechanism used by local governments to allow property owners to finance the up-front cost of energy efficiency and renewable	Modify existing programs as a viable financing option for cesspool conversions to allow a property owner to pay back costs over time at an	To finance individual cesspool conversions, a county would have to pass an ordinance to form a Community Facilities District

	energy improvements (such as solar) and then pay the costs back over time through a voluntary assessment. Funding is generally provided by private lenders, banks, or the issuance of municipal bonds.	agreed upon interest rate and length of loan term.	(CFD) or Special Improvement District (SID) and levy a special tax to fund the improvements and receive the required fifty-five percent approval from the property owners to form the CFD or SIDs. This could only be implemented where dense or concentrated areas of cesspool remediation are needed.
Public Private Partnerships (P3s)	P3s encourage private investment in public infrastructure projects and can be contractual arrangements in which governments or public entities form partnerships with the private sector to design, finance, build, and operate and/or maintain infrastructure such as toll roads, water supply facilities, and wastewater treatment plants.		Public agencies oversee financing and theoretically pass risks related to operating costs and project revenues to the private partner. However, P3s also have some negative aspects including potential local opposition, loss of public control and flexibility, potential need for in-house expertise or outside consultants, complicated contracts, and complex negotiations, as well as significant effort to enforce and monitor contracts.

Table 4. Financing Options.

Specific funding agencies with potential financing mechanisms include:

- United States Environmental Protection Agency
- United States Department of Interior, Bureau of Reclamation
- United States Department of Agriculture
- United States Department of Housing and Urban Development
- United States Department of Commerce - Economic Development Administration
- State of Hawai'i Clean Water State Revolving Fund (CWSRF)
- State of Hawai'i - Non-Point Source (319) (NPS) Grants
- State of Hawai'i Rural Community Assistance Corporation
- State of Hawai'i Rural Water Association
- State of Hawai'i Cesspool Compliance Pilot Grant Project per Act 153 of SLH 2022
- Hawai'i Cesspool Remediation and Conversion Loan Program (Proposed)

Most of these financing programs outlined above provide reimbursement for incurred costs, requiring the individual homeowners first to pay upfront the cost associated with planning, design, and construction of the new onsite wastewater treatment system and then be reimbursed.

4.2 Affordability

Homeowner affordability may be one of the most pressing challenges with respect to cesspool conversion. Hawai'i, like many other states, face serious challenges meeting funding gaps when upgrading and replacing outdated or failed. The cost to most private, residential property owners is significant. Upgrades can be paid for in a lump sum payment, often in the tens-of-thousands of dollars or financed and paid in monthly installments. Both options present challenges and may create economic hardships. If a household was able to pay for cesspool conversion on a monthly basis, the average total monthly cost to convert a cesspool to an onsite wastewater treatment system would be $210 per month. A homeowner is financially burdened if this cost exceeds two percent of their annual income. As a result, homeowners with an annual income of less than $126,000 would realize a financial hardship by the cost to convert. If a hypothetical $10,000 rebate for the conversion were provided to homeowners, the estimated average monthly cost to convert would drop to $150, and homeowners with an annual income of less than $90,000 per year would be financially burdened. Approximately 97% of all residents in the State with cesspools have an income less than $126,000, and thus would be financially burdened by the cost to convert. If a $10,000 rebate were provided to each household, approximately 85% would be financially burdened. Hawai'i County, with the most cesspools of all counties, has the greatest affordability challenges. For a full overview of financing options for cesspool conversions, see the Cesspool Conversion Finance Research Summary Report in Appendix A.

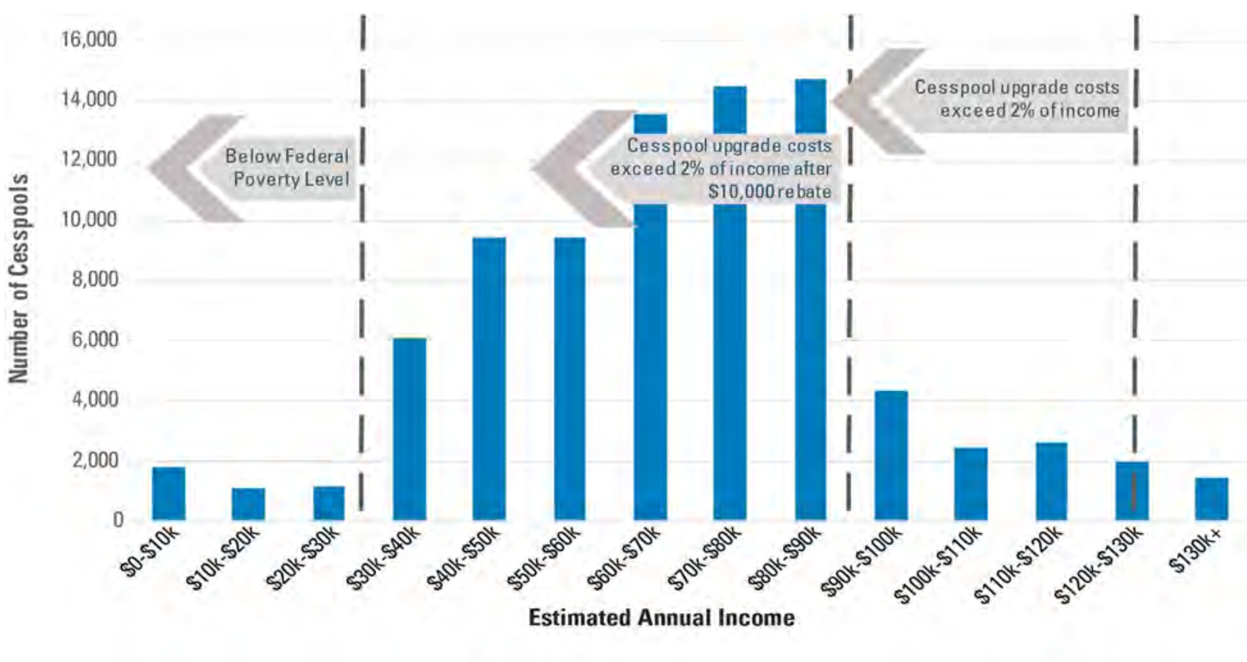


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Figure 11. State of Hawai'i Annual Estimated Household Income Levels for Residents with Cesspools. Notes: (1) Assumes average cesspool conversion cost of $210 per month. (2) Assumes $10,000 rebate reduces average cesspool conversion cost to $150 per month. (3) Estimated annual income is based on the census block median household income.

5. Mandatory versus Voluntary Participation

Objective 13: Evaluate mandatory versus voluntary participation in the cesspool conversion plan.

There are no benefits to human health or the environment if homeowners wait or postpone conversion until closer to the 2050 conversion deadline. The threat of no action will continue to have devastating impacts to Hawai'i's precious coral reefs. If action isn't taken soon, nearly all reefs in Hawaiʻi will be threatened by 2050. The rush to be last to convert would lead to severe bottlenecks around permitting and technology access, not to mention years of added wastewater pollution to the State's freshwater and marine resources. Hawaiʻi needs to create demand (along with adequate supply) for cesspool conversion resources, so households begin to convert sooner rather than later without unnecessary or burdensome regulation.

For those willing to convert before 2050, the state should pursue current sources of federal funding to provide higher levels of "early-bird" incentives, including grants, tax breaks, or other mechanisms to reduce any burden (monetary or other realized) on the homeowner. Incentives can also fade as time goes on to spur demand. Using tools like the Hawaiʻi Cesspool Prioritization Tool, along with other important indicators such as household income and other known pollution hazards/data will help guide program developers with solid data to make important and difficult decisions. It may be advantageous to focus early efforts on areas of low income and with the highest priority ranking.

For the classification of involuntary homeowners, the state will have to make a distinction between unwilling and unable. For those who are unable to convert, the state may wish to explore funding and methods to provide free or low-cost programs to develop onsite wastewater treatment plans, which could be used at a later date when financial assistance is available. Other similar types of programs that help low-income homeowners move in the right direction or ease burdens should be considered and prioritized, such as on-bill financing programs, property assessment programs, public-private ownership partnerships, low-interest loans, and grants.

For those homeowners who are unwilling to convert, a mix of strategies should be considered versus solely using a punitive approach to gain cooperation. According to research by Harvard University and the Stockholm School of Economics, rewards work better than punishment when human participation is needed[6].

Emphasis on gentle, but compelling, methods to all facets of conversion would be advantageous and likely prove more successful, especially when one takes into consideration the public's lack of trust in government. However, that isn't to say that all forms of mandates or stronger "stick" approaches shouldn't be considered. State or County governments should

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[6] *Dreber, A., Rand, D. G., Fudenberg, D., & Nowak, M. A. (2008). Winners don't punish. Nature, 452(7185), 348–351. https://doi.org/10.1038/nature06723*

develop laws or regulations that require wealthy vacation rentals convert sooner or face cesspool fees (which could be used to assist the overall conversion process). Another example might be creating a timeline to convert homes that are not a primary residence sooner. This assumes second homeowner income levels are higher than those who reside in the State and have a single dwelling. Any approaches regarding unwilling participants should be carefully studied and evaluated.

Any cesspool conversion program must take into account environmental justice challenges for diverse communities across Hawaiʻi with respect to plan development, implementation, and enforcement. The State and associated partners should consult with national institutions like the U.S. Environmental Protection Agency Office of Environmental Justice or other local partners who actively work with rural communities to develop strategic plans and necessary relationships prior to implementing a conversion plan. Effective community engagement demonstrates sensitivity for diverse cultural resources as well as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income. The U.S. Environmental Protection Agency regularly offers grants to help entities and governments integrate environmental justice into state and local programs and is currently working with local partners on Hawaiʻi Island to help develop strategies to close large-capacity cesspools in under-resourced communities.

On a more local level, partnerships can be formed with agencies such as Honolulu's Office of Climate Change, Sustainability and Resiliency. Key positions similar to the Climate Resilience and Equity Manager can help a conversion program gather data and target resources more effectively to have positive impacts on the lives of those most affected by environmental injustices. Meaningful stakeholder engagement is critical to the success of all wastewater projects, especially as it relates to determining the location of new facilities and infrastructure in rural communities. Partnerships with entities like the Office of Climate Change on a County level can help to establish a more effective system of providing information to homeowners about available cesspool upgrade technologies and financing options, especially in Hawaiʻi's diverse rural communities. Other organizations with resources that can be brought to bear may include the University of Hawaiʻi William S. Richardson School of Law's Environmental Law Program, the Office of Hawaiian Affairs, or the Hawaiʻi Community Foundation. To achieve effective systematic change, a diverse set of voices must participate in a thoughtful and thorough process to ensure the long-term viability and acceptance of a conversion program. Adding representation from native Hawaiian organizations such as the Department of Hawaiian Home Lands and the Office of Hawaiian Affairs is highly recommended. This critical representation was lacking on the initial Cesspool Conversion Working Group.

A voluntary program will not be effective for the cesspool conversion plan. A mandate that requires compliance is necessary for the cesspool conversion plan to be successful. Since Act 125 was passed in the 2017 legislative session that mandated the replacement of all cesspools by 2050, the Department of Health has not been observing a significant increase in replacements of existing cesspools. Act 120 of 2016 provided an income tax credit of up to $10,000 for a qualified cesspool owner. The income tax credit was available for five years, starting with tax year 2016 and ending tax year 2020. For each year, there was a $5,000,000 cap that was available for this program. There was a potential for 500 cesspool owners that could take advantage of this income tax credit program each year and a total of 2,500 that could be replaced during the five years. During the five years of this program, only 200 cesspools were replaced. If the deadline to convert was earlier than 2050, there may have been a higher utilization of the income tax credit program.

6. Policies and Practices from Other States

Objective 9: Consider best policies, practices, and laws from other jurisdictions related to cesspool conversions, including but not limited to Rhode Island and New Jersey that have undertaken large efforts to phase-out cesspools in their jurisdictions.

The Cesspool Conversion Working Group commissioned the University of Hawai‘i Water Resources Research Center and Hawai‘i Sea Grant College Program to research policies, practices, and regulations from other U.S. states related to cesspool conversions. The report produced for the Cesspool Conversion Working Group is titled: “A Multi-State Regulation and Policy Survey of Onsite Wastewater Treatment System Upgrade Programs” and is available in Appendix E. The report included evaluations of six states that have undertaken large efforts to phase-out cesspools or outdated onsite wastewater treatment system in their respective jurisdictions. Although each state or governmental agency has adapted its cesspool and onsite wastewater treatment system conversion programs within their local context, there are several key themes that emerge from other state programs which may assist Hawai‘i with its cesspool conversion plan development.

Conversion programs take time and require concerted long-term effort, planning and flexibility. The average age of the programs studied was about 12 years. Many programs adapted and revised elements if the desired results were not achieved. For example, Rhode Island adapted conversion requirements at the time of property sale or transfer, because the original method to update cesspools had limited success. Many local governments also adopted their own ordinances on top of State requirements to assist with the conversion process, however, careful examination by a program administrator should be undertaken to ensure that new legislation does not hinder the overall goal or restrain the program as whole.

Conversions require long-term programmatic funding and significant administrative support through staffing and technology. States like Vermont (not detailed in the report) have digitized wastewater tracking systems which track maintenance, permit amendments, and other requirements to facilitate proper maintenance and system effectiveness. Barnstable County, Massachusetts developed a similar processing tool that allows service providers to input testing results quickly online.

The entire cost of Hawai‘i’s cesspool conversion process has been floated in the two to three billion dollar price range, meaning significant capital will be required to meet our goals. This financial challenge was universal across conversion programs. Onsite wastewater treatment systems are critical pieces of infrastructure that the public doesn’t see every day like a bridge or road, but no less important in sustaining quality of life and the protection of natural resources. However, areas like Suffolk County New York, which have almost 200,000 more cesspools than Hawai‘i recognize the gravity of the situation. State and local governments like counties or cities have collaborated to allocate needed initial funding. In 2021, the state of New York committed $408 million to expand sewer infrastructure and stormwater systems in Suffolk County. The County government has also committed $100 million to upgrade cesspools. County towns have repurposed community preservation funds and dedicated a 2% tax on property transfers for water quality projects such as upgrading cesspools. The State of Hawaiʻi should offer initial funding to help study and develop a financial road map or game plan which can be used to search and acquire needed funding. A more detailed financial analysis is in Section 4.2 of this report.

Many of the programs evaluated in the report recognized that outdated policies, plumbing codes, and regulations lead to their current conditions where substandard wastewater treatment systems remained in use and had the potential to harm human health and the environment. By evaluating and updating the mechanisms that allowed outdated infrastructure to be used, places like Suffolk County, New York and Rhode Island could codify practices that would reduce or eliminate future challenges while simultaneously promoting advancements in technology and resilience. For Hawaiʻi, this could take shape along several avenues, including updating plumbing codes for buildings and allowing more onsite wastewater treatment system pilot projects to be evaluated for performance on Hawaiian soils and climatic conditions. Simultaneously, the recommended regional onsite wastewater treatment system research and training center could assist with providing a critical lens on technological advances to promote sustainable and resilient onsite wastewater treatment system policies. See the report in Appendix H.

Finally, all successful programs implemented extensive public outreach and education efforts. The United States Environmental Protection Agency has outlined critical outreach and education elements, though responsibility for administering the various components may fall on several agencies or entities involved. Because the public is directly impacted by cesspool conversion, careful consideration must be given to public input, challenges, and educational needs. Outreach and education consist of more than producing materials for consumption – it's an opportunity to understand the groups that are impacted and a method to solve problems and achieve success.

Though not necessarily a theme across programs, there are clear distinctions on how the types of programs are administered. In Massachusetts, onsite wastewater treatment programs are run locally by town health offices, while the State of Vermont is centrally administered by its state Department of Environmental Conservation. There is no right or wrong way to administer a program. However, Hawaiʻi should carefully look at the different methods and examine what, if any, impacts they may have on accessibility of funding to help convert cesspools. Future working groups or task forces should partner with relevant state and local agencies listed in this section to collaborate on implementation and discuss the process and challenges undergone in their respective areas.

Public-private partnerships can also be viable options for governments to help complete and finance large infrastructure projects. Regarding onsite wastewater treatment system upgrades, Craft3 Clean Water Loans in Washington State is an example where a nonprofit has successfully implemented programs that may be challenging for state or local governments. Craft3 financed septic system repair and replacement, including permitting, design, and installation costs. Craft3 loans provide low rates for lower-income borrowers and are designed to be accessible to a wide range of homeowners. Due to a limited number of skilled workers in the onsite wastewater sector, Hawai‘i should investigate and develop public-private partnerships for construction or financing.

Four onsite wastewater treatment system programs are highlighted below in Table 5 to briefly detail relevant and successful elements of onsite wastewater treatment system upgrade programs.

State/ County	# of Cesspools	Key Learnings
Suffolk County, NY	~250,000	Technology Requirements: Coastal areas and drinking water priority areas must use innovative/alternative technology systems for nitrogen reduction or hook up to municipal sewer. Management Highlights: Created Reclaim Our Water Initiative to make water quality a priority issue and develop a long-range plan to convert cesspools.
Rhode Island	~25,000	Conversion Mechanisms: Blanket phase-out to identify and replace cesspools on all properties subject to sale or transfer and replacing cesspools within 200 feet of tidal waters, drinking water reservoirs, or public wells. Technology Requirements: Special Area Management Plan Areas require innovative and alternative systems to reduce nitrogen. Innovative and alternative systems can improve resiliency when facing challenges like rising groundwater levels or frequent flooding. Management Highlights: Cities and towns also have the authority to establish local management programs.
Maryland	Unknown	Funding Opportunities: Water Quality Trading Program, which creates a public market for nutrient reductions, including nitrogen. The program promotes onsite wastewater treatment system upgrades as a mechanism for generating a credit to meet National Pollutant Discharge Elimination System permit requirements.
Massachusetts	Unknown	Funding Opportunities: Developed a robust financial program to assist homeowners. Many Grants of up to $25,000 are available, plus tax credits up to $1,500 per year for four years for a maximum total of $6,000. Conversion Mechanisms: Title 5 requires inspection of onsite wastewater treatment systems before property transfer or dwelling enlargement. By creating a required inspection mechanism, the state can convert outdated technologies at a faster pace and develop a robust inventory of systems. Onsite wastewater treatment systems that fail an inspection must be repaired or replaced within two years. Management Highlights: Title 5, primary mechanism to regulate the proper siting, construction, and maintenance of onsite wastewater treatment systems. Local Health boards have autonomy to make regulations.

Table 5. Research on Cesspool Programs.

7. Research and Innovation

Objective 12: Research and recommend measures to encourage and stimulate research and innovation for new wastewater technologies, including systems that treat waste not only for bacteria but also to remove nutrients and contaminants that impact the environment.

There are several centers in the continental United States where onsite wastewater treatment technology is installed, tested, and researched. Many of these centers also provide education and outreach to professionals and homeowners. Hawaiʻi should research and explore the creation of an official testing and training center similar to that of the New York State Center for Clean Water Technology, Massachusetts Alternative Septic System Test Center, or the New England Onsite Wastewater Training Program and Center. Some notable themes that exist among the centers includes:

1. Offering sampling, analysis, and processing for onsite wastewater treatment system programs and technologies.
2. Promote education, training, and professional capacity of onsite wastewater treatment technology, including hosting full scale systems constructed in and above ground for education and training.
3. Research such as onsite wastewater treatment system and climate change, nitrogen reduction, regulation, and onsite wastewater treatment system performance.
4. Developing non-proprietary technologies that can be installed and repaired by average trained wastewater professionals, which may reduce barriers and be more cost effective in the long-run for homeowners.
5. Focus on serving community specific needs while advancing the broader field of onsite wastewater technology.

Developing an official testing and training center in Hawaiʻi will allow research to focus on the needs of Hawaiʻi and the broader Pacific regarding onsite wastewater treatment system technology and education and workforce development. A testing and training center could provide the Department of Health and the broader wastewater community with more accurate real world testing data related to island specific climate and soils. Additionally, an official center could collaborate with other workforce development programs, assisting the workforce pipeline (shortage of workers) that will be needed to convert Hawaiʻi's cesspools by the 2050 deadline.

As a conversion program is pursued and established, a testing and training component will be important to enable the adoption of new technologies. Currently if a new technology is proposed Department of Health has to review and approve on a case-by-case basis with limited staff and capacity. New partnerships and organizational structures for training and testing would need to be pursued to get to the same level of capacity as some of the programs outlined above. Hawaiʻi could explore using government property to offset initial costs and collaborate with existing partners to reduce operating expenses. Additional options include surcharges for manufacturers who wish to test equipment.

8. Stakeholder Feedback

Objective 10: Include feedback from each county's community members, wastewater divisions, and boards of water supply.

Through the Cesspool Conversion Working Group (see Table 1 for the member list), a broad set of perspectives has been represented, including feedback from members of the public.

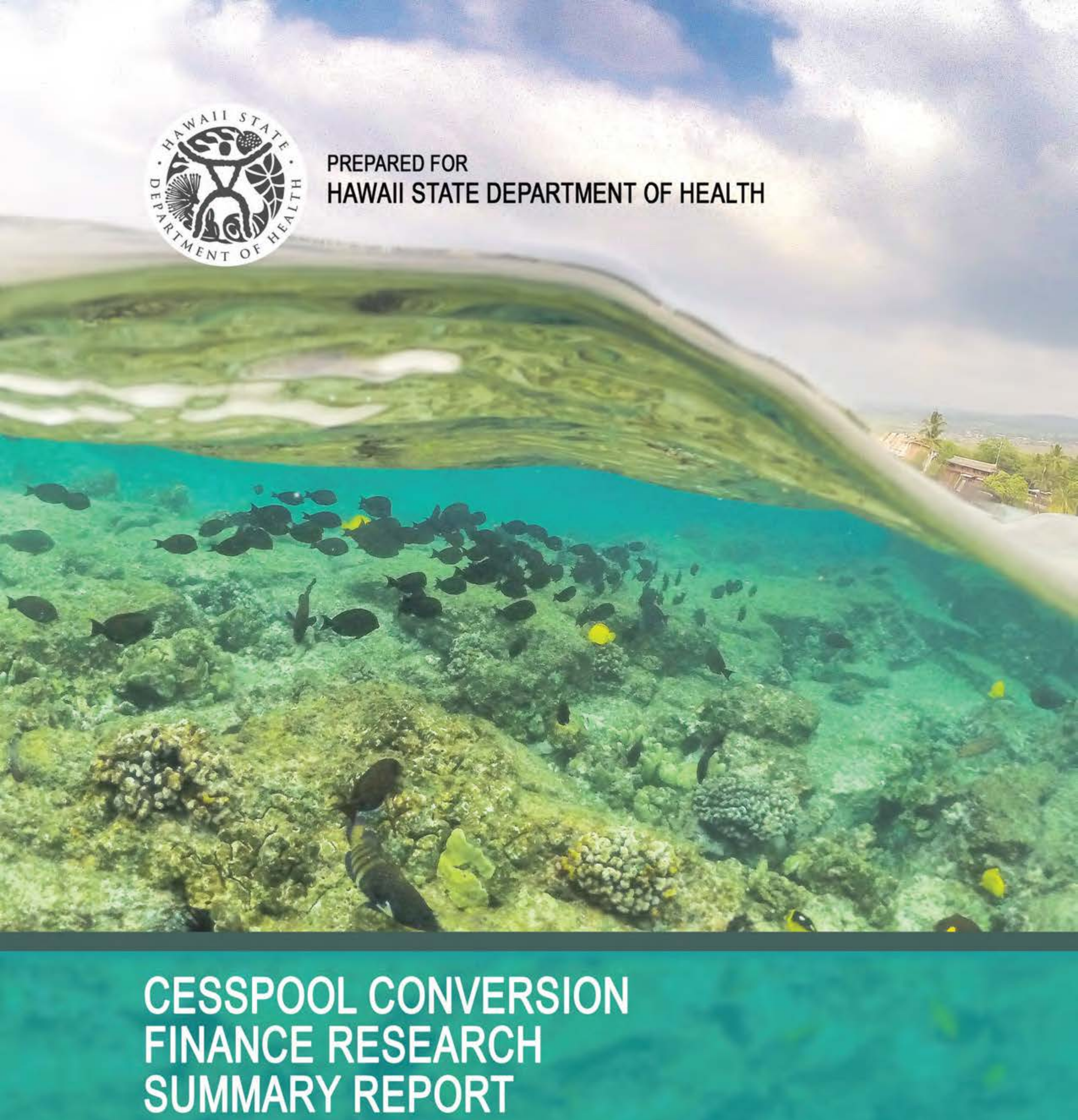
County representation has been a key focus, with outreach coordinated around sewer planning and possibilities. That feedback is summarized here, and continued coordination between State and County agencies around cesspool conversions is recommended.

Honolulu City & County	Will be performing a Cesspool Conversion Implementation Plan to determine what the City and County can do to convert cesspools.
Kauaʻi County	Limited areas for expansion have been determined at this point in time. There are investments being made in improving infrastructure at current plants in Līhuʻe and Wailua. The goal is to be able to expand in the future.
Maui County	Will continue to identify and expand sewer service areas to cesspool areas where it is economically viable. Will continue to work with the State in accessing and making funding available for private homeowners to convert cesspools to approved treatment systems.
Hawai'i County	Will be working on wastewater feasibility studies for the Puna district, Pahoa in addition to the northern west side of the island (including but not limited to Puakō, Waimea, Waikoloa). The feasibility study recommendations and findings will be presented to the county council for considerations and next steps. Cesspool areas within or nearby the current wastewater facilities will be required to connect if the sewer infrastructure exists.

Hawai'i REALTORS®, a working group member, has shared the following precautions and considerations: Hawai'i REALTORS® *respectfully opposes recommendations in this report which will severely weaken private property rights. As an example, for many homeowners a "point-of-sale" requirement will unduly restrict their ability to sell their property on a timely basis and may cause homeowners added personal and financial hardship. Greater public outreach and dialogue is necessary before moving forward in order to avoid any unintended consequences.*

A working group member Dave Smith, previously representing USEPA, provided a departing memo of his recommendations and observations. The full memo can be found in Appendix I and recommends several actions and strategies for consideration by the Cesspool Working Group as it prepares to make policy and program development recommendations to the Hawaii Legislature in 2022. These recommendations are based on Dave Smith's observations of working group actions and products to date and discussions with organizations around the country that have faced similar challenges in planning and executing strategies to replace septic tanks and similar distributed infrastructure. *These views are his own and do not necessarily represent the policies or views of USEPA.*

Appendix A: Cesspool Conversion Finance Research Summary Report Prepared by Carollo Engineers



PREPARED FOR
HAWAII STATE DEPARTMENT OF HEALTH

CESSPOOL CONVERSION FINANCE RESEARCH SUMMARY REPORT

FINAL | JANUARY 2021

Prepared by

carollo
Engineers...Working Wonders With Water ®

in association with

Harris & Associates

State of Hawai`i Department of Health

CESSPOOL CONVERSIONS FINANCE RESEARCH
Summary Report

FINAL | JANUARY 2021

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THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE

04/30/2022
EXPIRATION DATE OF THE LICENSE

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Table of Contents

Introduction

Act 125 requires the conversion of all cesspools in Hawai'i to approved wastewater treatment systems by 2050. The purpose of this study is to assist the Department of Health (DOH) with the evaluation of the funding, financing, and affordability of cesspool conversions.

LEGISLATIVE ACTIONS TO BAN CESSPOOLS IN HAWAI'I

Throughout the State of Hawai'i, there are approximately 88,000 cesspools, releasing an estimated 53 million gallons per day (mgd) of wastewater to the environment. Most of the existing cesspools provide wastewater disposal for single family residences, as opposed to large-capacity systems serving multiple residences or commercial areas. Given that over 90 percent of the State's drinking water supplies are from groundwater sources, cesspools pose a potential environmental and public health risk.

In 2017, the Hawai'i State Legislature passed Act 125, which mandates that by January 1, 2050, all cesspools in the State, unless granted exemption, shall upgrade or convert to a septic or aerobic treatment unit, or connect to a sewer system (Act 125, 2017). The Legislature subsequently passed Act 132 in 2018, which established a Cesspool Conversion Working Group (Working Group) to develop a long range, comprehensive plan and commission a statewide study of sewage contamination in nearshore marine areas (Act 132, 2018).

As a result of Act 125, homeowners will be required to upgrade their existing cesspools to a wastewater technology that complies with environmental and public health regulations. Historical costs of cesspool upgrades to approved systems range widely from approximately $9,000 to $60,000 or more depending on the wastewater system capacity (based on bedroom count), technology, and location or site constraints.[1] Assuming an average conversion cost of $23,000, the potential magnitude of the financial burden to convert all 88,000 cesspools is over two billion dollars.[2] Cesspool conversion costs will likely be a financial burden to many residential owners in a state where the cost of living is already high. The Legislature tasked the Working Group to develop a strategy to aid the funding and financing of the cesspool upgrades.

Assuming an average conversion cost of $23,000, the potential magnitude of the financial burden to convert all 88,000 cesspools is approximately two billion dollars.

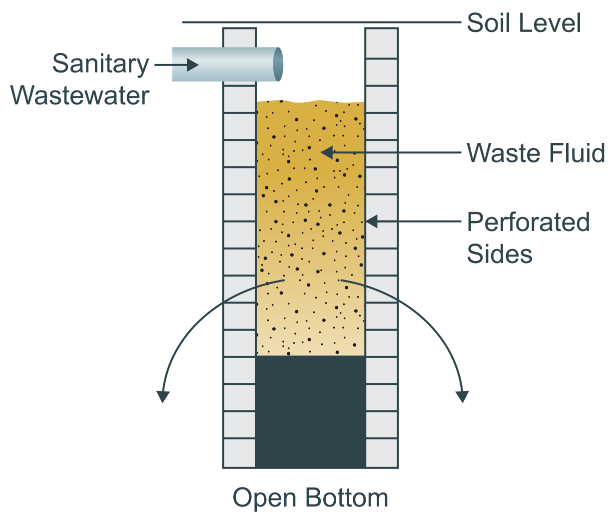


FIGURE 1. Cesspool Schematic
Cesspools are underground excavations that receive sanitary wastewater from bathrooms, kitchens, and washers. The structure usually has an open bottom and perforated walls. Domestic wastewater flows into the structure and the solid waste collects at the bottom of the cesspool. The liquid waste flows out of the perforations and percolates into the subsurface.

1. Based on cost data from DOH.
2. Costs shown in 2020 dollars.

SCOPE OF FINANCIAL EVALUATION OF CESSPOOLS CONVERSIONS

The scope of this study is primarily focused on the funding and affordability challenges associated with cesspool conversions using new or upgraded, single family onsite treatment and disposal systems. Although conversions can also take place via the construction of a new decentralized system, handling wastewater from multiple homes, or connection to an existing treatment plant, the specific financing of these approaches was beyond the scope of this effort.

Given the magnitude of the potential financial burden of cesspool conversions, this report includes the following information to support future planning and considerations for the Working Group:

- Preliminary affordability analysis.
- Potential funding and financing options.
- Lessons learned from conversion programs in other states.
- Other factors which may inhibit cesspool conversions in Hawai'i.

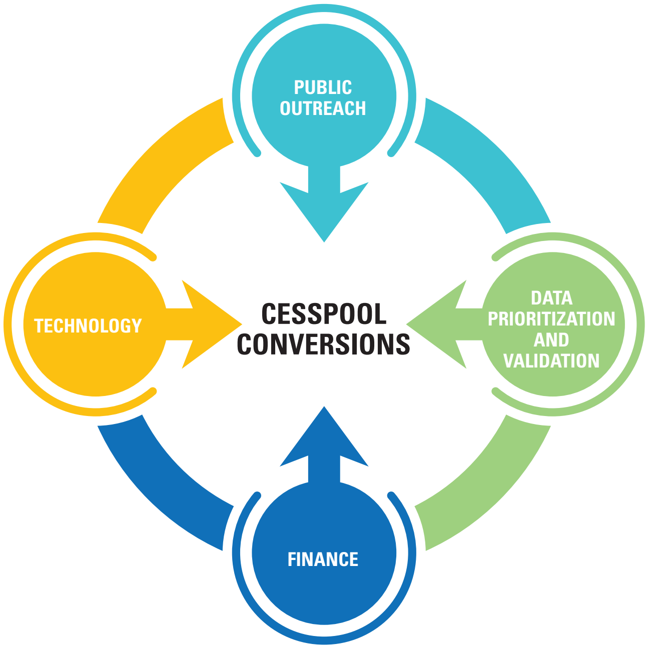


FIGURE 2. Four Aspects of Cesspool Conversion
The working group is engaged in four aspects of cesspool conversions—conversion technologies, finance and funding needs, data prioritization and validation , and public outreach and education.

The details of this effort were presented in a series of the following previously prepared technical memoranda (TMs):

- TM 1 – Cesspool Conversion Funding Mechanisms
- TM 2 – Affordability Evaluation for Cesspool Conversions

Each of these TMs are presented in their entirety in Appendices A and B of this report.

Besides financial considerations, it should be noted that the Working Group is engaged in other areas critical to the success of cesspool conversions, including evaluation of onsite system technologies, public outreach and education, and data validation and prioritization.

LIMITATIONS

The cesspool conversion financial evaluation summarized in this report was prepared specifically for use by the Working Group and was completed based on publicly available information.

Factors that may impact the affordability evaluation include exemptions to cesspool conversion, or changes to the priority areas. Granting exemptions to cesspool conversions are at the discretion of the DOH per Act 125. Ongoing efforts are underway to study available cesspool data validation and prioritization and that new information may result in a new prioritization or even exemption. If new information or guidance results from either of these two efforts, the affordability evaluation should be revisited.

Affordability Evaluation

Homeowners will need to invest significant funds to upgrade their cesspools and maintain their new onsite systems. This study provides a high-level evaluation of the affordability of cesspool conversions for homeowners.

METHODOLOGY

"Affordability" refers to the ability of a household to pay for wastewater services without facing economic hardship. For example, costs would be considered unaffordable, or the household "financially burdened", if they had to consider forgoing medically necessary prescriptions or doctors' visits, sacrifice meals, face the inability to pay for child care, energy bills, or rent/mortgage to pay for a cesspool conversion (Raucher et al, 2019).

A preliminary affordability analysis was performed to estimate the potential financial impacts of cesspool conversions on homeowners. The analysis compared estimated average conversion costs to commonly used measures of affordability, including federal poverty and median household income levels. Figure 3 presents a summary of the approach to affordability used in this study.

Data Sources and Analysis

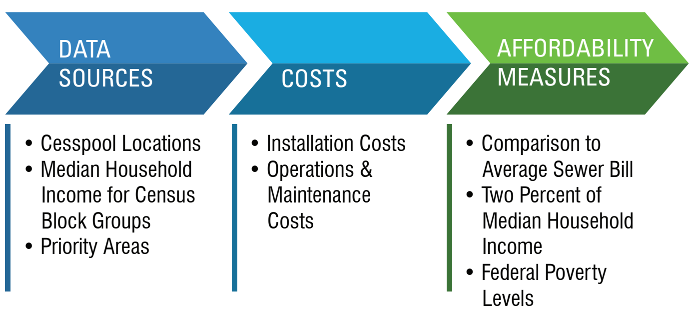


FIGURE 3. Data Sources, Cost, and Affordability Measures Included in Affordability Analysis

The primary data sources for the affordability analysis included:

- Maps of cesspool locations gathered from the Hawai'i Statewide Geographic Information System (GIS) Program.
- Median household income data from the United States Census Bureau (U.S. Census Bureau, 2018).
- Priority areas for cesspool conversions based on environmental and public health risks (DOH, 2018).

KEY AFFORDABILITY QUESTIONS

The affordability analysis aimed to answer some of the following key questions of the Working Group:

- What percent of income should a typical household be expected to spend on cesspool conversion?
- How likely is it that a cesspool owner either lives below the poverty level or is significantly income-constrained?
- How much financial aid is required for those who are financially burdened so a cesspool conversion is affordable?
- How does the conversion cost compare to the monthly sewer bill for existing county sewered areas?

A geospatial analysis of the Hawai'i cesspool locations was performed to assign economic and prioritization data to each cesspool site. For each household with a cesspool, a corresponding median household income was assigned using the median household income data from the United States Census Bureau (U.S. Census Bureau, 2018). Cesspool conversion priority levels were based on those identified in the 2018 Legislative Report and are defined as follows, with Priority 1 being the highest priority and Priority 4 being the lowest.

- **Priority 1:** Significant risk of human health impacts, drinking water impacts, or draining to sensitive waters.
- **Priority 2:** Potential to impact drinking water.
- **Priority 3:** Potential impacts on sensitive waters.
- **Priority 4:** Impacts not identified.

Table 1 summarizes the current priority areas by geographic regions. DOH may revisit the cesspool prioritization methods, and as a result, priority areas could be revised.

TABLE 1. Initial Priority Upgrade Areas Established by DOH Wastewater Branch (DOH, 2018)

GEOGRAPHIC AREA	PRIORITY LEVEL ASSIGNED	NUMBER OF CESSPOOLS	ESTIMATED EFFLUENT DISCHARGE (MGD)
Upcountry area of Maui	1	7,400	4.40
Kahalu'u area of O'ahu	1	740	0.44
Kea'au area of Hawai'i Island	2	9,300	4.90
Kapa'a/Wailua area of Kaua'i	2	2,900	2.20
Poipu/Koloa area of Kaua'i	2	3,600	2.60
Hilo Bay area of Hawai'i Island	3	8,700	5.60
Coastal Kailua/Kona area of Hawai'i Island	3	6,500	3.90
Puako area of Hawai'i Island	3	150	0.60
Kapoho area of Hawai'i Island	3	220	0.12
Hanalei Bay area of Kaua'i	3	270	0.13
Diamond Head area of O'ahu	3	240	0.17
'Ewa area of O'ahu	3	1,100	0.71
Waialua area of O'ahu	3	1,080	0.75
Waimanalo area of O'ahu	3	530	0.35
	TOTAL ASSIGNED	42,730	26.87
Hawai'i Island Un-Assigned	NA	24,430	12.18
Kaua'i Un-Assigned	NA	6,930	4.57
Maui Un-Assigned	NA	4,800	3.50
O'ahu Un-Assigned	NA	7,610	5.08
Moloka'i Un-Assigned	NA	1,400	0.80
	TOTAL UN-ASSIGNED	45,170	26.13
	OVERALL TOTALS	87,900	53.00

Cost Impact of Cesspool Conversions on Homeowners

Depending on the financing source and onsite system required, conversion costs could range from approximately $94 to $339 per month as shown in the Table 2. The table summarizes the potential costs to homeowners for a range of cesspool upgrade options. The "low" scenario represents the simplest and most straightforward upgrade. The "average" and "high" scenarios represent typical and more complex cesspool upgrades, respectively for the purposes of this analysis. More complex onsite systems may be required if a higher level of treatment is needed due to the potential risks to the environment or human health or if individual site conditions such as size and topography warrant a more complex system.

TABLE 2. Summary of Potential Monthly Financial Impacts to Homeowners

COST DESCRIPTION	CESSPOOL CONVERSION COST SCENARIOS		
	LOW	AVERAGE	HIGH
Installation Cost(1)	$10,000	$23,000	$38,000
Monthly Installation Repayment Cost(2)	$61	$139	$230
Monthly O&M Cost(3)	$33	$71	$109
Estimated Total Monthly Cost	$94	$210	$339

Notes:
(1) Installation costs are based on historical costs for septic tank and aerobic treatment unit treatment and disposal systems from DOH. The low costs represent the 10th percentile, and the high costs represent the 90th percentile. All conversion costs are site specific and these costs may not be representative for more complex sites/installations.
(2) Assumes a 20-year loan at 4.0 annual interest rate.
(3) Assumed monthly operations and maintenance (O&M) costs for different levels of onsite treatment.

It is important to note that the costs shown in Table 2 are based on a limited data set of historical costs. Actual conversion costs for homeowners could be greater or less than the scenarios shown. Homeowners, or entities implementing cesspool conversions, should contact a licensed engineer or contractor for a site-specific estimate or price quote.

Affordability Measures

Median Household Income and Federal Poverty Levels

Historically, affordability for water and wastewater service has been benchmarked as a percentage of median household income. The United States Environmental Protection Agency (USEPA) has advanced this metric in the past, stating that wastewater service should be less than 2 percent of income to be considered "affordable" for customers (USEPA, 1997).

Shortcomings of using median household income data from the U.S. Census and federal poverty level data are that the data do not differentiate between renters and homeowners, which may provide further levels of income stratification. The income data used for this analysis is that of the "resident." Renters may report income that is then reflected in the census data but ultimately, they may not be directly paying for the cesspool conversion. However, considering the available information, median household income was considered the best data available for the affordability analysis.

Comparison to Local Sewer Rates

Many communities across the United States are served by centralized wastewater collection and treatment systems. While these are less prevalent in Hawai'i compared to other states, there are county owned and operated wastewater systems across the State that can offer a comparative monthly cost for residential households. While comparing cesspool conversion costs with county sewer service charges does not measure affordability (as the monthly sewer bills may exceed 2 percent of income for some customers), it does provide a local benchmark for sewer utility costs.

AFFORDABILITY RESULTS

Assuming the estimated average monthly cost to convert a cesspool to an onsite wastewater treatment system is $210 and a homeowner is financially burdened if this cost exceeds 2 percent of their annual income, homeowners with an annual income of less than $126,000 would realize a financial hardship by the cost to convert. If a hypothetical $10,000 rebate for the conversion were provided to homeowners, the estimated average monthly cost to convert would drop to $150, and homeowners with an annual income of less than $90,000 per year would be financially burdened.

Statewide Affordability

Figure 4 summarizes the household income for all residents with cesspools across the State. Approximately 97 percent of all residents with cesspools have an income less than $126,000 and thus would be financially burdened by the cost to convert. If a $10,000 rebate were provided to each household, approximately 85 percent would be financially burdened.

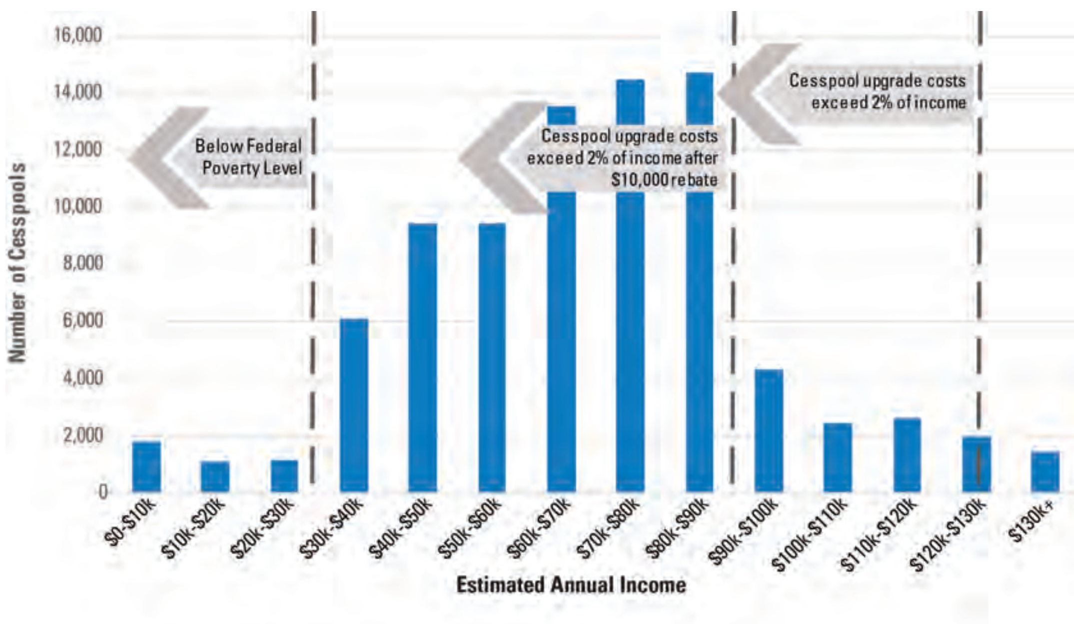


FIGURE 4. State of Hawai'i Annual Estimated Household Income Levels for Residents with Cesspools (1)

Notes:
(1) Assumes average cesspool conversion cost of $210 per month.
(2) Assumes $10,000 rebate reduces average cesspool conversion cost to $150 per month.
(3) Estimated annual income is based on the census block median household income.

County-by-County Affordability

The data were also evaluated at the county level to determine if certain counties or areas of counties were financially burdened more than others. Figure 5 summarizes the household income for all residents with cesspools across the State by county.

The following sections summarize the affordability results determined for each county. The results include:

- Maps that indicate the location and associated relative median household income of each cesspool, as well as priority areas for cesspool upgrades.
- Graphs summarizing the annual estimated household income levels for residents with cesspools.
- Discussion of the fraction of households who would be financially burdened by cesspool upgrade costs and the fraction of cesspools that are a high priority to upgrade (those classified as Priority Levels 1, 2, or 3).

The County of Hawai'i has the largest number of cesspools and the most residents that would be financially burdened by the cesspool conversion cost.

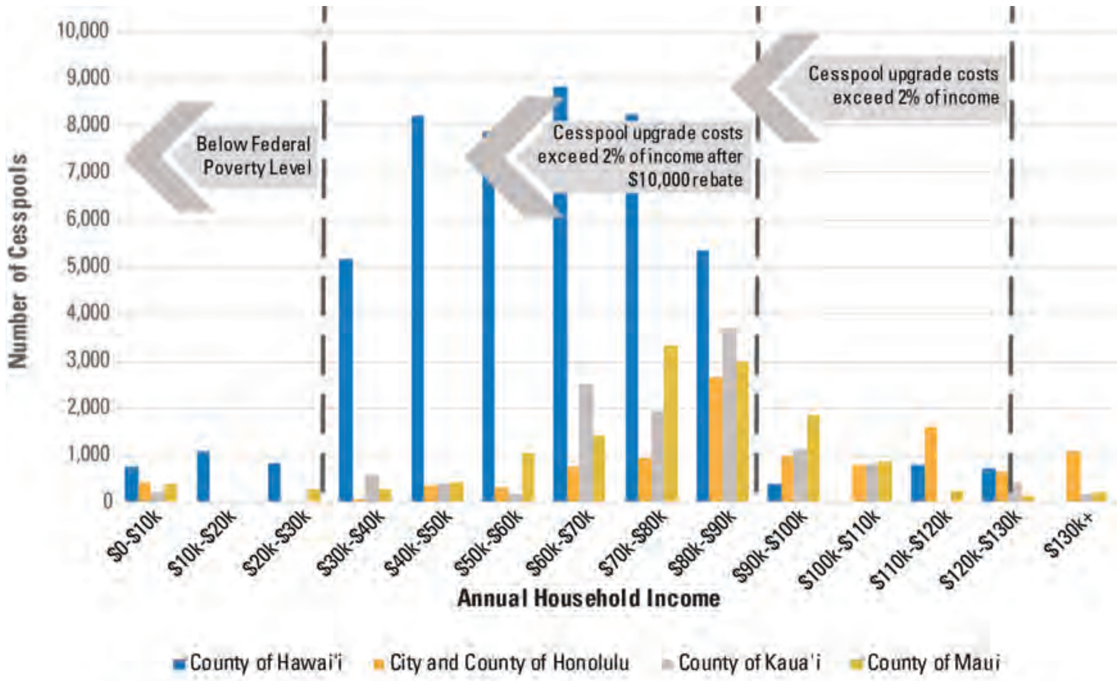


FIGURE 5. Annual Median Household Income of Residents with Cesspools Across the State

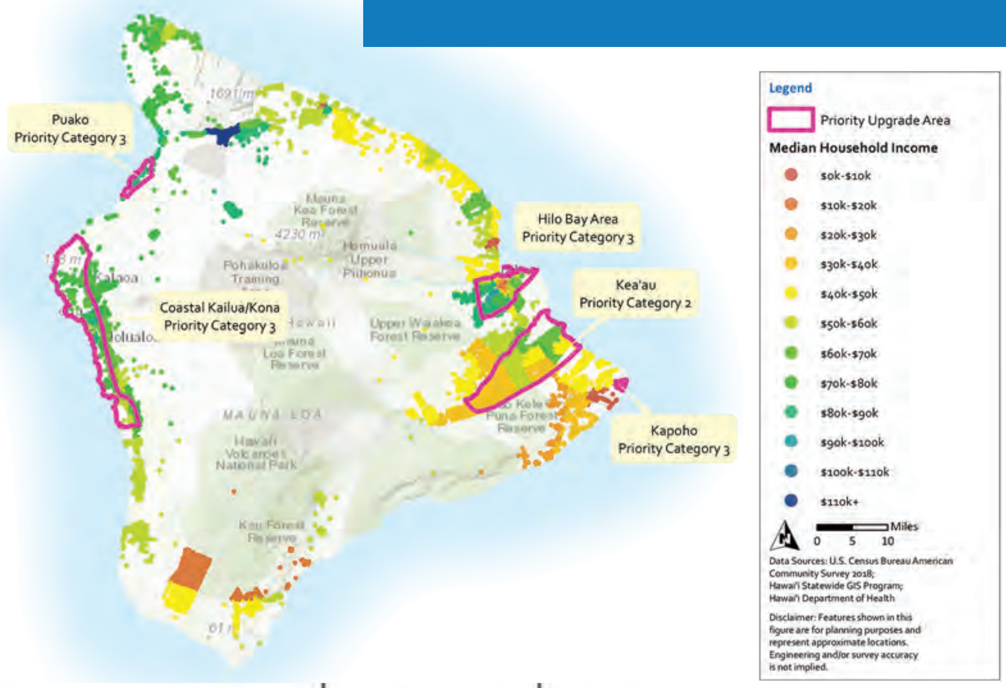
Notes:
(1) Assumes average cesspool conversion cost scenario of $210 per month.
(2) Assumes $10,000 rebate reduces average cesspool conversion cost to $150 per month.
(3) Estimated annual income is based on the census block median household income.

97 percent of households with cesspools would be financially burdened by the cost to convert their cesspool to an onsite wastewater treatment system.

County of Hawai'i

The County of Hawai'i has the largest number cesspools with 48,303, including approximately 9,300 categorized as Priority 2 with potential impacts to drinking water, and 15,570 Priority 3 cesspools with potential impacts to sensitive waters. Hawai'i County also has the most residents facing affordability challenges. Hawai'i County also has the greatest proportion of households without centralized sewers than any other county (71 percent), indicating that connection to a centralized sewer system is unlikely to be available for most properties. Without options to connect to an existing sewer, the only option for many cesspool owners in Hawai'i County is likely the installation of an approved onsite system.

Hawai'i County has the greatest affordability challenges, the most cesspools of all counties, and a large proportion with potential impacts to drinking water and sensitive coastal waters.



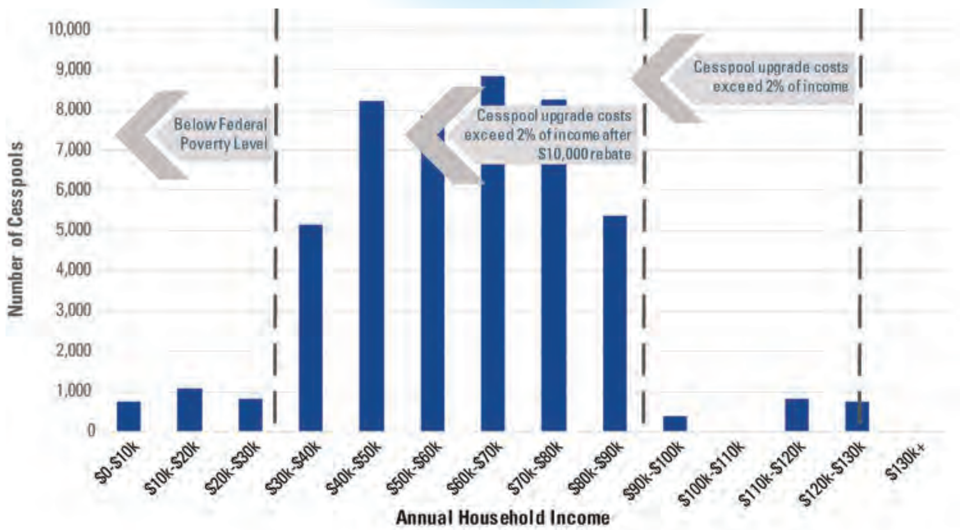


FIGURE 6. Hawai'i County Cesspools and Estimated Household Income Levels

Notes:

(1) Assumes average cesspool conversion cost scenario of $210 per month.

(2) Federal Poverty Level: $30,718 annual income or less.

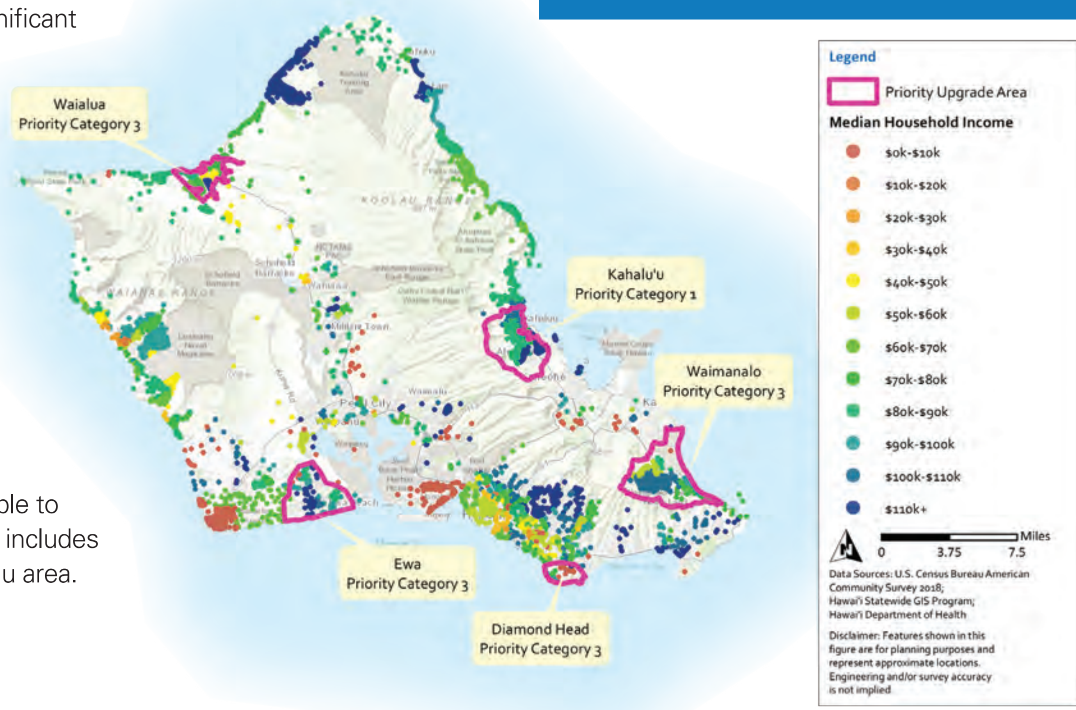
(3) Cesspool upgrade costs exceed 2 percent of income if the annual household income is less than $126,000.

(4) If a household is provided a $10,000 rebate, cesspool upgrade costs exceed 2 percent of income if the annual household income is less than $90,000.

City and County of Honolulu

The City and County of Honolulu has 10,749 cesspools. This includes 740 in the Kahulu'u area that are categorized as Priority 1 with significant risk to public health and the environment, and approximately 2,910 Priority 3 cesspools with potential impacts to sensitive waters. Most homeowners are connected to a regional sewer system. As a result, the City and County of Honolulu has the lowest percentage of households with a cesspool at 3 percent. Honolulu's residents have a higher income on average compared to the other counties, but Honolulu also has a significant number of residents with incomes below $10,000 per year. Therefore, while the county as a whole may not have the same broad affordability challenges as other counties, some households will be unable to pay for conversion. This includes residents in the Kahulu'u area.

The City and County of Honolulu has 740 Priority 1 cesspools in the Kahulu'u area, many of which will require financial assistance for conversions.



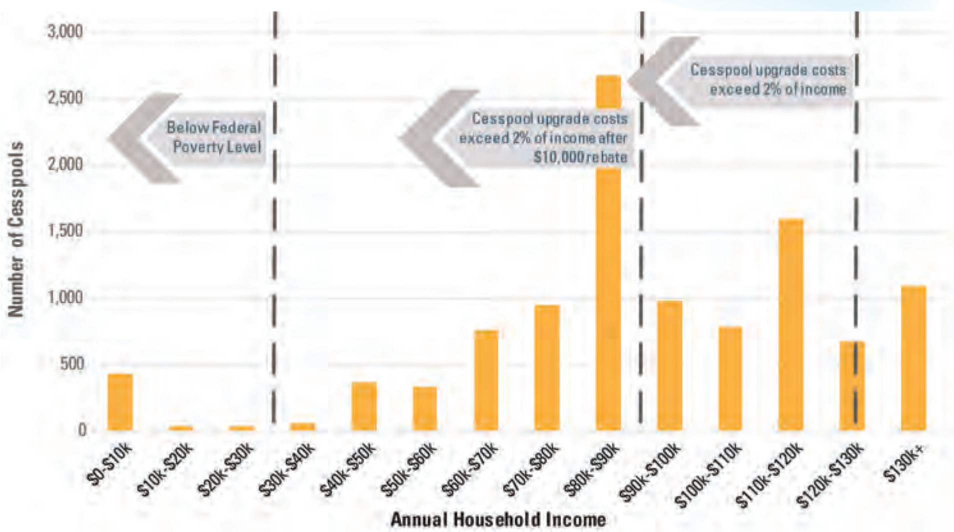


FIGURE 7. City and County of Honolulu Cesspools and Estimated Household Income Levels

Notes:
(1) Assumes average cesspool conversion cost scenario of $210 per month.
(2) Federal Poverty Level: $30,718 annual income or less.
(3) Cesspool upgrade costs exceed 2 percent of income if the annual household income is less than $126,000.
(4) If a household is provided a $10,000 rebate, cesspool upgrade costs exceed 2 percent of income if the annual household income is less than $90,000.

County of Kaua'i

The County of Kaua'i has 12,085 cesspools, including 5,211 categorized as Priority 2 with potential impacts to drinking water, and 160 Priority 3 cesspools with potential impacts to sensitive waters. Approximately 54 percent of all households on Kaua'i have cesspools. More than 11,000 households located in Kaua'i County, or 95 percent, are expected to face affordability challenges for cesspool conversions without some form of financial assistance.

The County of Kaua'i has 12,085 cesspools. Approximately 11,507 households in Kaua'i County, or 95 percent, are expected to face affordability challenges with conversions.

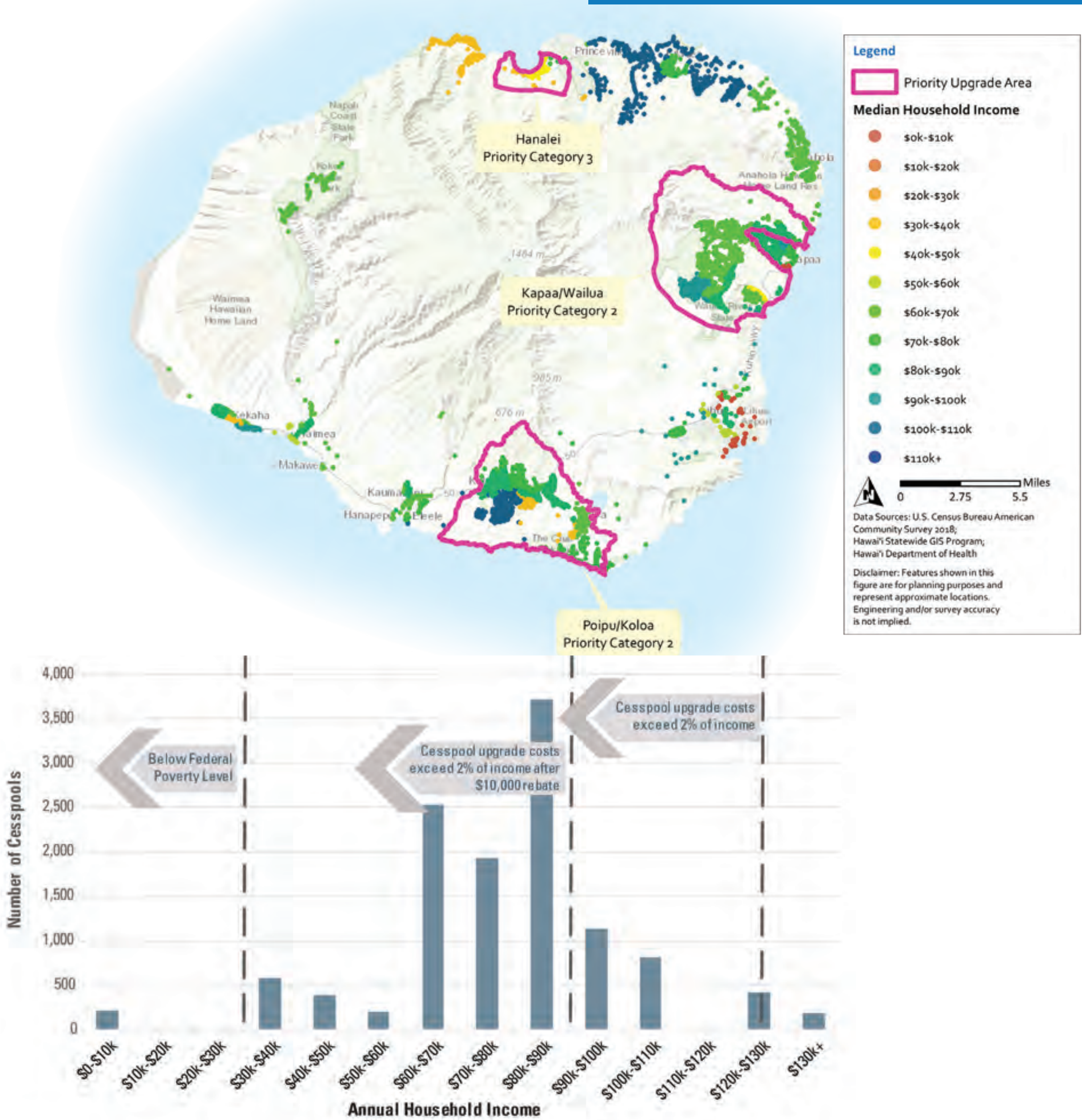


FIGURE 8. County of Kaua'i Cesspools and Estimated Household Income Levels

Notes:
(1) Assumes average cesspool conversion cost scenario of $210 per month.
(2) Federal Poverty Level: $30,718 annual income or less.
(3) Cesspool upgrade costs exceed 2 percent of income if the annual household income is less than $126,000.
(4) If a household is provided a $10,000 rebate, cesspool upgrade costs exceed 2 percent of income if the annual household income is less than $90,000.

County of Maui

The County of Maui has 12,085 cesspools on the island of Maui, and 1,439 cesspools on the island of Moloka'i. The Upcountry Maui region has the most Priority 1 cesspools in the State, with 5,777 that are predicted to have significant impacts to public health. Approximately 22 percent of all households in Maui County have cesspools. About 98 percent of Maui cesspool homeowners (11,888), and 100 percent of Moloka'i cesspool homeowners will be challenged to afford cesspool conversions without financial assistance.

Upcountry Maui has the most Priority 1 cesspools in the State. Approximately 98 percent of Maui cesspool homeowners (11,888), and 100 percent of Moloka'i cesspool homeowners will be challenged to afford cesspool conversions without financial assistance.

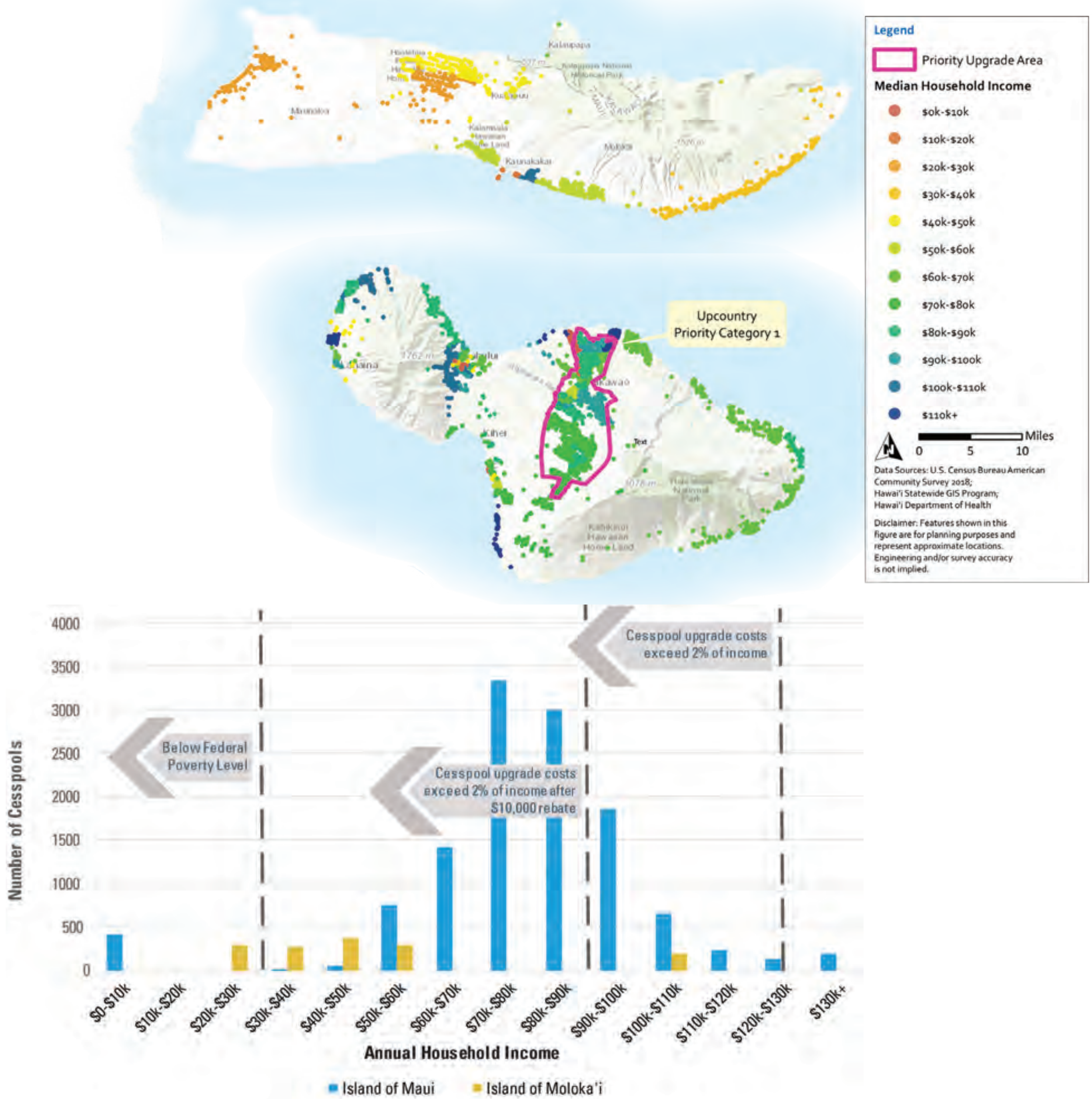


FIGURE 9. Island of Maui and Island of Moloka'i Cesspools and Estimated Household Income Levels

Notes:

(1) Assumes average cesspool conversion cost scenario of $210 per month.

(2) Federal Poverty Level: $30,718 annual income or less.

(3) Cesspool upgrade costs exceed 2 percent of income if the annual household income is less than $126,000.

(4) If a household is provided a $10,000 rebate, cesspool upgrade costs exceed 2 percent of income if the annual household income is less than $90,000.

Comparison to Local Sewer Rates

Figure 6 shows typical average monthly sewer service charges for wastewater collection and treatment for the various counties compared to the monthly cost for cesspool conversion for the low, average, and high cost conversion scenarios. In general, monthly conversion costs are estimated to be higher than monthly sewer bills. Hawai'i County has the lowest monthly wastewater bill at $40 per month on average, while the City and County of Honolulu has the highest at $111 per month. As a percent of median household income for each county, the monthly wastewater bills range from 0.8 percent (Hawai'i County) to 1.6 percent (City and County of Honolulu). Given monthly conversion costs are estimated to be higher than monthly sewer bills, and in some cases substantially higher, it is reasonable to assume that additional funding will be required to make conversions affordable for most residents.

On average, monthly cesspool conversion costs are estimated to be higher than monthly sewer bills.

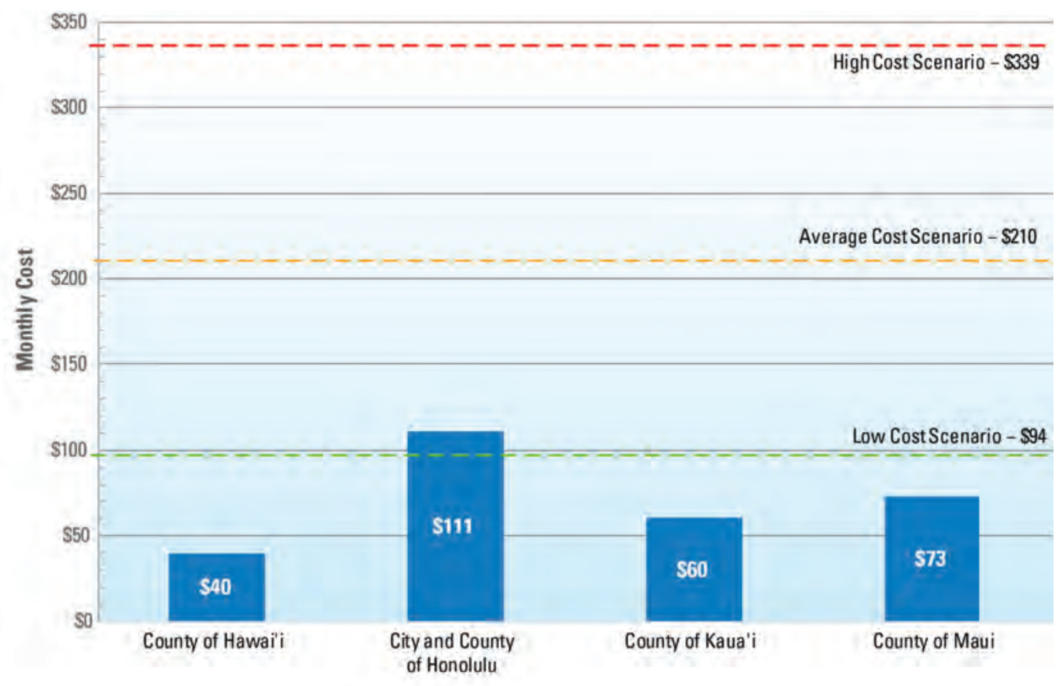


FIGURE 10. Typical Monthly Sewer Bill Compared to Monthly Cesspool Conversion Costs for Low, Medium, and High Cost Scenarios

Notes:
(1) County of Hawai'i – single family monthly flat rate of $40.00.
(2) City and County of Honolulu – based on estimated single family water usage of 9,000 gal/month. Wastewater bill is 80 percent of water usage$4.63/kgal + base fee of $77.55 = $110.89.*
(3) County of Kaua'i – single family monthly flat rate of $60.09.
(4) County of Maui – based on estimated single family water usage of 9,000 gal/month. Wastewater bill is based on all water usage up to 9,000 gals at $4.50/kgal + base fee of $32.50 = $73.00.

Cost and Affordability Relative to Priority Levels

With limited funds available to directly support conversions, the State may need to prioritize how available financial assistance is allocated. Table 3 presents the estimated cost to upgrade all cesspools in the State broken down by priority area and affordability based on two percent of the median household income. The average conversion cost of $23,000 was assumed to estimate the total funding required for complete conversions.

To fully fund all cesspool conversions for those who are financially burdened, an estimated $1.9 billion in funding is required.

TABLE 3. Estimated Cost to Convert All Cesspools by Priority Level and Median Household Income

PRIORITY LEVEL	NUMBER OF CESSPOOLS	TOTAL CONVERSION COST ($ MILLIONS)[1]
Replacement Costs are Considered Affordable (Costs are Less than 2 percent of Estimated Household Income[2])		
1	98	$2.3
2	179	$4.1
3	589	$13.5
4	1,427	$32.8
SUBTOTAL	2,293	$52.7
Replacement Costs are Considered Unaffordable (Costs are Greater than 2 percent of Estimated Household Income[3])		
1	8,434	$194.0
2	14,321	$329.4
3	17,717	$407.5
4	41,952	$964.9
SUBTOTAL	82,424	$1,895.8
TOTAL	84,717[4]	$1,948.5

Notes:
(1) Based on average conversion cost of $23,000.
(2) Includes residents who may be able to afford cesspool conversions without financial assistance.
(3) Includes residents who are financially burdened by cesspool conversion costs and may require financial assistance.
(4) Total number of cesspools by Priority Level comes from the Hawai'i Statewide GIS Program. Note this is slightly lower than the 87,900 estimate from the Legislative Report (DOH, 2018).

Private Financing and What Can Be Afforded

Another way to determine the amount of financial assistance needed is to consider the portion of the cesspool conversions costs that can be afforded by homeowners. With the exception of those with estimated annual income below the FPL, it was assumed that households could afford to privately finance an amount that results in a monthly payment less than or equal to 2 percent of their estimated monthly income less the average monthly maintenance cost for the selected replacement technology. If that amount is less than the average of conversion costs, it is assumed the difference would require financial aid.

Table 4 summarizes the estimated amount of conversion costs that can be afforded or privately financed versus the amount of financial aid that may be required. It is anticipated that more than $1 billion in financial aid is required to support cesspool conversions for homeowners who are financially burdened.

TABLE 4. Estimated Private Financing and Financial Aid Required for Cesspool Conversions[1]

PRIORITY	TOTAL PRIVATE FINANCING[2] ($ MILLION)	TOTAL FINANCIAL AID REQUIRED[3] ($ MILLION)
1	$89.8	$106.5
2	$94.2	$239.3
3	$164.7	$256.3
4	$312.4	$685.3
TOTAL	$661.1	$1,287.4

Notes:
(1) Based on average conversion cost of $23,000.
(2) Assumes residents can afford up to 2 percent of estimated household income for cesspool conversions, financed at 4 percent interest over 20 years.
3) Assumes cesspool conversion costs in excess of 2 percent of estimated household income will require financial aid. Residents with income levels below the federal poverty limit are assumed to require financial support for all conversion costs.

Cesspool Conversion Funding Mechanisms

There are a limited number of financing mechanisms available to achieve the level of funding necessary to make all cesspool conversions affordable.

CESSPOOL CONVERSION FUNDING CHALLENGES

There are several challenges associated with identifying viable funding mechanisms for Hawai'i's cesspool conversion program. First, the magnitude of the potential amount of funding that the program requires is significant, whereas, based on the average cost of cesspool conversions, it is estimated that the total cost of the conversions within the State is on the order of $2 billion, this cost may range from $880 million to more than $5.3 billion.[2] While there are low interest loan and grant funding opportunities from federal, state, and local financing sources, all of these combined fall significantly short of that required to fully fund all conversions. In addition, most of the financing programs are available only to government entities such as the state or counties, or non-profit organizations, and are not targeted at private, residential property owners. This is further complicated by the fact that the State and the counties do not currently have the staff or the administrative capabilities to receive grant or loan funds, review and process individual applications, disperse the funds to homeowners, and, in the case of loans, conduct follow-up payment collection. Lastly, most of these financing programs provide a reimbursement for incurred cost, requiring the individual homeowners to first pay upfront the cost associated with planning, design, and construction of the new onsite wastewater treatment system, and then be reimbursed.

Due to the varying demographics, socio economics, implementation timeline, and system costs, there is not a "one size fits all solution" for the financing mechanism across all counties in Hawai'i.

The ideal cesspool conversion funding program will need to meet several objectives.

KEY OBJECTIVES OF THE CESSPOOL CONVERSION FUNDING PROGRAM

- Consider equitability and affordability issues.
- Incentivize individual homeowners to convert existing cesspools.
- Provide funding support for upfront cesspool conversion costs.
- Consider the funding recipient (e.g., cesspool homeowner, agency, etc.)
- Balance the need for immediate-, near-, and long-term expenditures.
- Potentially fund a variety of onsite wastewater treatment technology options.
- Minimize the administrative burden on the DOH while leveraging support from existing or new local agencies to administer cesspool conversion funding responsiblities.

There is a need to identify or develop a mechanism that can funnel federal, state, or other funding or incentives to individual homeowners through existing or new organizations such as the counties, non-profits, or financial institutions. The proposed financing program will also likely need additional funding for state and/or local governments to administer and fund the program options.

2. Historical cesspool replacement costs range from $9,000 to $60,000 per conversion. The range shown is for conversion of all 88,000 cesspools in Hawai'i.

FINANCING OPTIONS

Financing options may include tax credits or rebates, federal, state, or county grants, and private/mortgage loans. A notable difference between grants and loans are that grants do not need to be repaid, while loans are borrowed funds that require repayment, typically with interest. These financing options and potential funding agencies are summarized below.

Private/Mortgage Loans

It will be a challenge and likely infeasible for financial support to be provided to all cesspool owners for the conversions. Thus, it will likely be necessary for homeowners to seek private or mortgage loans to finance the conversions. There are several private financing options available to homeowners including: personal loans, home equity loans, or the use of personal savings. Given the economic turmoil caused by the global COVID-19 pandemic in 2020, the current, low interest rates provided by private lending options may be an economical option for some residents.

State Tax Credits or Rebate Programs

The State of Hawai'i's temporary tax credit program (Act 120), which provides up to $10,000 in incentives for individual homeowners to convert cesspools to septic systems or aerobic treatment units, is set to expire on December 31, 2020. Legislation which would extend the term of the credits did not pass in the most recent legislative session. Given that less than 100 applications have been filed for this credit to date, tax credits may have limited appeal and application and there may be a need to re-evaluate the tax credit mechanism and identify opportunities to make the program more enticing. A rebate program may have broader appeal and applicability for cesspool conversions.

Grants and Loans

Federal, state, and local grant and loan funding sources should also be considered as potential funding mechanisms. While these sources do not provide a reliable long-term solution for financing cesspool upgrades, they can help with the implementation of portions of the program.

Funding agencies with potential financing mechanisms include:

- United States Environmental Protection Agency
- United States Department of Interior, Bureau of Reclamation
- United States Department of Agriculture
- United States Department of Housing and Urban Development
- United States Department of Commerce - Economic Development Administration
- State of Hawai'i Clean Water State Revolving Fund (CWSRF)
- State of Hawai'i - Non-Point Source (319) (NPS) Grants
- State of Hawai'i Rural Community Assistance Corporation
- State of Hawai'i Rural Water Association
- Proposed – Hawai'i Cesspool Remediation and Conversion Loan Program

Potential CWSRF Funding Mechanisms

There may be opportunities within the State of Hawai'i's CWSRF program for non-profits or public entities to pursue funding or to create a pilot program to provide loans or grants to residential homeowners. The CWSRF program provides low interest loans for a wide range of water quality infrastructure projects. Loans to finance non-point source projects, including cesspool conversions, can be provided through several funding mechanisms, depending on type of project, repayment source, and on agreement by the state program.[3] Typically, CWSRF funding can only be provided to public entities, however the State of Hawai'i's program allows for funding to be provided to individuals for cesspool conversions or can be provided via the counties, other federal/state agencies, non-profits, or financial institutions. These institutions can act as the broker to make sub-loans to individual homeowners for the cesspool upgrades.

In a survey of other cesspool funding programs, funding is provided by the state or the CWSRF program to a local intermediary agency that is then fiscally responsible for the loan and the overall administration, thereby reducing the burden on the CWSRF staff. Cesspool financing programs in other states, have been funded with CWSRF funds, USEPA grants, state bonds, legislative funding or other state funding sources. Mechanisms that have been utilized successfully include: Conduit Lending (Pass Through), Linked Deposits, Sub-state Revolving Funding, and Direct Loans.

It is estimated that $5 million per year is the maximum financing that can currently be obtained through the CWSRF program. This level of funding represents less than 10 percent of the average annual cost of all conversions to meet the 2050 deadline.

3. A non-point source is a source of pollution that originates from widely distributed elements (such as runoff from agricultural or residential areas) as opposed to a single point source (such as a wastewater treatment plant or a factory). In the 2015-2020 Hawai'i Nonpoint Source Management Plan, cesspool wastewater runoff was identified as a non-point source impacting the State's resources and therefore may be eligible for NPS Grant funding.

Other Funding Models and Partnerships

Funding approaches and partnerships employed by the energy sector or other utilities may serve as a model. While other utilities have different drivers and payback periods, some of their funding models may be applicable to funding a portion of cesspool conversions.

On-Bill Financing Program – Example: Hawai'i Green Infrastructure Authority

Two funding models previously utilized in Hawai'i are on-bill financing and on-bill repayment programs. On-bill financing allows the electric utility (e.g., Hawaiian Electric, Maui Electric, or Hawai'i Electric Light) to incur the cost of a clean energy upgrade to a home, which is then repaid by the homeowner through their monthly utility bill. Upfront capital is provided by a third party, by the Hawai'i Green Infrastructure Authority, not the electric utility. In some on-bill repayment programs, the loan is transferable to the next owner of the home, building, or property. The idea of an on-bill financing program could be adapted to finance cesspool conversions with the assistance of county or local agencies (e.g. water or wastewater utilities) that could assist in the billing administration function similar to electric utilities.

An on-bill financing model that currently exists in Hawai'i is the Green Energy Money $aver On-bill (GEM$) program whose purpose is to deploy clean infrastructure. The program enables ratepayers to finance clean energy improvements through an on-bill financing model that spreads the initial capital costs of installing green infrastructure up to 20 years.

Property Assessments – Example: Property Assessed Clean Energy Program

Another energy-based funding model that could be adapted to finance cesspool conversions is the Property Assessed Clean Energy (PACE) program. This is a mechanism used by local governments to allow property owners to finance the up-front cost of energy efficiency and renewable energy improvements (such as solar) and then pay the costs back over time through a voluntary assessment. A PACE program could be modified as a viable financing option for cesspool conversion to allow a property owner to pay back costs over time at an agreed upon interest rate and length of loan term. Funding would occur through private lenders, e.g., private banks, or the issuance of municipal bonds.

Property Assessments – Example: Community Facilities District and Special Improvement Districts

The use of Community Facilities Districts or Special Improvement Districts, which are independent, local special-purpose financing districts that levy taxes and assessments and issue bonds to provide infrastructure to develop communities of all types, could be another mechanism by which to fund cesspool conversions. A special improvement district specifically created to address the USEPA's requirement to close large-capacity cesspools is the Lono Kona Sewer Improvement District in North Kona in the County of Hawai'i. This program funds the connection of 110 parcels to the county wastewater system. A similar funding mechanism could be applied to the funding of onsite systems for a neighborhood of current cesspool owners.

Public Private Partnerships

Another potential funding mechanism is the development of Public-Private Partnerships (P3s) that encourage private investment in public infrastructure projects. P3s are contractual arrangements in which governments or public entities form partnerships with the private sector to design, finance, build, and operate and/or maintain infrastructure such as toll roads, water supply facilities, and wastewater treatment plants. Public agencies are in charge of financing and theoretically pass risks related to operating costs and project revenues to the private partner. However, P3s also have some negative aspects including potential local opposition, loss of public control and flexibility, potential need for in-house expertise or outside consultants, complicated contracts and complex negotiations, as well as significant effort to enforce and monitor contracts.

LESSONS FROM FUNDING OF CESSPOOL CONVERSIONS IN OTHER STATES

Cesspool conversion mechanisms used in eleven other states were reviewed with the focus on those with programs funding the conversion of cesspools with onsite systems. These states incentivized individual residential or commercial owners to convert failing systems by providing financial support, in the form of loans, grants or incentives, to defray the costs associated with the implementation of the new technology.

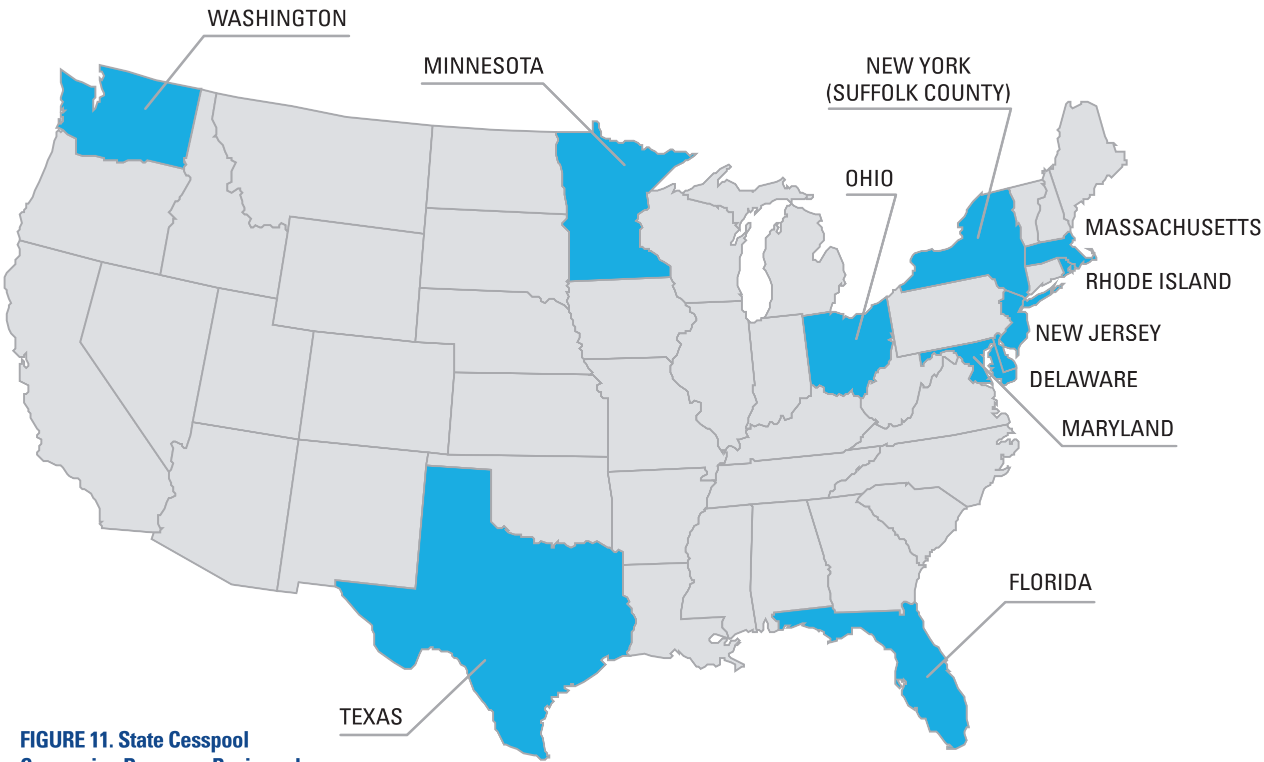


FIGURE 11. State Cesspool Conversion Programs Reviewed

Each state's cesspool conversion financing mechanism varies and is adapted to the individual state's demographics, technologies, and needs. However, there are lessons to be learned from each program as to what has worked and what has needed improvement. Some key takeaways from other states include:

Long-term Effort. The conversion process is a long-term effort that is generally slow moving. This requires all aspects of the program to be sustainable for an extended period of time (over 20 – 30 years), including but not limited to public outreach, funding, and administration.

Funding. Cesspool financing programs were funded through state funding, CWSRF, and the USEPA, with CWSRF funding being the primary source.

- Maryland's Bay Restoration Fund is unique in that they charge an annual user fee for onsite wastewater treatment systems and a monthly sewer connection fee to cover the program administration and grant costs.

Financing. Given the long implementation timeline, a suite of sustainable long-term financing mechanisms are required.

- While the financing programs of each state varied, most provided low interest loans to individual homeowners utilizing CWSRF or other state funds through a conduit/ pass through mechanism. Utilizing this approach, the CWSRF programs funnel funding to individual homeowners through a "conduit" or intermediate agency which assumed responsibility for the loan and all administrative activities – thereby reducing administrative demands on the CWSRF program. Conduit agencies included other state programs, financial institutions or non-profit organizations.
- In addition to low interest loans, some states offer grants. New York, Maryland, and Rhode Island offer grants to individual homeowners, while Texas provides competitive grants to support applied research of onsite wastewater treatment systems.
- Massachusetts provides an ongoing tax credit program to cesspool homeowners if they convert/upgrade their cesspool.
- Washington provides a regional loan program (RPL) managed by Craft3 (a non-profit financial institution) to manage lending activities for onsite sewage system repair or replacement.

WASHINGTON'S REGIONAL ONSITE SEWAGE SYSTEM LOAN PROGRAM

- Partnership between state and local agencies and Craft3 (a non-profit third-part lender).
- Established in 1990.
- $15 million in CWSRF funding provided since establishment.
- Craft3 provides program management, approves or denies loan requests, and manages all loan disbursement and activity tracking.
- Craft3 assumes financial risk associated with lending and is obligated to repay the CWSRF funds.
- CWSRF loans provided to both residential and commerical owners to replace failing onsite sewage systems or to connect to existing sewer systems.
- 15-year loans with interest rates ranging from 1.99 to 4.99 percent dependent on household income.

Common Upgrade/Conversion Mechanisms. The most common upgrade and conversion mechanisms instituted by states were the requirements that the upgrade occur at the time of the property sale or property transfer, if the system failed during inspections, or as required by a blanket cesspool phase-out program (as is being implemented in Hawai'i).

Eligibility. Project costs eligible for financing included planning, design, implementation/ construction, and permitting costs associated with converting failing or existing cesspool system or connecting to a sewer system. Additional financing eligibility requirements are as follows:

- Although there is no minimum income requirement, individual homeowners are required to have good standing credit and the loan must be secured by a mortgage lien or some other similar mechanism. Two programs provided alternative funding for applicants who could not qualify due to credit issues.
- Individual homeowners are required to secure approval of the proposed onsite system and design prior to start of construction in order to be eligible for financing. Approval was typically provided by the county or local permitting agency.

Homeowner Loans. Individual homeowner loans ranged from $1,000 to $35,000, with interest rates ranging from zero interest to low interest (3 to 6 percent), and loan periods ranging from 10-20 years or the useful life of the system.

- Several programs provided incentives for disadvantaged communities, low income households, or the elderly.
- There was no pre-payment penalty for programs reviewed.
- In several programs the homeowner was required to repay the loan upon sale or transfer of property.
- Loan repayment mechanisms included, but were not limited to: monthly payments, interest only/balloon payment, deferred payment, annual payment, and charge on property tax bill.

Disbursements. Most programs required construction to be completed prior to the disbursement of funds, therefore homeowners were required to pay the project costs upfront and then be reimbursed.

- Method of monetary disbursements varied, with most programs directly compensating the homeowner. In two programs, the states directly compensated the contractor for construction costs.
- Repayment mechanisms included monthly payments or annual line item in property tax bill.

Program Administration. Program administration efforts need to be covered with a sustainable financing mechanism.

- Most programs recovered administrative costs through the interest rate on the loan; while one state program utilized state funds to cover administrative costs.
- Several programs have established partnerships with non-profits, counties, or financial institutions to serve as a conduit agency responsible for administrative loan activities.

Public Outreach. States with successful programs had implemented extensive public outreach programs to educate residents on the public health and water quality benefits of converting cesspools and provided information on incentives and state programs homeowners could leverage to help cover the conversion cost.

As the Working Group develops a recommended approach to financing the cesspool conversions, its is recommended that discussions be conducted with various funding agencies as well as the lessons learned from other statewide mechanisms be investigated further, especially programs in New York, Washington, Maryland, and Massachusetts.

Other Factors Inhibiting Cesspool Conversions

Besides affordability and funding challenges, there are other obstacles to cesspool conversions in Hawai'i.

OVERVIEW AND OBJECTIVES

Previous discussion presented herein highlighted the affordability and funding challenges associated with the implementation of a program of this magnitude in the State. In this section, other factors which may inhibit the conversion of cesspools to a more appropriate technology and/or jeopardize the long-term success of the program are explored. In many cases, these factors were identified based on the experiences from conversion programs implemented in other states. Additional insight was gained from stakeholder input received as part of the Investigation of Cesspool Upgrade Alternatives in Upcountry Maui (Babcock et al, 2019).

PUBLIC ACCEPTANCE AND EDUCATION

Successful cesspool conversion programs implemented in other states have all included an aggressive public outreach and education effort. Getting homeowners to invest tens of thousands of dollars to upgrade their onsite system without a direct and visible benefit will be difficult. As a result, providing education and examples of tangible benefits such as reducing pollution and preserving sensitive ecosystems will be important for long-term success. Efforts should initially focus on public understanding and acceptance of the key underlying premise of the problem and the basis of area prioritizations. Subsequent and on-going outreach plans can be designed to inform the public of methods of conversion, available technical and financial resources, as well long-term operations, maintenance, and/or reporting requirements for onsite systems. Consideration should be given to the development of a centralized program-focused website along with other diverse methods of communication tailored to a public audience.

PERCEPTION OF INEQUITY

As presented previously, the cost of cesspool conversions can vary widely based on specific site conditions and level of treatment needed. In addition, it is expected that the cost of conversion to a more advanced onsite technology will generally exceed that paid by those currently connected to a county-owned wastewater collection system and treatment plant. These differences give rise to the potential perceptions of inequity between various homeowners within a given county or within the state as whole. Questions such as: Why should I pay more for sewer service than my neighbors?; Why should I have to pay more just because I don't have the good fortune to be connected to the county sewer system?; have been raised in previous stakeholder settings. Concerns have also been expressed that groundwater quality in some areas has been significantly impacted by legacy sources such as agriculture and that these past operations should also contribute their fair share to the solution of the problem. These issues of potential inequity should be clearly addressed to assist in gaining public acceptance and support.

NEAR-TERM INCENTIVES

Act 125 requires the conversion of all 88,000 in the State by 2050, or an average conversion rate of about 3,000 per year. Of the conversion programs evaluated in other states, most moved at a very slow pace, converting about 2,000 or less cesspools per year. Therefore, Hawai'i will to need to move at an aggressive pace compared to other states to meet the 2050 deadline required by the Act. Should the pace of near-term conversions lag, the task to convert all cesspools by 2050 becomes even more challenging. Development of an effective plan to identify and implement incentives to homeowners for complete conversions in the near-term would greatly assist in meeting program goals. The plan should consider the benefits of focusing incentives on the highest priority areas.

AVAILABLE WORKFORCE AND RESOURCES

It has been estimated that the overall conversion program will cost about $2 billion to implement. This represents an average annual cost of about $70 million. It is unknown if there is adequate qualified engineering, materials supply chains, and construction contractors currently available to meet program needs. If the number of conversions becomes more concentrated in the later part of the compliance period, workforce and resource concerns could dramatically increase. An assessment of available resources within the State should be performed to determine if this will be a factor which will inhibit cesspool conversions.

RESPONSIBLE MANAGEMENT ENTITY

Successful programs implemented by other states identified a single management entity to be responsible for obtaining, organizing, and managing the large amount of data required to assess ecosystem impacts, inventory and permit onsite systems, and conduct follow-up inspections and reporting. The role of this entity may also include the development of comprehensive regional or watershed management plans which outline strategies and implementation measures to insure compliance with water quality objectives through proper management, inspection, and regulatory enforcement. Without a single management entity, with a comprehensive long-term management approach, the overall effectiveness of the cesspool conversion program could suffer and ultimately negatively impact water quality improvement goals. This effort requires a source of significant ongoing funding for staff time and support services.

STABLE SOURCE OF REVENUE

Municipal water and wastewater programs rely on a stable source of revenue in the form of user fees or general taxing authority to fund system capital and on-going operations and maintenance (O&M) efforts. However, many major non-traditional projects, such as the cesspool conversion program, lack a reliable, dedicated revenue stream to cover the long-term costs associated with project implementation such as special financial assistance plans, data gathering, permitting, monitoring, regulatory enforcement, and general program administration. Consideration should be given to leveraging existing available and potential new revenue sources to assist with the financing of the conversion program. An example of such a program is the Bay Area Restoration Fund created by the State of Maryland which charges a fee of $2.50 to $5.00 per month to all municipal sewer customers and $60 per year to all those served by an onsite system. Resulting revenue is used to assist with the conversion of onsite systems, finance wastewater treatment plant upgrades, and cover on-going administrative costs.

Findings and Recommendations

As the State continues to develop the cesspool conversion strategy, there are several issues that warrant further investigation. This section summarizes findings, recommendations, and identifies the need for future studies and other early actions.

THE BURDEN OF AFFORDABILITY

Significant affordability challenges are anticipated for cesspool conversions across the State. It is projected that 97 percent of cesspool homeowners will pay more than 2 percent of their income for the conversions. As a result, there is likely to be a significant financial burden at the household level. Measures of poverty and income constraints show that most homeowners have little room in their household budgets for such a significant expense.

The affordability analysis breaks down the cesspools by priority levels and households with the greatest financial needs. Considering the limited potential funding available, homeowners with cesspools in priority areas and with the greatest financial need should be targeted.

THE FUNDING GAP

Because of the magnitude of the funding needs (an estimated total of about $2 billion), the State will likely need to develop a suite of funding sources to support cesspool conversions. While there are low interest loan and grant funding opportunities from federal, state, and local financing sources, the combination of these falls significantly short of what is required to fully fund all conversions. The example presented in Figure 12 illustrates that the potential funding gap could be as large as $1.1 billion given certain funding option assumptions.

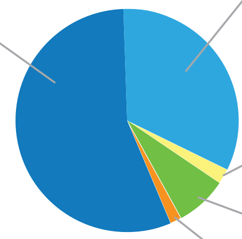


FIGURE 12. Hypothetical Distribution of Funding Sources and Potential Funding Gap.

DEFINING THE PIECES OF THE CESSPOOL CONVERSION "FUNDING PIE"

Figure 12 is a hypothetical financing scenario to estimate the remaining funding gap for cesspool conversions in Hawai'i.

ASSUMPTIONS:

- Total Conversion Cost: $2 billion
- Federal Grants/Loans: $30 million (@$1 million per year for 30 years)
- State CWSRF: $150M (@$5 million per year for 30 years)
- Rebate Program: $43 million ($10,000 rebate for those below the federal poverty level)
- Private Financing: $661 million (Based on households paying up to 2 percent of estimated monthly income)
- **Remaining Funding Gap: $1.1 billion**

RECOMMENDATIONS AND POTENTIAL NEXT STEPS

Recommendations and potential next steps to support cesspool conversions include:

Coordinate state legislative efforts to establish and facilitate a cesspool conversion program. Potential efforts include:

- Create a rebate program to incentivize conversions.
- Create legislation to require that cesspools are disclosed as part of real estate property inspections/transactions.
- Evaluate legislation for establishment and funding of a cesspool conversion financing program.
- Evaluate potential federal legislative actions.

Identify viable financing mechanisms. Potential actions include:

- Conduct additional research into preferred options identified by the Working Group.
- Conduct outreach to federal and state funding programs to confirm applicability, program requirements, and timing.
- Follow-up with other states' financing programs to discuss program details to understand the "nuts and bolts" of the programs. Identify lessons learned, successes and failures, and what program elements could work in Hawai'i.

Identify administrative resources. Identify and contact potential agencies, non-profits, and financial institutions within the State to determine technical expertise, ability and willingness to conduct administrative activities, what financial mechanisms they could help implement, and other functions they can perform (e.g., technical support, permitting, etc).

FIGURE 13. Cesspool Upgrades.
Most homeowners will need significant financial support to upgrade their cesspools.

Coordinate with and leverage federal, state, and local entities. Conduct discussions with the following entities to assess and understand available resources (staff/financial), technical expertise, level of engagement/responsibility desired, and resource requirements:

- State
- Private lenders
- CWSRF Administrators
- U.S. Department of Housing and Urban Development
- U.S. Department of Agriculture
- USEPA
- Other identified agencies/non-profits

Determine distribution of financial aid. Distribution of financial aid should consider both the homeowner's ability to pay and the priority area of the cesspool to ensure funding is allocated to the highest needs.

Conduct public outreach. Work with the public outreach subgroup to establish comprehensive and extensive public outreach. Public outreach should be conducted to:

- Gain public understanding and acceptance of the key underlying issues and need for cesspool conversions.
- Inform the public of available conversion methods, technical information, financial resources, and long-term O&M and/or reporting requirements for their upgraded onsite wastewater system.
- Inform the public through various communication mediums including a program-focused website.

Overcome other factors inhibiting cesspool conversions. In addition to gaining public acceptance and educating cesspool owners through public outreach these include:

- Address perception of inequity. Clearly address these perceptions to gain public acceptance and support.
- Implement near-term incentives. Implement incentives that encourage homeowners to convert their cesspools in the near term, with a focus on homeowners within the highest priority areas.
- Identify available workforce resources and shortfalls. Assess available resources to implement the program (administration, engineering, construction, etc.) to determine if resource limitations will be an issue. If resources are limited, work to identify and/or develop additional workforce resources.
- Establish responsible management entity. Establish a single management entity to be responsible for comprehensive long-term implementation of the program so efforts are well coordinated and effective. Given this requires significant staff time and support services, identify an on-going source of funding for this entity.
- Establish stable source of revenue. Consider leveraging existing available and potential new revenue sources to provide a stable, long-term source of revenue to support the program.

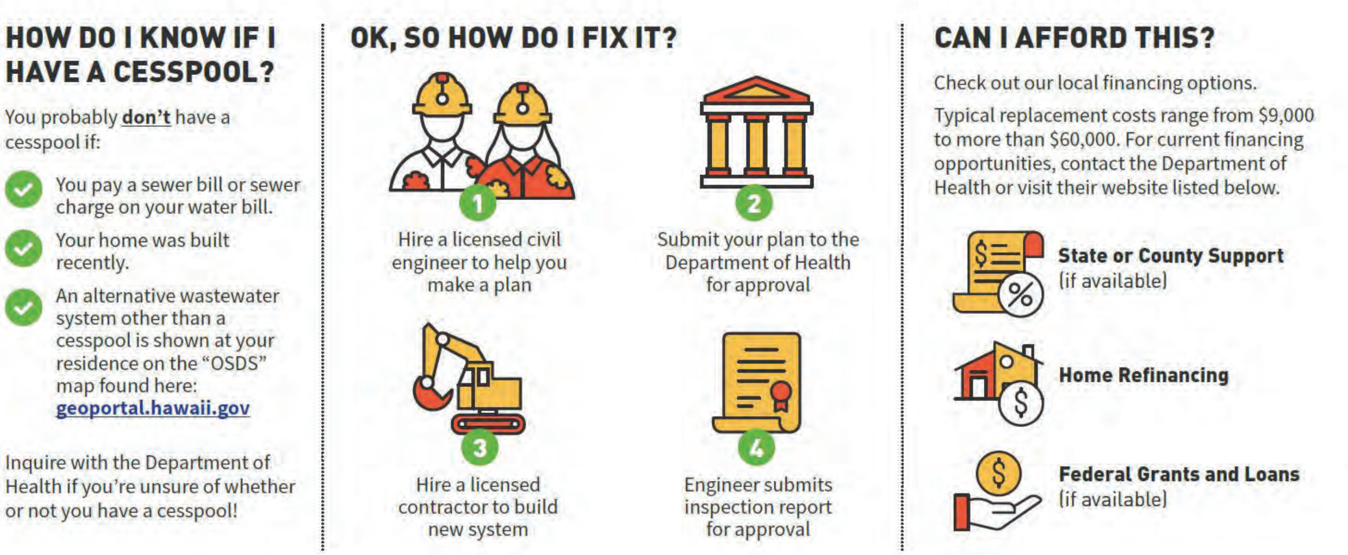


FIGURE 14. Example Public Outreach Handout
See Appendix C for the full page example handout.

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Appendix A

Technical Memorandum 1:
CESSPOOL CONVERSION FUNDING MECHANISMS
(October 2020)

Hawaiʻi State Department of Health
Cesspool Conversion Finance Research

Technical Memorandum 1
CESSPOOL CONVERSION FUNDING MECHANISMS

FINAL | August 2020

carollo
in association with Harris & Associates

Hawaiʻi State Department of Health
Cesspool Conversion Finance Research

Technical Memorandum 1
CESSPOOL CONVERSION FUNDING MECHANISMS

FINAL | August 2020

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THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE

04/30/2022
EXPIRATION DATE OF THE LICENSE

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Abbreviations

AIE	alternative, innovative, or emerging
ATU	aerobic treatment unit
AWIA	America's Water Infrastructure Act
BMAP	Basin Management Action Plan
BRF	Bay Restoration Fund
Carollo	Carollo Engineers, Inc.
CCWG	Cesspool Conversion Working Group
CDBG	Community Development Block Grants
CFD	Community Facilities District
C-PACE	Commercial Property Assessed Clean Energy properties
CSSLP	State of Rhode Island Community Septic System Loan Program
CWCA	Clean Water Commerce Act
CWMP	Cooperative Watershed Management Program
CWSRF	State of Hawaiʻi Clean Water State Revolving Fund
DAC	disadvantaged community
DBEDT	Department of Business, Economic Development and Tourism
DBOM	design-build-operate-maintain
DCA	Department of Community Affairs
DEM	Rhode Island Department of Environmental Management
DEP	Department of Environmental Protection
DNREC	Delaware Department of Natural Resources and Environmental Control
DOE	Department of Energy
DOH	Department of Health
EDA	Department of Commerce Economic Development Administration
EFC	New York Environmental Facilities Corporation
EPA	United States Environmental Protection Agency
FFY	federal fiscal year
FHA	Federal Housing Administration
FSCAA	First State Community Action Agency
FY	fiscal year
GEM$	Green Energy Money $aver On-bill Program
GO	general obligation (bonds)
gpd	gallons per day
HCF	Hawaii Community Foundation
HELOC	home equity line of credit
HGIA	Hawaiʻi Green Infrastructure Authority
HRS	Hawaiʻi Revised Statutes

HUD	U.S. Department of Housing and Urban Development
Hui	Hanalei Watershed Hui
HVAC	heating, ventilation, and air conditioning systems
ID	Lono Kona Sewer Improvement District
LCC	large capacity cesspool
LDP	linked deposit program
LHD	Local Health District
LLP	Local Loan Program
MACOG	Missouri Association of Councils of Government
MDA	Maryland Department of Agriculture
MDE	Maryland Department of Environment
mgd	million gallons per day
MGP	New Jersey Municipal Grant Program
NEPA	National Environmental Policy Act
NJDEP	New Jersey Department of Environmental Protection
NJWB	New Jersey Water Bank
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint sources
OHA	Office of Hawaiian Affairs
OSWT	Onsite wastewater treatment
OSSF	on-site sewage facility
P3	Public-Private Partnership
PACE	Property Assessed Clean Energy
PAYGO	pay-as-you-go
PCA	Minnesota Pollution Control Agency
PFA	Minnesota Public Facilities Authority
PPL	Project Priority List
PRC	Polluted Runoff Control
Program	Septic Upgrade Incentive Program
RCAC	Hawaiʻi Rural Community Assistance Corporation
RI Housing	Rhode Island Housing and Mortgage Financing Corporation
RI-I	Rhode Island Infrastructure
RLF	Revolving Loan Funds
RLP	Regional On-site Sewage System Loan Program
R-PACE	Residential Property Assessed Clean Energy properties
RWLF	Rural Water Loan Fund
S.A.F.E.	Save, Accelerate, Fill and Expedite
SCADA	supervisory control and data acquisition
SEFO	Septic Extended Funding Option

SEP	Supplemental Environmental Project
SID	Special Improvement District
SRF	State Revolving Fund
SRLP	Septic Rehabilitation Loan Program
SSTS	Subsurface sewage treatment systems
STILF	Sewer Tie-in Loan Fund Program
TM01	Technical Memorandum 1
TM02	Technical Memorandum 2
TOGP	Texas On-site Sewage Facility Grant Program
Trust	New Jersey Environmental Infrastructure Trust
Ulupono	Ulupono Initiative
USBR	United States Department of Interior, Bureau of Reclamation
USDA	United States Department of Agriculture
VA	Veterans Affairs
WIFA	Water Infrastructure Finance Authority
WIFIA	Water Infrastructure Finance and Innovation Act
WIIN	Water Infrastructure Improvements for the Nation
WPCLF	Ohio Water Pollution Control Loan Fund
WQFA	Water Qualify Financing Administration
WQT	Maryland Water Quality Trading Program
WRRDA	2014 Water Resources Reform and Development Act
WRRSP	Ohio Water Resource Restoration Sponsor Program

Technical Memorandum 1

EXECUTIVE SUMMARY

ES.1 Introduction

Throughout Hawaiʻi, there are approximately 88,000 cesspools that release an estimated 53 million gallons per day (mgd) of wastewater to the environment. Most of the existing cesspools provide wastewater disposal for single-family residences, versus large-capacity systems serving multiple residences or commercial areas. Given that over 90 percent of the state's drinking water supplies are from groundwater sources, it was recognized that cesspools pose an environmental and public health risk.

In 2017, the Hawaiʻi State Legislature passed Act 125, which states that by January 1, 2050 all cesspools in the state, unless granted exemption, shall upgrade or convert to a septic or aerobic treatment unit (ATU), or connect to a sewer system (ACT 125, 2017). Act 132 was passed in 2018 to establish a Cesspool Conversion Working Group (CCWG) to develop a long range, comprehensive plan and commission a statewide study of sewage contamination in nearshore marine areas (ACT 132, 2018). The CCWG retained Carollo Engineers, Inc., (Carollo) to provide expertise on onsite wastewater treatment (OSWT) technologies and cesspool conversion funding and finance options.

As a result of Act 125, homeowners will be required to upgrade their existing cesspools to approved OSWT technologies. The cost associated with cesspool conversions will likely be a financial burden to most residential owners and in a state where the cost of living is already high, many homeowners will be challenged to afford the costs to upgrade. One of the complex challenges tasked to the CCWG is to develop a strategy to aid the funding and financing of the cesspool upgrades. The purpose of this technical memorandum (TM01) is to summarize potential funding mechanisms that may be available to provide financial support to homeowners. A subsequent technical memorandum (TM02) will evaluate affordability issues.

ES.2 Summary of Funding Mechanisms

There are several challenges associated with identifying viable funding mechanisms for Hawaiʻi's cesspool conversion program. First, and likely the most important, is the magnitude of the potential total amount of financing that the program may require. It is estimated that the total cost of the cesspool conversions within the state may range from $880 million to more than $5.3 billion[1]. While there are low interest loan and grant funding opportunities from federal, state, and local financing sources, all of these combined fall significantly short of that required to fully fund all conversions. In addition, most of the financing programs are available only to government entities such as the state or counties, or non-profit organizations, and are not targeted to private, residential property owners. This is further complicated by the fact that the state and the counties do not currently have the staff or the administrative capabilities to receive grant or loan funds, review and process individual applications, disperse the funds to homeowners, and, in the case of loans, conduct follow-up payment collection. Lastly, most of these financing programs provide a reimbursement for incurred cost,

[1] Historical cesspool replacement costs range from $9,000 to $60,000 per conversion. The range shown is for conversion of all 88,000 cesspools in Hawaiʻi.

requiring the individual homeowners to first pay upfront the cost associated with planning, design, and construction of the new OSWT system, and then be reimbursed.

Due to the varying demographics, socio economics, implementation timeline, and geographical terrain, there is not a "one size fits all solution" for both the conversion technology as well as the financing mechanism across all counties in Hawaiʻi. As a result, financing mechanisms implemented for the cesspool upgrades will need to:

1. Consider equitability and affordability issues.
2. Incentivize individual homeowners to convert existing cesspools.
3. Provide funding support for upfront cesspool conversion costs.
4. Consider the funding recipient.
5. Balance the need for immediate, near-, and long-term expenditures.
6. Potentially fund a variety of OSWT technology options.
7. Minimize the administrative burden on Department of Health (DOH) while providing support to existing or new local agencies.

Key to the successful implementation of the program will be to identify or develop a mechanism that can funnel federal and state funding or incentives to the individual homeowner through the DOH or other organizations, such as the counties, non-profits, or financial institutions. The financing program will necessitate additional funding for state and/or local government to administer the program and will likely consist of a mixture of funding options. This may include incentives (e.g. tax credits or rebates), existing federal and state grants/low interest loans, and/or the establishment of a state or county financing program (including funding legislation) targeted at individual cesspool conversions.

ES.2.1 Financing Options

Financing options may include tax credits or rebates, federal, state, or county grants, and private/mortgage loans. A notable difference between grants and loans are that grants do not need to be repaid, while loans are borrowed funds that need to be repaid, typically with interest. These financing options are summarized below.

ES.2.1.1 Private/Mortgage Loans

A subsequent TM will evaluate the relative affordability of cesspool conversions. It will be a challenge and likely infeasible for financial support to be provided to all cesspool owners. Thus, it will be necessary for homeowners to seek private or mortgage loans to pay for the cost of cesspool conversions. Given the economic turmoil caused by the global pandemic (COVID-19) in 2020, the current, low interest rates provided by private lending options may be an economical option for some residents.

ES.2.1.2 State Tax Credits or Rebate Programs

The state of Hawaiʻi's temporary tax credit program (Act 120), which provides up to $10,000 in incentives for individual homeowners to convert cesspools to septic systems or ATUs, is set to expire on December 31, 2020. Legislation which would extend the term of the credits did not pass in 2020. Given that only 47 applications have been filed for this credit to date, this incentive with its current structure, may have limited appeal and application and there may be a need to re-evaluate the tax credit mechanism to identify opportunities to make the program more enticing. A rebate program may have broader appeal and applicability for cesspool conversions.

ES.2.1.3 Grants and Loans

Federal, state, and local grant and loan funding sources should also be considered as potential funding mechanisms. While these sources do not provide a long-term solution for financing cesspool upgrades, they can help with the implementation of portions of the program. While most programs require a public entity or agency as the applicant, there are mechanisms by which money is secured by a public entity, non-profit, or financial institution who act as the broker to make sub-loans to individual homeowners for the cesspool upgrades. Funding agencies with potential financing mechanisms identified in this TM include:

- United States Environmental Protection Agency (EPA)
- United States Department of Interior, Bureau of Reclamation (USBR)
- United States Department of Agriculture (USDA)
- United States Department of Housing and Urban Development (HUD)
- United States Department of Commerce - Economic Development Administration (EDA)
- State of Hawaiʻi - Non-Point Source (319) (NPS) Grants
- State of Hawaiʻi Rural Community Assistance Corporation (RCAC)
- State of Hawaiʻi Rural Water Association
- Proposed – Hawaiʻi Cesspool Remediation and Conversion Loan Program

ES.2.1.4 Potential CWSRF Funding Mechanisms

There may be opportunities within the state of Hawaiʻi's Clean Water State Revolving Fund (CWSRF) program for non-profits or public entities to pursue funding or to create a pilot program to provide loans or grants to residential homeowners.

The CWSRF program provides low interest loans for a wide range of water quality infrastructure projects. Loans to finance non-point source projects can be provided through several funding mechanisms, depending on type of project, repayment source, and on agreement by the state program. Per statute, CWSRF funding can only be provided to public entities, however the state's CWSRF program can funnel funding to individual or private entities via the counties, other federal/state agencies, non-profits, or financial institutions. Typically, funding is provided by the state or the CWSRF program to a local intermediary agency that is then fiscally responsible for the loan and the overall loan administration, thereby reducing the burden on the CWSRF staff. Cesspool financing programs in other states, have been funded with CWSRF funds, EPA grants, state bonds, legislative funding or other state funding sources. Mechanisms that have been utilized successfully include: Conduit Lending (Pass Through), Linked Deposits, Sub-state Revolving Funding, and Direct Loans.

It is estimated that $5 million per year is the maximum financing that can currently be obtained through the CWSRF program. This level of funding represents less than 10 percent of the average annual cost of all conversions over the 30-year period.

ES.3 Lessons from Cesspools Funding Mechanisms in Other States

Cesspool conversion mechanisms used in ten other states were reviewed with the focus on those with programs funding the replacement of cesspools with OSWT systems. These states incentivized individual residential or commercial owners to convert failing systems by providing financial support to defray the costs associated with the implementation of the new technology. Some key "lessons learned" from other programs include:

- Financial Programs:
  - Eight states have created robust financial programs which provide low to no interest loans and incentives to ease the high cost of upgrading cesspools to alternative, innovative, and emerging (AIE) technologies.
  - The states of New York, Maryland, and Rhode Island offer grants and low interest loans to individual homeowners.
  - Massachusetts provides an ongoing tax credit program as an incentive.
  - Texas provides competitive grants to support applied research of OSWT systems, which is funded from a fee collected for each permit issued.
  - In most states, homeowners are required to upgrade the OSWT system upon sale or property transfer.
- Funding Mechanisms for Cesspool Conversion Financing Programs:
  - Cesspool financing programs were funded through EPA, CWSRF or state funds, with CWSRF funding being the primary source.
    - The primary CWSRF mechanisms utilized to fund individual homeowner programs were Conduit Lending or Linked Deposits.
    - Most CWSRF programs utilize a pass-through entity (e.g. county, local governing body, financial institution or approved non-profit) to administer the loans from loan application to loan repayment.
    - The pass-through entity was ultimately responsible for the loan repayment to the CWSRF program but had mechanisms established to recover loans if there was a default.
  - Maryland's Bay Restoration Fund is unique in that they charge an annual user fee to OSWT systems and a monthly sewer connection fee to cover the program administration and grant costs.
- Program Administration:
  - Several programs have established partnerships with non-profits, counties, or financial institutions to serve as the conduit agency responsible for the administrative loan activities, thereby reducing the administrative burden on the states' CWSRF program.
  - The long timeline for program implementation also required that states establish a sustainable financing mechanism including sources and revenue streams to cover program administration and other costs. Most programs recovered costs through the interest rate on the loan; one program utilized state funds to cover the administrative costs of the program.
- Eligible Project Costs
  - Eligible project costs include converting failing or existing cesspool systems or connecting to sewer systems.
  - Eligible costs include planning, design, implementation/construction, and permit costs.
  - Funding was not applicable to new developments.
- Project Eligibility Criteria
  - All programs required that the applicant have good standing credit and that the loan be secured by a mortgage lien or some other similar mechanism. Two programs provided alternative funding for applicants who could not qualify due to credit issues.
  - Individual homeowners were required to secure approval of proposed AIE technology and design prior to start of construction in order to be eligible to receive financing. Approval was typically provided by the county or local permitting agency.

  - Most programs did not have an income requirement; however, several provided incentives for disadvantaged communities (DACs), low income households, or the elderly.
- Program Funding:
  - Individual homeowner loans ranged from $1,000 to $35,000.
  - Interest rates ranged from no interest loan to low interest (3-6 percent) to individual homeowners.
  - Loan periods ranged from 10-20 years or the useful life of the system.
  - There was no pre-payment penalty for any program.
  - In several programs the homeowner was required to repay the loan upon sale or transfer of property.
- Disbursements:
  - Key issues included the timing of disbursements as well as method of disbursement.
  - The majority of programs required construction to be completed prior to the disbursement of funds, therefore homeowners were required to pay the project costs upfront and then be reimbursed.
  - Method of monetary disbursements varied with most programs directly compensating the homeowner. In two programs, the states directly compensated the contractor for construction costs.
  - Repayment mechanisms included monthly payments or annual line item in property tax bill.

Each state's cesspool conversion financing mechanism varies and is adapted to the individual state's demographics, technologies, and needs. However, there are lessons to be learned from each program as to what has worked and what has needed improvement. As the CCWG develops its recommended approach to financing the program, it is recommended that further outreach be conducted and vetting of identified state-wide funding mechanisms - especially programs in the states of Delaware, New York (Suffolk County), Washington, Maryland, and Massachusetts.

ES.4 Other Funding Models and Partnerships

In addition to evaluating cesspool funding mechanisms in other states, models used by other infrastructure systems were reviewed and are summarized in the following sections.

ES.4.1 On-Bill Financing Program – Example: Hawaiʻi Green Infrastructure Authority

Two funding models utilized in Hawaiʻi are on-bill financing and on-bill repayment programs. On-bill financing allows the electric utility (e.g., Hawaiian Electric, Maui Electric, or Hawaiian Electric Light), to incur the cost of a clean energy upgrade to a home, which is then repaid by the homeowner through their monthly utility bill. Upfront capital is provided by a third party, not the electric utility. In some on-bill repayment programs, the loan is transferable to the next owner of the home, building, or property. The idea of an on-bill financing program could be adapted to finance cesspool conversions with the assistance of county or local agencies (e.g. water or wastewater utilities) that could assist in the billing administration function similar to electric utilities.

An on-bill financing model that currently exists in Hawaiʻi is the Green Energy Money $aver On-bill (GEM$) program whose purpose is to deploy clean infrastructure. The program enables ratepayers to finance clean energy improvements through an on-bill financing model that spreads the initial capital costs of installing green infrastructure of up to 20 years, thus providing an affordable way to invest in green infrastructure that will reduce monthly energy costs.

ES.4.2 Property Assessments – Example: Property Assessed Clean Energy Program

Another energy-based funding model that could be adapted to finance cesspool conversions is the Property Assessed Clean Energy (PACE) program. This is a mechanism used by local governments to allow property owners to finance the up-front cost of energy efficiency and renewable energy improvements (such as solar) and then pay the costs back over time through a voluntary assessment. A PACE program could be modified as a viable financing option for cesspool conversion to allow a property owner to pay back the costs of their cesspool remediation over time at an agreed upon interest rate and length of loan term. Funding would occur through private lenders, e.g., private banks, or the issuance of municipal bonds.

ES.4.3 Property Assessments – Example: Community Facilities District and Special Improvement Districts

The use of Community Facilities Districts (CFDs) or Special Improvement Districts (SIDs), which are independent, local special-purpose financing districts that levy taxes and assessments and issue bonds to provide infrastructure to develop communities of all types, could be another mechanism by which to fund cesspool conversions. An improvement district specifically created to address the EPA's requirement to close large-capacity cesspools is the Lono Kona Sewer Improvement District (ID) in North Kona in the County of Hawaiʻi. This ID funds the connection of 110 parcels to the county wastewater system. A similar funding mechanism could be applied to the funding of on-site treatment systems for a subdivision of current cesspool owners.

ES.4.4 Public Private Partnerships

Another potential funding mechanism is the development of Public-Private Partnerships (P3s) that encourage private investment in public infrastructure projects. P3s are contractual arrangements in which governments or public entities form partnerships with the private sector to design, finance, build, and operate and/or maintain infrastructure such as toll roads, water supply facilities, and wastewater treatment plants. Public agencies are in charge of financing and theoretically pass all the risks related to operating costs and project revenues to the private partner. However, P3s also have some negatives including local opposition,, loss of public control and flexibility, potential need for in-house expertise or outside consultants, complicated contracts and complex negotiations, as well as significant effort to enforce and monitor contracts.

ES.5 Legislative Efforts

Legislative efforts, both at the state and county levels, may help to address cesspool conversion funding options. Political coordination on legislative efforts would help provide consistent and clear messaging to stakeholders and decision makers. This will be particularly important with economic recovery plans during and following the COVID-19 pandemic.

ES.6 Recommendations and Next Steps

Financing options for the cesspool conversions to approved OSWT systems will likely be comprised of a hybrid of financing options depending on several factors including: affordability, overall cesspool identification and prioritization, cost of preferred technologies, funding recipient (individual versus a subdivision versus homeowners' association), financing sources/restrictions, available staffing resources, stakeholder feedback, and other factors that still need to be identified and assessed.

Identification of stable revenue sources will be helpful to fund the cesspool conversion program. Potential revenue sources may include:

- Developer fees.

- Nutrient impact fees.
- Permit fees.
- Property taxes.
- Recreational or license fees.
- Resort taxes/fees.
- General excise tax.
- Special assessments.
- User fees.

The next steps in the initial evaluation of potential funding mechanisms that are within the scope of this study includes:

1. Evaluate affordability issues as well as the equitable distribution of funds (TM02).
2. Present funding options to DOH to solicit input, identify preliminary list of preferred financing mechanism, and identify considerations/concerns.

Recommendations and potential next steps to support cesspool conversions include:

1. Coordination of legislative efforts, such as:
    a. Extension of Act 120 tax credits beyond 2020 or creation of a potential rebate program.
    b. Creation of legislation to require that cesspools are disclosed as part of real estate property inspections/transactions.
    c. Evaluation of legislation for establishment and funding of a cesspool conversion financing program.
    d. Evaluation of potential federal legislative actions.
2. Work towards the identification of potential viable financial mechanism through the following actions:
    a. Conduct additional research into preferred options identified by the CCWG.
    b. Outreach to federal and state funding programs to confirm applicability and program requirements, timing, etc.
    c. Follow-up with financing programs to discuss program details to understand the "nuts and bolts" of the programs. As well as identify lessons learned, successes and failures, and what program elements could work in Hawaiʻi.
3. Identify and contact potential agencies, non-profits and financial institutions within the state to determine technical expertise, ability and willingness to conduct administrative activities, what financial mechanisms they could help implement, and other functions they can perform.
4. Conduct discussions with DOH, private lenders, CWSRF, counties, HUD, USDA, and other identified agencies/non-profits to assess and understand available resources (staff/financial), technical expertise, level of engagement/responsibility desired, and resource requirements.
5. Link preferred funding options to affordability and equitability distribution considerations to provide a complete picture of options and affordability mitigation measures.
6. Work with public outreach subgroup to develop strategies for presenting technology and financing options to groups of affected cesspool owners to solicit input.

Technical Memorandum 1

CESSPOOL CONVERSION FUNDING MECHANISMS

1.1 Introduction & Background

The 2004 *Clean Watersheds Needs Survey Report to Congress* found that in the state of Hawaiʻi, 62 percent of the residents are served by centralized wastewater treatment facilities and the remaining 38 percent are served by decentralized or OSWT systems. There are approximately 110,000 OSWT systems, including 88,000 cesspools and over 21,000 septic systems in Hawaiʻi. A cesspool is defined by the EPA as an underground excavation that receives sanitary wastewater from bathrooms, kitchens, and washers. Cesspools are not designed to treat wastewater but rather capture solids. The structure usually has an open bottom and perforated sides. Domestic wastewater flows into the structure and the solid waste collects at the bottom and the liquid waste flows out to percolate into the subsurface that may be hydraulically connected to groundwater and surface water.

The majority of the cesspools in Hawaiʻi serve single-family, residential units and are spread out throughout the islands. Table 1.1 summarizes the estimated number of cesspools by island, as well as the estimated total wastewater discharge. Of these, 43,000 cesspools have been identified as posing a risk to the state's water resources of which 31,000 are located within the perennial watersheds on the islands of Hawaiʻi, Kauaʻi, Maui, and Molokaʻi.

Table 1.1 Estimate of Cesspools and Total Anticipated Discharge by Island(1)

Island	Housing Units	Number of Cesspools	Cesspool Effluent (mgd)
Hawaiʻi	82,000	49,300	27.3
Kauaʻi	29,800	13,700	9.5
Maui	65,200	12,200	7.9
Oʻahu	336,900	11,300	7.5
Molokaʻi	3,700	1,400	0.8
Total	**517,600**	**87,900**	**53.0**

Notes:
(1) Confirmation of the actual number of cesspools, locations, and priorities is being conducted under a separate task of the CCWG.

In total, these cesspools are estimated to discharge 53 mgd of untreated sewage to the groundwater system and coastal waters. Untreated wastewater from cesspools contain nutrients (nitrogen and phosphorous) and pathogens such as bacteria, protozoa and viruses which can have an impact on the quality of drinking water, general water quality, the health of the state's reefs and the health of Hawaiʻi's residents and visitors.

To incentivize "early adopter" cesspool conversion, the state of Hawaiʻi established a temporary tax credit program in 2016 (Act 120). Act 120 provided a $10,000 tax credit to homeowners for the upgrade of qualifying cesspools and is set to expire on December 31, 2020.

In 2017, the Hawaiʻi State Legislature passed Act 125, which states that by January 1, 2050 all cesspools in the state of Hawaiʻi, unless granted exemption, shall upgrade or convert to a septic system or aerobic treatment unit, or connect to a sewer system (ACT 125, 2017).

Act 132 was then passed in 2018 to establish the CCWG to develop a long range, comprehensive plan and commission a statewide study of sewage contamination in nearshore marine areas (ACT 132, 2018). Act 132 directed the DOH to evaluate residential cesspools in the state, develop a report to the legislature that includes a prioritization method for cesspool upgrades, and work with the Department of Taxation on possible funding mechanisms to reduce the financial burden on homeowners. The CCWG retained Carollo to provide expertise on OSWT technologies and cesspool conversion funding and finance options.

As a result of Act 125, homeowners will be required to upgrade their existing cesspools to more appropriate technologies. The CCWG recognized that the cost associated with the conversion of these onsite sewage disposal systems will be a significant financial burden to individual residential owners. One of the complex challenges tasked to the CCWG is to develop a strategy to aid the funding and financing of the cesspool upgrades.

Figure 1.1 shows a stepwise approach to guiding homeowners with cesspools through the conversion process. The CCWG and key advisors are developing the overall strategy to the cesspool conversion program, including public outreach, treatment technologies, data validation and prioritization, and finance research. The information on funding mechanisms provided in this TM is to support step #5 shown in Figure 1.1. However, there is a significant amount of strategy, planning, and coordination that will be completed by the CCWG and other over the next few years.

Figure 1.1 Stepwise Approach to Cesspool Conversions for Homeowners

It is estimated that the cost to convert a cesspool to an OSWT system (e.g. septic system or identified AIE technologies) ranges widely from $9,000 to $60,000 or more depending on system capacity, technology, location and size of dwelling unit–a cost that many homeowners cannot afford (Babcock, 2019). With 88,000 cesspools requiring upgrades, total upgrade costs could range between $880 million to more than $5.3 billion[2].

While there are low interest loan and grant funding opportunities from federal, state, and local financing sources, all of these sources combined fall significantly short of that required to fully fund all conversions. In addition, most of the financing programs are available only to government entities, such as state agencies or counties, and are not targeted to private, residential property owners. This is further complicated by the fact that state agencies and the counties do not currently have the staff or the administrative capabilities to receive grant or loan funds, review and process individual applications, disperse the funds to the homeowners, and, in the case of loans, conduct follow-up payment collection.

Motivating residents to implement the conversion of existing cesspools will be challenging. Despite the benefits of improving public health and the environment and the state mandates contained in Act 125, there are few financial incentives for homeowners to convert or upgrade their systems. The cost of cesspools is

[2] Historical cesspool replacement costs range from $9,000 to $60,000 per conversion. The range shown is for conversion of all 88,000 cesspools in Hawaiʻi.

low and there are minimal maintenance requirements. A major challenge to the successful conversion of the state's cesspools is the identification of individual residential incentives, as well as the identification of a funding mechanisms for the financing of both the capital expenditures and the long-term costs associated with the maintenance and management of OSWT systems and overall program administration. In addition to financial incentives, there is a need to identify and quantify the benefits (e.g. economic, environmental, water quality, etc.) to be gained from converting cesspools that can be communicated to individual homeowners to further incentivize the homeowners to convert.

1.1.1 Method of Cesspool Conversion and Funding Needs

There are generally three options for cesspool conversions including:

- **Connection to existing or new centralized sewer systems.** In the large municipal areas of Hawaiʻi, homes and businesses are connected to county or privately owned, sewer collection and treatment systems, where the wastewater flows to a centralized treatment facility for treatment and disposal. Centralized sewer collection and treatment systems are generally cost efficient because of economies of scale, treating the water either for discharge or for water reuse applications (e.g., golf course irrigation). However, there are significant capital investments required by counties or private developers, and connections to centralized systems may not be feasible for many cesspool conversions.
- **Connection to decentralized sewer systems.** Decentralized sewer systems (also "cluster" wastewater systems) are similar to centralized sewer systems, but typically have a smaller collection system service area and wastewater treatment facility. Decentralized treatment can range from passive treatment with soil dispersal to more sophisticated, mechanical treatment, such as membrane bioreactors. Within the rural portions of Hawaiʻi, which are extensive, the costs to excavate and construct long sewer systems from remote locations to a centralized treatment facility are substantial.
- **Conversion of cesspools to approved OSWT and disposal systems.** A 1999 survey conducted by DOH showed that approximately 19 percent of the households in Hawaiʻi had OSWT and disposal systems, including cesspools. Since many of the cesspools are located in rural areas without centralized wastewater systems, conversion to OSWT and disposal may be the most cost-effective option for some homeowners.

The focus of both the technology and finance research efforts are on technology and finance options for OSWT systems. Thus, this TM is focused on identifying funding mechanisms assuming existing cesspools will be upgraded to OSWT systems.

1.1.2 Purpose

The magnitude of the potential total amount of financing required for the conversions is a challenge and likely infeasible for financial support to be provided to all cesspool owners. The cost to convert all 88,000 cesspools by 2050 will require a consortium of financing solutions including self-financing, state and county incentives, individual loans from financial institutions, federal, state and local financing sources, and potentially establishing a cesspool financing program.

Federal, state, and local financing options, such as grants and low-interest loans were identified as a potential source of financing, however these programs are limited in their funding capacity, with program funding allocated amongst a variety of project types. There are other challenges for these programs including funding program purpose/priority which may limit the programs ability to fund cesspool conversions, other demands/needs on the program, the requirement for repayment, and most require a public entity be the recipient of the funding and are not targeted to private, residential property owners. Lastly, most of these financing programs provide a reimbursement for incurred cost, requiring the individual homeowners to first pay upfront the cost associated with planning, design, and construction of the approved OSWT system, and then being reimbursed.

The establishment of financing programs requires staff or the administrative capabilities to receive grant or loan funds, review and process individual applications, disperse the funds to homeowners, ensure implementation of projects and, in the case of loans, conduct follow-up payment collection. With a clearer understanding of the economic impacts to convert 88,000 cesspools, identification of responsibilities, and the affordability of these conversions, the CCWG should consider further the establishment of a financing program to incentivize homeowners to convert their system (e.g. financial assistance for planning, design and construction). The funding program must:

1. Be sustainable and address the required governance structure/institutional requirements.
2. Identify and provide mechanisms to fund the program (e.g. CWSRF, EPA, bonds, governmental bill, fees, etc.).
3. Provide equitable distribution of financing to homeowners considering priority, income level, etc.
4. Outline administrative requirements (e.g. DOH, county, other agency or a hybrid) governance, and financing provided.

Other states with similar mandates to convert cesspools have implemented programs with varying degrees of success. Successful implementation of these programs has required agency partnerships, participation of local cities/counties/other government entities to support program implementation/oversight, and allocation of dedicated funding sources. Where staffing resources are limited, some states have partnered with outside lending institutions for overall program administration, however, the interest rates are typically much higher. These financing programs are often complemented with other sources of funding including state incentives, other program financing, and individual resident financing.

The focus of this effort is on identifying potential funding sources and financing mechanisms that are available to private, residential OSWTs. There may be additional source of funding for centralized options or options sponsored by public entities. Funding options to connect to a county or private wastewater system are not included in the scope of this TM. However, a summary of traditional funding mechanisms typically applied to decentralized or centralized sewer options is provided in the following section. Other treatment options will have differing financing mechanisms due to the nature of the borrower, especially if it is a public entity. One of the major challenges in financing the conversion of cesspools will be balancing affordability impacts. The topic of affordability will be explored in a separate, forthcoming technical memorandum (TM02).

This TM also provides an assessment of financial mechanisms used in other states for the funding of cesspool conversion projects; summarizes potential federal and state funding programs, including state of Hawaiʻi funding options, that could be utilized to pay for cesspool conversions; provides a summary of recommendations; and identifies potential next steps.

1.2 Traditional Funding Mechanisms

There are two types of costs associated with cesspool conversions: 1) capital costs required to plan, design, and convert the cesspool to an OSWT system; and 2) re-occurring operational costs required to maintain, operate, and repair the new OSWT system. For projects that connect to centralized systems or decentralized systems, capital costs for the cesspool connection to a sewer or a decentralized system may be funded through a variety of sources that range from traditional funding options, such as revenues from internal user charges and bond financing, to non-traditional funding sources such as grants, low interest loans, and market-based programs. Operating revenues remaining after operating expenses and debt service obligations have been met can be a significant source of funding for capital expenses or placed in reserves for future projects. In addition, operation and maintenance costs are typically funded through user rates and other recurring annual sources of revenue. Mechanisms available to public utilities include:

- **Pay-as-you-go (PAYGO) financing —** Depending on an agency's existing capital reserves, it can potentially build up its financial capacity to fund expenditures in peak users. Funds are raised through upfront payment of project costs from revenues of existing and new users for future capital improvement projects. It is common for utilities to fund major capital expansions through other methods, particularly bond financing, to avoid the burden that PAYGO's high upfront cash requirement places on rate or reserve funds.
- **Debt financing —** acquisition of funds through borrowing mechanisms (e.g. debt issuance) which enable an agency to lessen the rate payer's upfront burden.
- **Grants and loans —** alternate sources of funds from public agencies at no or minimal interest cost. Examples include federal, state, and local programs that provide funding at zero interest for projects that meet select criteria.
- **Other Mechanisms —** refers to financing through funds obtained from tax credits, purchase agreements, voluntary programs, and trading and offset programs.

Appendix A includes a discussion of each of these mechanisms that traditionally fund centralized or decentralized wastewater treatment systems. Most of these traditional funding mechanisms cannot be used to finance individual residential conversion of cesspools to new OSWT and disposal systems for a variety of reasons including: project fit; eligibility of funding recipient (pubic vs private entity); lack of a dedicated revenue stream; administrative challenges; and state restrictions. However, two traditional mechanisms may potentially be applicable for OSWT systems include: 1) assessment district bonds (if an assessment district can be formed); and 2) federal and state grants and low interest loans (if a mechanism to funnel monies to individual homeowners is established).

1.3 Private Financing Options

It will be a challenge and likely infeasible for financial support to be provided to all cesspool owners for the conversions. Thus, it may be necessary for homeowners to seek private or mortgage loans to pay for the cost of cesspool conversions. There are several private financing options available to homeowners including: personal loans, home equity loans, or the use of personal savings. Given the economic turmoil caused by the global pandemic (COVID-19) in 2020, the current, low interest rates provided by private lending options may be an economical finance mechanism for some cesspool owners. Figure 1.2 shows the historical 30-year fixed rate mortgage interest rate in the United States from April 2, 1971 through July 2, 2020. The lowest interest rate on record is 3.07 percent as of July 2, 2020[3]. The gray shaded areas of the graph indicate U.S. recessions with the latest due to COVID-19. If mortgage rates remain relatively low (in the 3-4 percent range), private loan options are well within the low interest loan (0-6 percent) range of other financing options discussed later in this TM. As there is an increase in private financing options for cesspool conversions, financial institutions may consider developing a specific financing plan for conversions as well as a streamlined application process, as seen with the solar programs. Given the number of cesspools to be converted, financial institutions will need to consider the fiscal ability, as well as staffing needed to issue and manage private loans.

[3] https://fred.stlouisfed.org/series/MORTGAGE30US

Table 1.2 is a summary of the different types of private/mortgage loans that may be used by homeowners to finance their cesspool upgrade costs. The maximum loan amounts and interest rates are subject to change.

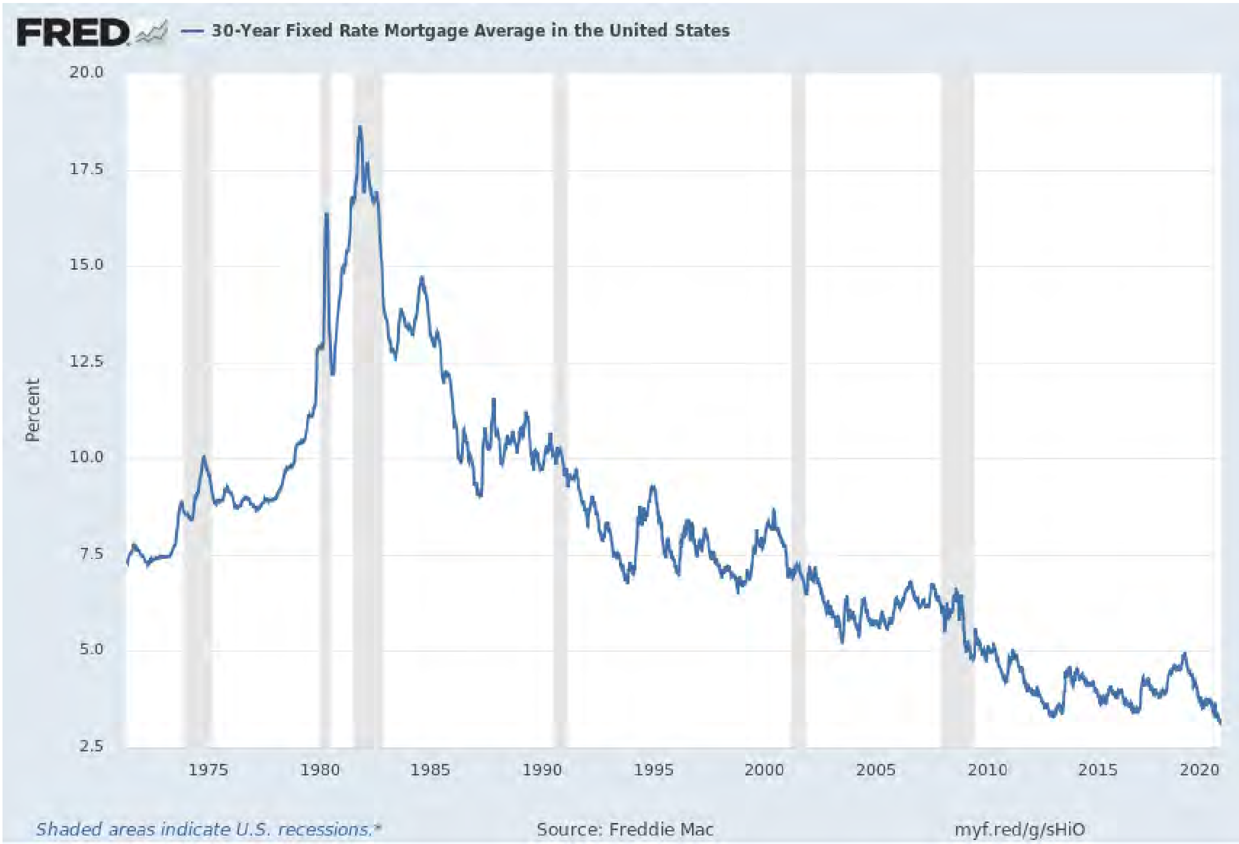

Figure 1.2 30-Year Fixed Rate Mortgage Average in the United States

Table 1.2 Summary of Private Lending Options

Loan Product	Borrowing Power	Notes
Federal Housing Administration (FHA) 203b – Cash out Refinance	Refinance Loan to Value 85%	Rates range from 3.25% - 4.0%
FHA 203K – Rehabilitation	Finance up to $35,000 in Home Rehabilitation	Rates range from 3.25% - 4.0%
FHA 247 – Cash out Refinance Hawaiian Homelands	Up to 85% with documented proposals for work	Rates range from 3.25% - 4.0%
U.S. Department of Housing and Urban Development (HUD) 184a – Cash out Refinance Hawaiian Homelands	Up to 85% no documentation required for proposed work	Rates range from 3.25% - 4.0%
RD- Refinance for Site Work	Restrictions such as income, County lending limits, and type of refinance	Rates range from 3.375% - 4.125%
Veterans Affairs (VA) – Cash out Refinance	Up to 100% of the value	Rates range from 3.25% - 4.0%

Loan Product	Borrowing Power	Notes
Fannie Mae/Freddie Mac – Conventional Cash out Refinance	Up to 80% of the value	Rates range from 3.50% - 4.25%
Lender's Portfolio Cash out Refinance	Up to 80% of the value	Rates range from 3.75% - 4.50%
Home Equity Line of Credit	Up to 85% of the value if a first mortgage is in place. Line Size varies	Interest only for a fixed period of 10 or 15 years with Introductory Rate offered for 2, 3, or 4 years. Rates range from 2.70% - 3.85% for the Introductory Period
Home Equity Loan	Up to 85% of the value if a first mortgage is in place. Line Size varies	Fixed Rate Loan Option Rate 4.50%
Personal Unsecured Loan	Amounts vary depending on Institutions offerings. $35,000 average loan size	Payment depends on Term 36 months with Rates ranging from 7.0% - 14.0% depending upon Credit Score
Personal Flex	Varies by Institution with Line Sizes up to $30,000	Rates range from 11.0% -14.0%
401K Loan	$30,000 - $50,000 with repayment being auto deducted from employee's payroll	Rates range from 4.25% - 5.25% with Loan Terms up to 5 years

1.4 Cesspool Funding Mechanisms in Other States

A review was conducted of funding mechanisms that have been successfully utilized in other states facing similar issues. The ten state programs reviewed were selected based on work previously authorized by the CCWG, identified program successes, as well as in coordination with the Cesspool Conversion Technologies Research. Information was gathered from publicly available, online resources for each state. While each state evaluated maintains websites with pertinent information, it is possible that some information is out of date.

Appendix B includes a discussion of each of the ten states and their funding programs. Table 1.3 summarizes the highlights of the cesspool conversion funding mechanisms of six of these states.

Table 1.3 Summary of State Programs

Program Feature	Delaware	Washington	Rhode Island	New York	Maryland	Massachusetts
Funding Mechanism	Direct Lending	Conduit Lending/Pass Through	Sub-State Revolving Loan	Conduit Lending/Pass Through	Credit and Linked Deposit	Pass Through Lending, Direct Loans and Tax Credits
Type of Financing Assistance Provided	Low Interest Loan	Low-Interest Loan	Low Interest Loans	Grant	Grants and Low Interest Loans	Low interest loans and Tax Credits
Funding Program(s)	• Septic Rehabilitation Loan Program (SRLP) • Septic Extended Funding Option (SEFO) (*if denied SRLP*)	• Local Loan Program (LLP) • Regional On-site Sewage System Loan Program (RLP)	• Community Septic System Loan Program (CSSLP) • Sewer Tie-in Loan Fund (STILF) • (0% interest loans for local sewer connection)	• Septic System Replacement Fund • Counties may have additional programs (e.g. Suffolk County provides an additional grant of $20,000 and low interest loans)	• Bay Restoration Fund (BRF) – Grant • Linked Deposit Program (LDP) – low interest loan	• Community Septic Management Program • Homeowner Septic Loan Program • Tax Credits
Funding Priority/Purpose	Both Programs: Repair or Replace of privately-owned decentralized wastewater treatment systems	• LLP: Repair or replace failing onsite sewage systems • RLP: Abandon septic and connect to sewer	Both Programs: Repair or replacement of substandard or failing septic systems or to replace cesspools with septic systems	Replacement of cesspool with a septic system; installation/ replacement/upgrade of a septic system; or installation of enhanced treatment technologies.	• BRF – WWTP Upgrades to the best available technology for nitrogen removal or to connect to existing public sewer • LDP – Low interest loans for capital improvements to reduce nutrient delivery to the Chesapeake Bay	• Community Septic Management Program Repair, replacement, or upgrade of failed septic systems or the connection to an existing sewer • Homeowner Septic Loan Program Home septic system repairs. • Tax Credits: Septic systems and cesspool upgrades and repairs after January 1997
Funding Source	• Both Programs: – CWSRF Funds – CWSRF Allocation (1% fee charged on CWSRF loans)	• Both Programs: – CWSRF (loan financing) – Centennial Clean Water Fund (administrative costs/loan losses and grants)	Rhode Island Infrastructure Bank (RI Bank) utilizes funds from recycled CWSRF loans	State of New York's State's Clean Water Infrastructure Act 2017 *(including $75 million for Septic System Replacement Fund)*	• BRF – Dedicated fund from Municipal Fees ($2.50 or $5/month); User Fees for OSWT ($60 annual fee) • LDP – Maryland DEP	• Community Septic Management Program CWSRF offers 0% interest via MA Water Pollution Abatement Trust. Trust then provides $5 million a year to municipalities • Homeowner Septic Loan Program Massachusetts DEP
Financial Responsibility	Department of Natural Resources and Environmental Control	• LLP: Program: County serves as Pass Through Entity • RLP: Craft 3	Municipal Agencies apply for a Lending Facility from the RI bank from which to make direct loans to homeowners	New York Environmental Facilities Corporation (EFC) provides funding to Counties/County Health Departments	LDP: Maryland DEP provides participating lender a below-market rate of interest agreement	• Community Septic Management Program Communities are responsible for loans • Homeowner Septic Loan Program Massachusetts DEP
Fund Administrator	First State Community Action Agency	• LLP: County or Local Health Department • RLP: Craft3	Rhode Island Housing and Mortgage Financing Corporation (RI Housing).	Counties/County Health Departments	• BRF: Maryland Water Quality Financing Administration • LDP: Financing Lender executes loans with individual entities and are responsible for administration of program including risk of default	• Community Septic Management Program Local board of Health to local homeowners through Betterment Agreement • Homeowner Septic Loan Program Massachusetts Housing Program

Program Feature	Delaware	Washington	Rhode Island	New York	Maryland	Massachusetts
Amount of Funding	• $1,000 to $35,000 (homeowner) • $250,000 (mobile home parks)	Loan can cover full cost of the conversion project	Maximum of $25,000	50% of cost or maximum of $10,000 per resident	• BRF: Grant of up to $20,000 per household • LDP: Pending financial institution	• Community Septic Management Program – $200,000 to communities to develop Community Inspection Plan/Septic Management Plan – $20,000 grant to first time communities for administrative costs • Homeowner Septic Loan Program $1,000 to $25,000 • Tax Credits: Commonwealth provides a tax credit of up to $6000 over 4 years
Eligibility Requirements	• Residential Owners • Low to moderate income households • Good financial standing/credit (no judgements, collections or serious delinquencies) • Not in bankruptcy • Debt: Income ratio greater than or equal to 41% • New construction on vacant lots are not eligible	• Residential and Commercial owners • New construction on vacant lots are not eligible	• Residential Owners and Non-owner Occupants – Prerequisite: – Approved On-Site Wastewater Management Plan – Municipality is on Project Priority List – Certificate of Approval • Debt: Income ratio greater than or equal to 45% • New construction on vacant lots are not eligible	• Located in participating county/ within a priority geographic area. • Single family, two family and small businesses (design sewage flow < 1,000 gallons per day (gpd) and seasonal or secondary homes may be eligible. • Cannot have any outstanding or open real property tax liens. • New construction on vacant lots are not eligible	• Residential Owners • Credit worthiness of application per lenders underwriting criterion. • New construction on vacant lots are not eligible	• Community Septic Management Program Project on a community's priority list – Prioritized based on environmental/public health impacts, income and funding needs. • Homeowner Septic Loan Program Residential owner with up to 4 family homes
Secured by	Mortgage lien on property	Upon transfer or sale of property, loan to be repaid or transferred to new owner.	Mortgage lien on property	N/A	Bank assumes all risk of default/State and MDE is not liable to reimburse bank for loses or expenses associated with program	• Betterment Agreement with homeowner • Municipal lien on property if default

Program Feature	Delaware	Washington	Rhode Island	New York	Maryland	Massachusetts
Financial Loan Terms	• SRLP: • 20 years loan term • Interest ranges 3%-6% (based on income) • SEFO • 20-year loan • 0% interest rate • No monthly payments.	• 15-year loan term • Interest rate 1.99%-4.99% • Payment options include: No monthly payment, monthly interest only or monthly principal plus interest (based on income and occupancy)	• 10-year loan term • $300 loan origination fee • 1% annual serving fee on outstanding balance	• Grants provided on a reimbursement basis • Property owners are initially responsible for the total cost of their septic system project.	• BRF: – Grants provided on a reimbursement basis – Property owners are initially responsible for the total cost of their septic system project. • LDP: – Terms based on financial lending agency requirements. – Lending institution passes the below-market rate of interest to the borrower; may add fees to cover costs	• Community Septic Management Program – Interest rate ranges between 3% -5% based on affordability – 15-20-year loan term – Repaid through the Community's tax collection (property tax bill line item) – If the property is sold, the payments is assumable by the buyer of a property. • Homeowner Septic Loan Program – 3-20-year loan – Interest rates between 3%-5% based on family size, income and market area. – Min. monthly payment is $27 – Due in full upon sale, transfer or refinancing of the first mortgage
Pre-Payment Penalty	No	No	No	No	No	No
Reimbursement Program	Yes	Yes	Yes	Yes	Yes	Yes
Eligible Costs	Site evaluations, design, permits, impact and connection fees, electrical construction costs, abandonment of septic systems and closing/ recording costs.	Design, permitting, installation of new septic system, maintenance and reserve for ongoing inspections and repairs.	Engineering and system replacement costs	Engineering, construction and system costs	Capital facility, user connection, master plumbing charges, and the purchase of cost-effective nitrogen, phosphorus, or sediment loading reductions	Engineering, Construction and System Costs
Income Requirement	Moderate to low income homeowners,	• No income restrictions • Favorable rates/terms for lower income households	No income restrictions	No income restrictions	• BRF: No income restrictions • LDP: No income restrictions	• Community Septic Management Program No income restrictions • Homeowner Septic Loan Program No income restrictions

1.4.1 Summary/Findings

Recognizing that many residents could not afford to pay for the cost associated with the conversion of individual cesspools, other states have established financing mechanisms to incentivize residents to convert. The states reviewed utilized similar funding mechanisms; however the state programs are tailored to address specific demographic, geography, and selected OSWT systems, thereby helping to achieve the state's program goals. Some programs had greater success than others, and many developed programs in consideration of the successes and lessons learned from other state programs. Key take a ways from other financing programs include:

- Financial Programs:
  - Eight states have created robust financial programs which provide low to no interest loans and incentives to ease the high cost of upgrading cesspools to AIE technologies.
  - The states of New York, Maryland, and Rhode Island offer grants and low interest loans to individual homeowners.
  - Massachusetts provides an ongoing tax credit program as an incentive.
  - Texas provides competitive grants to support applied research of OSWT systems, which is funded from a fee collected for each permit issued.
  - In most states, homeowners are required to upgrade the OSWT system upon sale or property transfer.
- Funding Mechanisms for Cesspool Conversion Financing Programs:
  - Cesspool financing programs were funded through EPA, CWSRF or state funds, with CWSRF funding being the primary source.
    - The primary CWSRF mechanisms utilized to fund individual homeowner programs were Conduit Lending or Linked Deposits.
    - Most CWSRF programs utilize a pass-through entity (e.g. county, local governing body, financial institution or approved non-profit) to administer the loans from loan application to loan repayment.
  - The pass-through entity was ultimately responsible for the loan repayment to the CWSRF program but had mechanisms established to recover loans if there was a default.
  - Maryland's Bay Restoration Fund is unique in that they charge an annual user fee to OSWT systems and a monthly sewer connection fee to cover the program administration and grant costs.
- Program Administration:
  - Several programs have established partnerships with non-profits, counties, or financial institutions to serve as the conduit agency responsible for the administrative loan activities, thereby reducing the administrative burden on the states' CWSRF program.
  - The long timeline for program implementation also required that states establish a sustainable financing mechanism including sources and revenue streams to cover program administration and other costs. Most programs recovered costs through the interest rate on the loan; one program utilized state funds to cover the administrative costs of the program.
- Eligible Project Costs
  - Eligible project costs include converting failing or existing cesspool systems or connecting to sewer systems.
  - Eligible costs include planning, design, implementation/construction, and permit costs.
  - Funding was not applicable to new developments.

- Project Eligibility Criteria
  - All programs required that the applicant have good standing credit and that the loan be secured by a mortgage lien or some other similar mechanism. Two programs provided alternative funding for applicants who could not qualify due to credit issues.
  - Individual homeowners were required to secure approval of proposed AIE technology and design prior to start of construction in order to be eligible to receive financing. Approval was typically provided by the county or local permitting agency.
  - Most programs did not have an income requirement; however, several provided incentives for disadvantaged communities (DACs), low income households, or the elderly.
- Programs Funding:
  - Individual homeowner loans ranged from $1,000 to $35,000.
  - Interest rates ranged from no interest loan to low interest (3-6 percent) to individual homeowners.
  - Loan period ranged from 10-20 years or the useful life of the system.
  - There was no pre-payment penalty for any program.
  - In several programs the homeowner was required to repay the loan upon sale or transfer of property.
- Disbursements:
  - Key issues included the timing of disbursements as well as method of disbursement.
  - The majority of programs required construction to be completed prior to the disbursement of funds, therefore homeowners were required to pay the project costs upfront and then be reimbursed.
  - Method of monetary disbursements varied with most programs directly compensating the homeowner. In two programs, the states directly compensated the contractor for construction costs.
  - Repayment mechanisms included monthly payments or annual line item in property tax bill.

As the CCWG develops the recommended financing approach to the cesspool conversion program, it is recommended that the further outreach and vetting be conducted of identified state-wide funding mechanisms - especially programs in the states of Delaware, New York (Suffolk County), Washington, Maryland, and Massachusetts.

1.5 Federal and State Low Interest Loans and Grants for Cesspool Conversions

Available federal, state, and local funding sources should be considered as potential funding mechanisms to help reduce the overall costs on individual homeowners in the near-term. However, it is important to recognize that with federal and state budget constraints and an overall increased interest in grants and low interest loan programs, sources of low interest loan financing and grant funding are limited and/or are more competitive to secure especially for non-point source projects.

Larger funding programs generally provide some of the best opportunities to obtain sources of funding (e.g. Water Infrastructure Finance and Innovation Act [WIFIA], CWSRF, USDA, etc.). While these programs provide relatively large sources of grant funding, there are limitations. There are numerous factors that should be considered in the pursuit of low interest loan and grant funding, including:

- **Project Specific.** Most programs target a specific type of project or purpose. For a project to be competitive, it needs to meet the intent of the program.
- **Funding Recipient.** Most federal and state programs require that the funding recipient be a public entity or in some cases a qualified non-profit. *For the cesspool conversions, this may require*

partnerships or public entities serving as a conduit agency (resulting in associated increased administration costs) to funnel funding to private homeowners.

- **Established Application Timelines.** Application timing is critical for most grant and loan programs. While some funding agencies accept applications on a rolling basis, many have prescribed submission dates. Grant tracking is critical to align an agency for a funding program.
- **Project Readiness.** Availability of shovel-ready projects is a key consideration for several programs. For example, potential COVID-19 stimulus monies are anticipated to prioritize projects that are ready to be implemented and help kick start the economy.
- **Funding Restrictions.** Most programs do not allow for the retroactive funding of design and construction work, and some programs will only fund activities that are conducted post project approval. *For the cesspool conversions, this may be a consideration for DOH to ensure the technologies that are implemented comply with state performance requirements.*
- **Does not cover the full cost of the project.** Most funding programs do not cover the full cost of the project, requiring the sponsoring entity or funding recipient to provide a minimum cost share ranging from 50-60 percent of the eligible project costs. *This may be another challenge to the conversion of cesspools, as many residents may not even have the financing to cover a portion of the project costs.*
- **Funding award is NOT a promise of grant reimbursement.** Most loans and grants are reimbursements and not cash up front. *This requires that the funding recipient has a source of funding available for the construction of the project, and may be a significant hurdle to cesspool conversions in Hawaiʻi.*

1.5.1 Potential Grant and Loan Funding Sources for Hawaiʻi

Current funding options for cesspool conversions for individual homeowners or groups of homeowners are limited and typically consist of property assessments, tax credits, and low-interest loans and grants from various federal, state, and community-based agencies. The following is a summary of federal, state, and county funding options that can be used to fund cesspool conversion projects, but many require a public entity be the primary applicant. Appendix C includes a discussion of each of the federal and state programs presented below. Table 1.4 provides a summary of the key aspects of each of the funding programs.

Table 1.4 Summary of the Federal, State and Local Funding Programs, Models and Initiatives to Consider for the Conversion of Cesspools

Program	Agency	Type	Description
Federal Funding Programs			
Clean Water State Revolving Fund Program (CWSRF)	EPA	Low Interest Loan	CWSRF program is a federal-state partnership that provides communities with a source of low-cost financing for the construction, repair and rehabilitation or replacement of decentralized wastewater treatment systems. There are mechanisms by which the CWSRF funding can be funneled to individual residential owners for cesspool conversions. The state of Hawaiʻi's CWSRF program details are provided below under State Funding Programs. *Program provides a reimbursement for costs incurred. Requires applicant to provide initial outlay of cash for project.*
Water Infrastructure Finance and Innovation Act (WIFIA)	EPA	Low Interest Loan	Financing mechanism for large water/wastewater/infrastructure projects • Project cost > $20 million or $5 million for small community projects (25,000 of fewer) • Eligible projects include a single project, combination of projects or program of projects. • Eligible costs include planning, design and construction activities. • Provides for up to 49% of the project costs ; 51% to be provided by applicant (funds can include entity financing, bonds, SRF, grant, etc.) • Total amount of federal funding <80% • Single Fixed Rate established at loan closing (rate of securities of a similar maturity + basis point (0.01%)) • Loan term is 30 years (or useful life of project). • Payments can be deferred 5 years • Reserve requirement – 1-year repayment • Customized repayment schedule • Application fees apply (average $300,000-$500,000) • Compliance with federal requirements (National Environmental Policy Act [NEPA], AIS, Davis Bacon, etc.) • Project completion in 5 (preferred). *Program provides a reimbursement for costs incurred. Requires applicant to provide initial outlay of cash for project.*
Non-Point Source (NPS) Section 319 Program	EPA	Grants	Grants to states to control NPS from variety of sources including agricultural runoff, mining activities, and onsite septic systems. States are required to use 50% of their allocation for watershed projects, and the remaining funds can be used for non-point source projects including cesspools. In Hawaiʻi, the NPS grants administered through Hawaiʻi's Clean Water Branch Polluted Runoff Control Program (319 Grant Program). • For implementation projects that control polluted runoff and improve water quality; Projects typically implement a component of a Watershed Management Plan, TMDL or action plan. • Recipient may include counties, educational institutions, state agencies, non-profit entities, watershed groups, for profit organizations and environmental groups. • Program funding varies by year ($600,000 for FY 2018) • Grant match requirement 25% non-federal match • No limit on award. • Prefer projects to be completed with 36 months of NTP. *Program provides a reimbursement for costs incurred. Requires applicant to provide initial outlay of cash for project.*

Program	Agency	Type	Description
Title XVI/WIIN Water Reclamation and Reuse	USBR	Grant	• Eligible projects include recycled water feasibility, demonstration, and construction projects. • Provides 25% construction costs • Maximum grant limit of $20 million. • Requires Congressional Authorization • USBR approved feasibility study, • Comply with NEPA, • Demonstrate the ability to pay the remainder of the construction costs. *Program provides a reimbursement for costs incurred. Requires applicant to provide initial outlay of cash for project.*
Drought Resiliency Projects	USBR	Grant	• Funding is for implementation projects building long-term resiliency to drought. • Types of projects include moving pipelines, small recycling, storage reservoir construction, and projects that increase flexibility in drought. • Two Funding: Group 1 $300,000 (complete in 2 years); Group 2 $750,000 (complete in 3 years). • 50% cost share requirement. *Program provides a reimbursement for costs incurred. Requires applicant to provide initial outlay of cash for project.*
WaterSMART Small-Scale Water Efficiency Projects	USBR	Grant	• Eligible projects include small on the ground implementation projects (such as canal lining, supervisory control and data acquisition [SCADA], flumes, flow metering, turf irrigation) to support water planning. • The total project cost to be capped at $150,000. • 50 percent cost share. • Total Federal funding limit of $75,000. *Program provides a reimbursement for costs incurred. Requires applicant to provide initial outlay of cash for project.*
WaterSMART Water and Energy Efficiency Grants	USBR	Grant	• Eligible projects include projects that result in quantifiable and sustained water savings, increase renewable energy use and improve energy savings, and support broader water quality sustainability benefits. • Requires a 50% cost share. • Two funding limits: – $300,000 (typically for projects completed within a year). – Up to $1,000,000 (for projects to be completed in 3 years). *Program provides a reimbursement for costs incurred. Requires applicant to provide initial outlay of cash for project.*
Cooperative Watershed Management Program	USBR	Grant	**Watershed Group Development and Watershed Restoration Planning**: • Provides funding for the development of watershed groups, watershed restoration planning, and watershed management project design (Phase I). • Applicant must be a public entity. • Provides up to $50,000 per year for a period of up to two years (total of $100,000) with no non-Federal cost-share required. **Implementation of Watershed Management Projects**: • Provides cost-shared financial assistance to established watershed groups to implement watershed management projects. • Up to $300,000 per project. • Applicants must contribute at least 50% of the total project costs. *Programs provides a reimbursement for costs incurred. Requires applicant to provide initial outlay of cash for project.*

Program	Agency	Type	Description
Public Works and Economic Adjustment Assistance Programs	U.S. Department of Commerce - Economic Development Administration (EDA)	Grant	• Provides grants for public works projects, including wastewater and stormwater projects that promote economic development. • Provides a 50% percent match in funds up to $5 million based on the number of permanent jobs created by the proposed project (for every job created, the funding is $10,000). • Projects need to be completed within 5 years. *Program provides a reimbursement for costs incurred. Requires applicant to provide initial outlay of cash for project.*
Water and Waste Disposal Guaranteed Loans and Grants (water & sewer)	USDA Rural Development	Low Interest Loan	Predevelopment Planning Grants • Grant assistance to low-income communities for initial planning efforts. • Maximum grant amount of $30,000 or 75% of the predevelopment planning costs. • Requires a 25% cost share from applicant or third-party sources. Water and Waste Disposal Loan and Grant Program – • Direct loan/grant and loan guarantees for clean and reliable drinking water systems, sanitary sewage disposal, sanitary solid waste disposal, and stormwater drainage. • Eligible applicants: state/government entities, private non-profits and federally recognized tribes. • Populations of 10,000 or less. • 40-year loan term (maximum useful life of the facilities). • The interest rate is based on the need for the project and the median household income of the area to be served. *Program provides a reimbursement for costs incurred. Requires applicant to provide initial outlay of cash for project.*
Rural Housing Service Program	USDA Rural Development	Low Interest Loan	Provides assistance through home repair loans and grants to remove health and safety hazards or make a home accessible for household members. • Funds can be used to repair or replace septic systems and other health and safety hazards. • Loans are available up to $20,000 at a one percent fixed interest rate • Loan term is 20 years. • Seniors age 62 and older may be eligible for a loan and grant combination to make needed repairs and improvements. • The maximum lifetime grant amount is $7,500. • Must be located in a rural community and income <50% of median income. *Program provides a reimbursement for costs incurred. Requires applicant to provide initial outlay of cash for project.*
Rural Economic Development Loan and Grant Program	USDA Rural Development	Low Interest Loan and Grant	Provides zero-interest loans to local utilities to pass to local businesses for projects that will create and retain employment in rural areas. Grants of up to $300,000 are provided to the local utility which establishes a Revolving Loan Fund (RLF) from which loans are provided to local sponsors. • Funding for up to 80% of project costs. • Eligibility is based on household income < 50% of the area median income and located in a rural community. *Program provides a reimbursement for costs incurred. Requires applicant to provide initial outlay of cash for project.*
Rural Water Loan Fund (RWLF)	National Rural Water Assoc.	Loan *Provides reimbursement for incurred cost*	RWLF is a funding program specifically designed to meet the unique needs of small water and wastewater utilities. The RWLF was established through a grant from the USDA/RUS, and repaid funds used to replenish the fund and make new loans. • Provides low-cost loans for short-term repair costs, small capital projects, or pre-development costs associated with larger projects. • Loan amounts may not exceed $100,000 or 75% of total project cost, whichever is less. • Loan offers below market interest rate. • Maximum repayment period of 10 years. *Program provides a reimbursement for costs incurred. Requires applicant to provide initial outlay of cash for project.*

Program	Agency	Type	Description
CDBG Program	US Department of Housing and Urban Development	Grant	Entitlement and Non-Entitlement Grants: Program offers both entitlement and non-entitlement grants to low to moderate income communities to meet housing and community development needs including public facilities. Eligible activities include construction of public facilities and improvements, such as water and sewer facilities, and streets, public services, activities related to energy conservation and renewable resources, etc. Honolulu Field Office directly administers the CDBG Program for non-entitlement counties in the State of Hawaiʻi including Hawaiʻi, Kauaʻi and Maui. Section 108 Loan Guarantee Program - Provides CDBG https://www.hudexchange.info/programs/cdbg/recipients the ability to leverage their annual grant allocation to access low-cost, flexible financing for economic development, housing, public facility, and infrastructure projects. Communities can use Section 108 guaranteed loans to either finance specific projects or to launch loan funds to finance multiple projects over several years. The loan term is 20 years. *Programs provide a reimbursement for costs incurred. Requires applicant to provide initial outlay of cash for project.*
State Funding Programs			
State Income Tax Credit	State of Hawaiʻi Department of Health	Credit	A State income tax credit is available for upgrading to a septic system or aerobic treatment unit, or connecting to a sewer, • Qualified cesspools depending on their location. Qualified cesspools are cesspools that are: located within 200 feet of a shoreline, perennial stream or wetland, or within a source water assessment program area. • A taxpayer may apply for a tax credit up to $10,000 for the documented expenses of upgrading each qualified cesspool. • Tax credits are available for five years, starting in tax year 2016, January 1, 2016, and ends in tax year 2020, December 31, 2020. • $5,000,000 total cap on the credits available for each tax year. Legislation to extend the tax credit did not pass in 2020.
CWSRF	State Department of Health	Loan	Financing for the construction of water pollution control projects necessary to prevent contamination of groundwater and coastal water resources and to protect and promote the health, safety and welfare of the citizens of the State. Provides low interest loans to county and state agencies to construct point source and nonpoint source water pollution control projects. • Covers planning, design and construction activities. • Loan proceeds fund up to 80 percent of project costs and require a 20 percent non-federal match. • Loan term of 30 years. • Annual interest rate of 0.25 percent and semi-annual loan fee of 0.5%. • Green Project Reserve of 10 percent which is reserved to fund green infrastructure. FY 2019 set aside was approx. $1.23 million.
Hawaiʻi Cesspool Remediation and Conversion Loan Program *(proposed)*	State SB 221	Loan	Enacted in July 2019, this bill authorizes the wastewater departments of all counties to offer low-interest loans for the upgrade or conversion of cesspools in each county to aerobic treatment unit systems. The loan program shall include an on-bill financing option supported by funding from the water pollution control revolving fund.
Environmental Infrastructure Loan Program	Rural Community Assistance Corporation (RCAC)	Loan	• Eligible projects include water, wastewater, solid waste and storm water facilities that primarily serve lower-income rural communities. • Public agencies, tribal governments, and nonprofits in rural populations of 50,000 or less in Hawaiʻi are eligible to apply. • Feasibility, pre-development, and construction phases are eligible. • Max for construction funding is $3M. • 20 years repayment. • 5% interest for first 10 years.
Fresh Water Initiative	Hawaiʻi Community Foundation (HCF)	Grant	The Initiative is supported by a funding partnership of 10 funders and is designed to proactively address and resolve water supply issues. HCF is specifically interested in organizations proposing to build or expand their own capacity to: 1) Lead a network of water entities; 2) Lead implementation around water conservation; 3) Lead implementation around water recharge; and/or 4) Lead implementation around water reuse in the Hawaiian Islands.
Fresh Water Initiative	Ulupono Initiative (Ulupono)	Grant/Other	Ulupono typically focuses on several investments of $1 million to $3 million in key mission projects: food, energy and waste in Hawaiʻi. UI identifies key partners, leverage points and linkages to determine where the most impact can occur. The initiatives goal is to infuse investment capital, or grants, along with collaboration and guidance to help our partner organizations find success in achieving impact.

Program	Agency	Type	Description
Green Energy Money $aver (GEM$) On-Bill Program	State of Hawaiʻi Department of Business, Economic Development & Tourism (DBEDT) Hawaiʻi Green Infrastructure Authority	On-Bill Financing Program	The Hawaiʻi Green Infrastructure Authority (HGIA) was created by the Legislature to make renewable energy investments accessible and affordable to Hawaiʻi's consumers. HGIA was capitalized through the issuance of a Green Energy Market Securitization (GEMS) bond, an innovative municipal bond financed mechanism allowing the advance of the State's goal of achieving 100% renewable portfolio standard in the electric sector by 2045. Some of the programmatic areas of the HGIA program, especially related to the GEM$ program can be used should cesspool remediation financing move towards a similar billing program.
Property Assessed Clean Energy (PACE)	State/ County/ Local	Financing Assessment	PACE programs are used by local governments to allow property owners to finance energy efficiency and renewable energy improvements (such as solar) to pay for the up-front cost of energy or other eligible improvements on a property and then pay the costs back over time through a voluntary assessment. By enabling a PACE program, local governments can greatly facilitate a commercial or residential property owner's ability to bundle energy efficiency and renewable energy investments to make comprehensive upgrades to their properties. A PACE program could be modified as a viable financing option for consideration to allow a property owner to pay back the costs of their cesspool remediation over time at an agreed upon interest rate and length of loan terms. Funding would occur through private lenders such as private banks or the issuance of municipal bonds.
Community Facilities District (CFD) Special Improvement District (SID)	State/ County/ Local	Financing Assessment on property	CFDs or SIDs, are independent, local special-purpose financing districts that levy taxes and assessments and issue bonds to provide infrastructure to communities.
HB 2151, HD 1 Relating to Cesspool Conversion	Department of Health	Grant	*This proposal is current moving through the State legislature.* Establishes a cesspool compliance pilot grant project to assist low- and moderate-income property owners with the costs of upgrading or converting a cesspool. Applies to cesspools identified as failing by the Department of Health.
Water Quality Program	The Hanalei Initiative	Community Group	The Hanalei Initiative, a collective group of citizens working for the betterment of Hanalei and the North Shore. Water quality is one of the main focus areas: Through potential DOH grant funding and private capital, the Hanalei Initiative is exploring financing options for converting cesspools to aerobic system conversions that actually treat water on site.
Hanalei Cesspool Conversion	Hanalei Watershed Hui	Community Group	Program provides funding to help pay for the replacement of cesspools, with a nonpolluting Advanced Treatment Unit, for residents living between Waioli and Hanalei Rivers and have a cesspool.

1.5.2 Federal Funding

The following is a summary of federal grant and low interest loan programs that may be viable financing opportunities for the cesspool conversions.

1.5.2.1 Environmental Protection Agency

The following sections summarize the applicable funding mechanisms supported by the EPA.

Clean Water State Revolving Fund Programs

The CWSRF program, a federal-state partnership, provides communities with a source of low-cost financing for a wide range of water quality infrastructure projects. One of the CWSRF program eligibilities includes the ability to provide financial assistance for the construction, repair and rehabilitation or replacement of decentralized wastewater treatment systems. CWSRF funding can be provided to public entities, such as municipalities, county governments, and state agencies, private, and non-profit organizations.

Applicability/Considerations for Cesspool Conversions:

- *See discussion under section 1.5.3.*

Water Infrastructure Finance and Innovation Act

The WIFIA program accelerates investment in water and wastewater infrastructure by providing low interest financing for planning/design and construction of large dollar value projects. WIFIA works separately from, but in coordination with, the CWSRF programs in each state.

Applicability/Considerations for Cesspool Conversions:

- *The program is a viable funding mechanism for cesspool conversions.*
- *Applicant will need to be either the CWSRF program, a public entity, approved non-profit or a conduit agency to apply and disburse funds to individual homeowners.*
- *Program provides low-interest loans which will require repayment.*
- *Minimum project cost is $20 million for large communities or $5 million for small communities (population<25,000). This will require packing of cesspool conversion projects or may be more appropriate for financing decentralized systems.*
- *Funding program provides loans for up to 49 percent of projects costs, requiring the applicant to provide the match financing of 51 percent.*
- *Loan is issued as a disbursement for costs incurred, so will require homeowner to initially pay for the conversion.*
- *Requires compliance with federal and state requirements.*

Non-Point Source Section 319 Grants

Under section 319 of the Clean Water Act, EPA provides grants to states to control nonpoint sources (NPS) of pollution from a variety of sources such as agricultural runoff, mining activities, and malfunctioning onsite septic systems. In Hawaiʻi, NPS grants are administered through Hawaiʻi's Clean Water Branch Polluted Runoff Control Program (PRC), which is under DOH. In the *2015-2020 Hawaiʻi Nonpoint Source Management Plan*, cesspool wastewater was identified as a source of non-point source runoff impacting the state's resources and therefore may be eligible for NPS Grant funding.

Applicability/Considerations for Cesspool Conversions:

- *May be a viable funding mechanism for near-term cesspool conversions.*
- *Applicant would need to be either a public entity, approved non-profit or watershed group.*

- *Grant is issued as a disbursement for costs incurred, so will require homeowner to initially pay for the conversion.*

1.5.2.2 United States Department of Interior, Bureau of Reclamation

The USBR WaterSMART program provides cost shared financial assistance to states, tribes and local governments to help them plan and implement projects to increase water supply through investments to modernize existing infrastructure. WaterSMART funding opportunities include: Title XVI/Water Infrastructure Improvements for the Nation (WIIN) grants, Water and Energy Efficiency Grants, Drought Program, Basin Study, Desalination, and Cooperative Watershed Management Programs (CWMP). These programs were evaluated for applicability for the cesspool conversion project and do not appear to be feasible at this time as viable funding options, except for the CWMP.

United States Department of Interior, Bureau of Reclamation – Cooperative Watershed Management Program

Through the CWMP, Reclamation provides funding to watershed groups to encourage stakeholders to form local solutions to address water management needs. Funding is provided for the development of watershed groups, watershed restoration planning, and watershed management project design (Phase I). A second program, Implementation of Watershed Management Projects, provides funds to established watershed groups to implement watershed management projects that address critical water supply needs and water quality concerns. As part of Phase I activities, applicants may use funding to develop bylaws, a mission statement, complete stakeholder outreach, develop a watershed restoration plan, and watershed management project design.

Applicability/Considerations for Cesspool Conversions:

- *May be a viable program for the organization of watershed groups and the development of watershed management plans.*
- *Eligible applicants include states, Indians, tribes, local and special districts, local government agencies, and non-profit organizations.*
- *Grant is issued as a disbursement for costs incurred, so the watershed group will have to cover the expenditures and then be reimbursed.*

1.5.2.3 United States Department of Commerce – Economic Development Administration

Public Works and Economic Adjustment Assistance Programs

The EDA provides grants for public works projects provide grant funding for public works projects, including wastewater and stormwater projects that promote economic development, through its Public Works and Economic Adjustment Assistance Program. Financial support is provided for up to 50 percent in matching funds (up to $3 million) based on the number of permanent jobs created by the implementation of the proposed project.

Applicability/Considerations for Cesspool Conversions:

- *May be a viable program for the cesspool conversions if it can be demonstrated that the project will result in permanent job generations.*

1.5.2.4 United States Department of Agriculture

Water and Waste Disposal Loan and Grant Program

The USDA provides funding directed at low-income and or small water/wastewater utilities. USDA provides Predevelopment Planning Grants which assist low-income communities with the initial planning and development of applications required for USDA Development program. The Water and Waste Disposal Loan and Grant Program provides direct loan/grant and loan guarantees for clean and reliable drinking water systems, sanitary sewage disposal, sanitary solid waste disposal, and stormwater drainage.

Applicability/Considerations for Cesspool Conversions:

- *May be a viable funding mechanism for cesspool conversions in rural communities or towns (population of less than 10,000 people).*
  - *Applicants include most state and government entities, private non-profits, and federally recognized tribes.*
  - *Grant is a disbursement for costs incurred, so it will require homeowner to initially pay for the conversion.*

1.5.2.5 Rural Housing Services Program

The Rural Housing Service Program provides assistance through home repair loans and grants to remove health and safety hazards or make a home accessible for household members.

Applicability/Considerations for Cesspool Conversions:

- *Source may be a viable funding mechanism for rural areas to help cover planning costs associated with the cesspool conversions.*
  - *Eligibility requirement includes rural and towns with populations of 10,000 or less.*
  - *Program eligibility is based on household income that cannot exceed 50 percent of the area median income and the property must be located in a rural community.*
  - *Funds can cover all upfront and construction costs, including septic system designs, permits and installations.*
  - *Funding is a disbursement for costs incurred, so will require homeowner to initially pay for the conversion.*

1.5.2.6 Rural Economic Development Loan and Grant Program

The Rural Economic Development Loan and Grant program provides funding for rural projects through local utility organizations that support economic development. USDA provides zero-interest loans to local utilities which they, in turn, pass through to local businesses (ultimate recipients) for projects that will create and retain employment in rural areas.

Applicability/Considerations for Cesspool Conversions:

- *Program may be a viable funding mechanism for cesspool conversions in rural areas.*
  - *Program eligibility is based on household income that cannot exceed 50 percent of the area median income and the property must be located in a rural community.*
  - *Loan or grant is a disbursement for costs incurred, so will require homeowner to initially pay for the conversion.*

1.5.2.7 United States Department of Housing and Urban Development – Community Development Block Grants (CDBG)

The HUD awards discretionary funding through various programs including the CDBG program.

CDBG Non-Entitled Counties in Hawaiʻi Program

HUD administers the Non-Entitled CDBG Program in Hawaiʻi and allocates funds on a formula basis using population, poverty and housing overcrowding as a basis for allocating funds. The Non-Entitled CDBG Grants in Hawaiʻi offer a source of funding to benefit community needs in but not limited to economic development, housing rehabilitation, public facilities, and construction or installation for the benefit of low-to moderate-income persons. In Hawaiʻi, three counties qualify for this program - Hawaiʻi, Kauaʻi and Maui. Many of the programs are similar to that of the entitlement program with grants for community development activities directed at neighborhood revitalization, infrastructure, economic development and improved community facilities and services.

Applicability/Considerations for Cesspool Conversions:

- *Source maybe a viable funding mechanism for the conversion of cesspools if the three eligible counties agree to utilize all or a portion of their CDBG funds for this purpose.*
  - *Non-entitled communities are defined as cities with a population of less than 50,000 and counties with populations less than 200,000.*
  - *Requires a Consolidation Plan to the Honolulu office to be considered eligible.*
  - *Funding is a disbursement for costs incurred, so will require homeowner to initially pay for the conversion.*

Section 108 Loan Guarantee Program

Section 108 Loan Guarantee Program[4] provides CDBG recipients the ability to leverage their annual grant allocation to access low-cost, flexible financing for economic development, housing, public facility, and infrastructure projects. Communities can use Section 108 guaranteed loans to either finance specific projects or to launch loan funds to finance multiple projects including economic development, housing, public facilities, infrastructure, and other physical development projects, including improvements to increase resilience against natural disasters.

Applicability/Considerations for Cesspool Conversions:

- *Source may be a viable funding mechanism for the conversion of cesspools if the three eligible counties agree to utilize all or a portion of their CDBG funds for this purpose.*
- *Loan is a disbursement for costs incurred, so will require homeowner to initially pay for the conversion.*

1.5.3 State Funding Options

The following is a short discussion on several state grant and low interest loan programs that may be viable financing opportunities for the cesspool conversions. The focus of the funding options review was limited to those options available for individual homeowners or groups of homeowners to finance OSWT systems and typically consist of property assessments and low-interest loans and grants from various state and community-based agencies.

Hawaiʻi State Department of Health Clean Water State Revolving Fund Program

The CWSRF program is a federal-state partnership that provides communities with a source of low-cost financing for a wide range of water quality infrastructure projects. With the passage of the 2014 Water Resources Reform and Development Act (WRRDA) Amendments, the CWSRF program eligibilities were greatly expanded, including the ability of the program to provide assistance for the construction, and repair or replacement of decentralized wastewater treatment systems that treat municipal wastewater or domestic sewage. In addition, CWSRF funding can be provided to public entities, such as municipalities, county governments, and state agencies, and through various mechanisms funding can be provided to private and non-profit organizations.

[4] https://www.hudexchange.info/programs/cdbg/

The CWSRF loan assistance program has flexibility and can set the conditions for loan assistance, which can be exceptionally helpful in financing nontraditional eligibilities, such as cesspools, including:

- Loan maturities can range up to 30 years or useful life of the project.
- Repayment schedules can be structured to meet the needs of the borrower.
- Interest rates can vary from market rates to zero percent.
- Ability to provide lower interest rates to DACs.
- Repayment source does not have to be the project itself; any dedicated source of revenue can be used to repay a non-point source loan.

It is estimated that $5 million per year is the maximum financing that can currently be obtained through the CWSRF program for cesspool conversions. This level of funding represents less than 10 percent of the average annual cost of all cesspool conversions over the 30-year period. In addition, distribution of these funds to individual homeowners will place a significant burden on the DOH, which currently does not have the staff nor the administration capabilities to review and process individual applications, disperse the funds, and conduct follow-up payment collection. Additional support with funding and finance applications and management from counties, financial institutions, or non-profits may be required.

Applicability/Considerations for Cesspool Conversions:

- *The program is a viable funding mechanism for cesspool conversions; however, the administrative workload on CWSRF staff will need to be addressed.*
- *Applicant would need to be either a public entity, such as the counties, financial institution, approved non-profit, or other conduit agency to disburse funds to individual homeowners.*
- *Loan is issued as a disbursement for costs incurred, so will require homeowner to initially pay for the conversion.*
- *Requires compliance with federal and state requirements.*

Appendix D includes more information on potential CWSRF funding mechanisms for non-traditional projects.

Hawaiʻi Rural Community Assistance Corporation (RCAC)

RCAC provides low interest loan financing for feasibility, pre-development, and construction projects. Feasibility efforts are typically not more than $50,000 and a typical term is 1 year. Pre-development projects such as engineering, legal, and bond counsel efforts are typically not to exceed $350,000 and the term is 1 year. Maximum loans for construction funding are $3M. Loan terms are up to 20 years; 5 percent for the first 10 years and subject to change for longer term loans. Loan fees are 1 percent.

RCAC has funded water projects on Maui and Oʻahu.

Applicability/Considerations for Cesspool Conversions:

- *This a viable funding program for cesspool conversions for low income rural communities.*
- *Applicant would need to be a public agency, tribal governments, or nonprofits in Hawaiʻi.*
- *Individual homeowners will likely need to create SIDs to apply for this source of funding.*
- *Loan is issued as a disbursement for costs incurred, so will require homeowner to initially pay for the conversion.*

Hawaiʻi Rural Water Association (Rural Water Loan Fund)

This state association is a chapter of the Rural Water Association and provides funding to infrastructure projects targeted at replacing equipment, providing system upgrades and completion of small projects including energy efficiency, sustainability and disaster recovery projects.

Applicability/Considerations for Cesspool Conversions:

- *This a viable funding program for rural communities. However, individual homeowners will likely need to create a SID to apply for this source of funding.*
- *Loan is issued as a disbursement for costs incurred, so will require homeowner to initially pay for the conversion.*

Proposed Hawaiʻi Cesspool Remediation and Conversion Loan Program

State SB 2850/HB2540 introduced legislation in 2018 that would create a specific program for cesspool remediation and conversions. This program is envisioned to provide low-interest loans to cesspool owners for the upgrade or conversion of cesspools to ATUs in each county. The loan program would include an on-bill financing option supported by funding from the water pollution control revolving fund. In 2019 SB 221 was passed to establish a similar loan program, effective July 2019. This program was to be implemented through the counties in coordination with DOH.

Applicability/Considerations for Cesspool Conversions: It is not clear whether this program has been implemented.

Office of Hawaiian Affairs Malama Loans

The mission of the Office of Hawaiian Affairs (OHA) is: "To enhance access for all persons of native Hawaiian ancestry to credit, capital and financial services and skills so as to create jobs, wealth, and economic and social well-being for all the people of Hawaiʻi." To support their mission, OHA provides loans and grants for native Hawaiian businesses and individuals.

The Malama Home Improvement Loan is available in amounts ranging from $2,500-$100,000. Loans over $20,000 must be secured by non-real estate assets. Current terms are 5-6 percent interest and up to a 7-year loan period. Loan applications must include: proof of Hawaiian ancestry and Hawaiʻi residency, contractor's estimate of the work, 2 years of federal tax returns and W-2s, and 1 month of current pay stubs.

While this program has limited eligibility, i.e. not all cesspool homeowners are native Hawaiian, it may be a financing option for those who do qualify. The state may consider evaluating funding options tied to native Hawaiian ancestry through organizations like Bishop Estate and the Department of Hawaiian Home Lands to assist the native Hawaiian community. This approach could already be available through federal programs such as HUD.

1.5.4 Hawaiʻi Cesspool Tax Credits, State Income Tax Credit (Act 120)

Hawaiʻi currently provides a state income tax credit for qualified cesspool owners upgrading to a septic system, ATU, or connecting to a sewer. Qualified cesspools are cesspools that are: located within 500 feet of a shoreline[5], perennial stream or wetland[6], or within a source water assessment program area[7]. A list of

[5] Hawaiʻi Administrative Rules §13-222-2

[6] Hawaiʻi Administrative Rules §11-54-1

[7] As determined by the Department of Health based on a two year time of travel from a cesspool to a public drinking water source

cesspools (identified by tax map key and county) that already meet the criteria of Act 120 is available on the DOH website[8].

A taxpayer may apply for a tax credit of up to $10,000 for documented expenses associated with upgrading each qualified cesspool. Under the current law, tax credits are available for five years (tax years 2016-2020), ending on, December 31, 2020. The state provided a maximum of $5,000,000 of credits that are available for each tax year. Any taxpayer who has upgraded a qualified cesspool but is not eligible to claim the credit in a taxable year because the cap has been reached shall be eligible to claim the credit in the subsequent years. Legislation to extend the tax credit did not pass in 2020.

While this program has several financial advantages for those homeowners who file state income taxes, there are likely many homeowners who are below the threshold for filing state income taxes and therefore are not able to take advantage of this option. Given that only 47 applications have been filed for this credit[9], this incentive may have limited application to current cesspool owners.

While the tax credits help to offset some construction costs associated with the conversion, it does not provide:

- Relief for the on-going maintenance and management of the new OSWT option.
- Relief to low-income customers who do not earn enough to qualify for this credit.
- Relief in upfront costs to retain assistance from a licensed civil engineer.

In addition, depending on the selected OSWT, the credit may only cover a fraction of the cost borne by the homeowner. Pending legislation may extend the term of this program, however an assessment of the accessibility by all homeowners to this incentive should be considered and other mechanisms identified.

1.6 Other Funding Models and Partnerships

This section summarizes less traditional funding models, including models used by other infrastructure systems in Hawaiʻi, e.g. energy, and specific, community-based funding models. Other non-traditional funding models include point of sale conversion requirements that would mandate the conversion of cesspools prior to sale of a house was initially considered in 2018 (SB 2567). However, at the time, it was not deemed feasible due to resistance from the real estate community and homeowners and was tabled for future discussion in 2020. This was prior to the COVID-19 impacts; consideration of mandated cesspool conversions prior to property sales may be postponed in light of larger economic issues in the State.

1.6.1 On-Bill Financing Program – Example: Hawaiʻi Green Infrastructure Authority

On-bill financing and repayment programs have been providing options for property owners for many years to pay for investments in clean energy upgrades through their utility. On-bill financing allows the electric utility to incur the cost of the clean energy upgrade, which is then repaid by the homeowner on the utility bill[10]. The upfront capital is provided by a third party, not the electric utility. In some on-bill repayment programs, the loan is transferable to the next owner of the home, building, or property. The idea of an on-bill financing program could be adapted towards the financing cesspool conversions with the assistance of other agencies that could assist in the billing administration function similar to electric utilities.

[8] https://health.hawaii.gov/wastewater/home/taxcredit/
[9] Number of filings from 2015-2017.
[10] Example utilities include Hawaiian Electric Company, Maui Electric Company, or Hawaiian Electric Light.

An on-bill financing model currently exists in the State. Act 211 authorized the establishment of the green infrastructure program, known as GEM$ to deploy clean infrastructure[11]. The legislation, among other key objectives, enabled ratepayers to finance clean energy improvements through an on-bill financing model that allows ratepayers to spread the initial capital costs of installing green infrastructure of up to 20 years, thus providing an affordable way to invest in green infrastructure that will reduce monthly energy costs.

The GEM$ program is operated under the Hawaiʻi Green Infrastructure Authority (HGIA) and has many of the similar on-bill functions a cesspool conversion program would require for implementation. For example, certain program functions of the GEM$ program, such as program marketing, construction contractor outreach, education and training, and loan functions[12] may be applied towards a cesspool conversion financing program. As of November 2017, $77.8 million in GEM$ funds have been committed to residential and commercial energy projects in the State. Following is a summary of key features of the GEM$ program:

- ***Possible Eligible Applicants.*** The GEM$ program serves low and moderate-income, single-family residential homeowners and renters, small businesses as defined by the U.S. Small Business Administration, multi-family rental projects, and non-profits. Financing for the GEM$ program was recently expanded so that participant eligibility under the program is not based on the creditworthiness of the applicant, and the on-bill repayments obligation is transferable to the next owner or tenant. In other words, the obligation for repayment is tied to the utility meter, not the individual homeowner. Approval does not require a credit check or income verification. HGIA bases approval on a good utility bill payment history – no disconnection notices in the previous 12 months – and an estimate that the project will deliver a minimum of 10 percent utility bill savings, including the repayment charge, after installation of the retrofit.
- ***Types of Projects.*** The HGIA has financed projects under its GEM$ program such as solar photovoltaic systems, energy storage, lighting upgrades, heating, ventilation, and air conditioning systems (HVAC) upgrades, mechanical upgrades, controls and monitoring devices and energy/water nexus systems.
- ***Pros and Cons***
  - *Pros:* The HGIA GEM$ program is an established on-bill loan program for private energy efficiency solar projects. Several elements of this program, including administration of funding, loan repayment and coordination with an entity for billing, may be applicable for the financing of residential cesspool conversion projects. GEM$ offers financing rates of approximately 5.5 percent over a 20-year loan term.
  - *Cons:* Unlike in the energy model, incentives associated with a cesspool conversion are hard to define for a water/wastewater utility companies to support any proposed bill financing. In addition, there is a question as to the implementation of on-bill financing in rural areas with low income applicants.

1.6.2 Property Assessments – Example: Property Assessed Clean Energy Program

PACE programs are used by local governments to allow property owners to finance energy efficiency and renewable energy improvements (such as solar) to pay for the up-front cost of energy or other eligible improvements on a property and then pay the costs back over time through a voluntary assessment.

A PACE program could be modified as a viable financing option for cesspool conversion to allow a property owner to pay back the costs of their cesspool remediation over time at an agreed upon interest rate and length of loan terms. Funding would occur through private lenders such as private banks or the issuance of municipal bonds.

[11] Sessions Laws of Hawaiʻi, 2013

[12] Loan functions include origination, underwriting, funding, and servicing.

- ***How PACE could be applied towards Cesspool Conversions.*** While Section 196 of the Hawaiʻi Revised Statutes (HRS) discusses Hawaiʻi's policies, goals, and objectives with respect to energy resource planning, there is no enabling legislation to establish a PACE program. However, HB 1669 was introduced in the 2020 legislative session and assigns the Hawaiʻi State Energy Office to work with the counties to establish a program. The program would allow a property owner to obtain a private loan for a renewable energy system on the property and pay back the loan through an addition to the owner's property tax bill. This PACE program concept, if approved by the legislature and signed by the Governor, could be modified to include cesspool conversions.
- ***Eligible Applicants.*** The PACE financing mechanism has been used in several states where legislation exists to finance improvements on private property such as:
  - Commercial properties (commonly referred to as Commercial PACE or C-PACE)
  - Residential properties (commonly referred to as Residential PACE or R-PACE).

  The unique characteristic of PACE assessments is that the assessment is attached to the property rather than to the individual. A PACE program can be modified to finance cesspool improvements through an assessment on the private property.
- ***Types of Projects.*** PACE programs are used to provide funds for a variety of types of needs, such as energy efficiency upgrades, disaster resilience improvements, water conservation measures, or renewable energy installations of residential, commercial, or industrial property owners. The PACE program could be expanded to include cesspool conversions.
- ***Funding of Projects.*** Historically, this funding has been applied to installation of roof top solar panels for residential homes with typical loans repaid over 5 to 25 years. If applied to cesspool conversion, the PACE financing model allows a property owner to pay back the conversion costs over time at an agreed upon interest rate and loan term. Funding would occur through private lenders or the issuance of municipal bonds depending on enabling state legislation.
- ***Program Requirements.*** In other states, the PACE financing model allows property owners to implement improvements and finance energy efficiency and renewable energy improvements without large up-front cash payments. Property owners that voluntarily participate in a PACE program repay their improvement costs over a set time period (typically 10 to 20 years) through property assessments. Property assessments are secured by the property itself and paid as an addition to the owners' property tax bills. Nonpayment generally results in the same set of repercussions as the failure to pay any other portion of a property tax bill. A PACE assessment is a debt of property, meaning the debt is tied to the property as opposed to the property owner. In turn, the repayment obligation may transfer with property ownership if the buyer agrees to assume the PACE obligation and the new first mortgage holder allows the PACE obligation to remain on the property. This can address a key disincentive to investing in energy improvements because many property owners are hesitant to make property improvements if the resulting savings are not sufficient to cover the upfront costs.
- ***Pros and Cons***
  - *Pros:* A PACE-type model would allow an individual property owner to secure private financing for a comprehensive list of projects, including cesspool conversion. The financing options may include spreading payments over a longer period of time, with the possibility of deducting payments from homeowner's income tax liability.
  - *Cons:* There are no active PACE programs in Hawaiʻi and implementation will require authorizing legislation. There may be resistance by lenders/mortgage-holders whose claims to the property may be subordinated to the unpaid assessment amount should the property go into foreclosure. The ability to provide discounts or accommodations to low income households

may not be feasible. In addition, the program is only applicable to primary property owners, thereby potentially disallowing renters to apply.

1.6.3 Property Assessments – Example: Community Facilities District and Special Improvement Districts

CFDs or SIDs, are independent, local special-purpose financing districts that levy taxes and assessments and issue bonds to provide infrastructure to develop communities of all types.

- ***How CFDs and SIDs Could be Used.*** Existing state legislation allows counties to create CFDs to finance special improvements[13]. Furthermore, the county has power to levy and assess a special tax on property located in the CFD or SID and issue bonds secured by the special taxes to provide funds for special improvements. Related to CFDs, Section 46-80.5 allows for the creation of a SID for the purpose of providing and financing supplemental maintenance and other improvements or services as the council of the county determines.
  An example of an improvement district specifically created to address the EPA's requirement to close large-capacity cesspools is the ID in North Kona in the County of Hawaiʻi. This ID funds the connection of 110 parcels to the county wastewater system. This funding mechanism could be applied to the funding construction and maintenance of OSWT systems for a subdivision of current cesspool owners.
- **Eligible Applicants.** The County must have a charter and adopt an ordinance to establish a district, "relating to special improvement financing by community facilities districts." The ordinance establishes procedures for the formation of CFDs. It is common for the ordinance to allow for written protest against creation of the CFD. If owners of more than 55 percent of the land proposed or more than 55 percent of owners protest against the proposed CFD, the creation of the district must cease. In the absence of protests as described, a county council may approve an ordinance forming a CFD and levy a special tax on properties with the district.
- **Types of Projects.** The ordinance passed by the county typically describes the types of special improvements that may be undertaken and financed through the formation of the CFD and secured by the special taxes that are imposed. Public improvements and services may be funded with proceeds of municipal bonds secured by the special taxes. SB3057 was passed during the 2018 legislation session to expand the authority of counties to use land-based financing to support operating costs for certain county services provided within SID and CFD.
- **Offer Low Interest Financing to Property Owners Requiring Cesspool Conversions.** CFDs and SIDs offer low interest tax-exempt financing of up to 30-year term (including 5 year principal deferment) to finance public improvements and services such as cesspool conversions. However, to date, this financing vehicle has been rarely used in the State to develop public improvements related to development of certain areas. To finance individual cesspool conversions, a county would have to pass an ordinance to form a CFD or SID and subsequently levy a special tax within the SID to fund the improvements. The use of CFDs and SIDs may only work in a county that has a concentrated area of cesspools requiring conversion.
- **Pros and Cons**
  - Pros: CFDs and SIDs offer low interest tax-exempt financing of up to 30 year term (including 5 year principal deferment) to finance public improvements and services such as cesspool conversions.

[13] See Section 12 of Article VII of the State Constitution and HRS Section 46-80.1.

- Cons: To finance individual cesspool conversions, a county would have to pass an ordinance to form a CFD or SID and levy a special tax to fund the improvements and receive the required fifty-five percent approval from the property owners to form the CFD or SIDs. Moreover, such a financing strategy could only be implemented where dense or concentrated areas of cesspool remediation are needed.

1.6.4 Public-Private Partnerships

Another potential funding mechanism is the development of P3s that encourage private investment in public infrastructure projects. P3s are contractual arrangements in which governments or public entities form partnerships with the private sector to design, finance, build, and operate and/or maintain infrastructure such as toll roads, water supply facilities, and wastewater treatment plants. Many different types of P3s exist because each of the five elements of development can be combined (design, finance, build, operate, and maintain). For instance, in the Design-build-operate-maintain (DBOM) arrangement, contracted private entities are responsible for project design and construction, and also take the responsibility of the operation and maintenance of the project. Public agencies are in charge of financing and theoretically pass all the risks related to operating costs and project revenues to the private partner. A P3 arrangement may shift project financing risks and long-term operations and maintenance responsibilities to the private sector; allowing agencies to leverage private capital and tap private sector expertise; which helps agencies avoid more debt issuance and preserve bond capacity. However, P3s also have some negatives including local opposition; the loss of public control and flexibility; may require a high degree of expertise in-house or having to hire consultants; may require complicated contracts and complex negotiations; and demand huge efforts of enforcement and monitoring contracts.

1.6.5 Hawaiʻi Non-Profit Partnerships

The following sections describe ways that Hawaiʻi's active and robust non-profit community could support cesspool conversions.

Fresh Water Initiative (Ulupono and Hawaiʻi Community Foundation)

The Fresh Water Initiative (Initiative) is an effort sponsored by the Hawaiʻi Community Foundation (HCF), a non-profit organization dedicated to advancing and supporting networks of social change. The goal of the Initiative is to bring together diverse partners to address the complexities of water security against the background of climate change. A key partner in the Initiative is the Ulupono Initiative (Ulupono). Ulupono is a social investment firm dedicated to improving the quality of life in Hawaiʻi through investment in sustainable projects.

The model used in the Initiative for collaboration and partnership should be considered as a model for the cesspool conversion plan since this is a highly complex community problem where multiple voices, many of whom need advocacy, need to come together for a successful solution.

Ulupono and HCF have come together around a common goal of water security and sustainability. Depending upon the technical strategies for the cesspool conversions, there are opportunities for cesspool conversions to improve Hawaiʻi's water security and sustainability. Both organizations may be able to help identify funding options that could achieve the multiple benefits of supporting their goals of not only water security but also acting as agents of community change and empowering communities to build sustainable solutions.

This is not a funding option in the traditional sense; it is more a model of collaboration and coalition-building around an issue aligned with cesspool conversions. It may be worth considering how these partners could assist in the cesspool conversion effort.

Hanalei Initiative and Hanalei Watershed Hui

The Hanalei Initiative is a collective group of caring citizens working for the betterment of Hanalei and the North Shore (of Kauaʻi). Water quality is one of the focus areas. Through potential DOH grant funding and private capital, the Hanalei Initiative is exploring financing options for cesspool conversions.

Hanalei Watershed Hui (Hui) was established in 2000 as a non-profit to implement the Hanalei American Heritage River Program and Hanalei Watershed Action Plan. The Hui was working with the DOH in 2017 to help residents apply for $500,000 in grants that would help finance 75 cesspool conversions. Due to lack of interest from residents, the grant was cancelled.

While not a direct funding option, this is another example of community models that could be established throughout the State to educate homeowners around the options for cesspool conversion and its funding.

1.7 Potential Revenue Sources

Traditional centralized municipal water and wastewater conveyance and treatment plant infrastructure projects generally have a stable revenue source in the form of user fees or general taxing authority that is used to fund system capital and on-going O&M costs. However, many nontraditional projects (such as the cesspool conversion program) lack a stable revenue stream to fund project implementation, special financial assistance programs, and/or on-going permitting, monitoring, and administration. Consideration should be given to leveraging potentially available revenue sources to assist with financing the conversion program. Use of these revenue sources may require legislative action and/or voter approval and may include the following:

- Developer fees.
- Nutrient impact fees.
- Permit fees.
- Property taxes.
- Recreational or license fees.
- Resort taxes/fees.
- General excise tax.
- Special assessments.
- User fees.

1.8 Potential Future Federal Legislation and COVID 19 Stimulus Bills to Track

The Senate Committee on Environment and Public Works approved two partisan bills - America's Water Infrastructure Act (AWIA) of 2020, a broad water infrastructure and water resources bill, as well as the Americas Drinking Water Infrastructure Act of 2020, which together invest nearly $20 billion in wastewater infrastructure projects and community drinking water improvements. AWIA 2020 is anticipated to provide $17 billion in funding for water infrastructure projects, with $2.5 billion in funding for the Drinking Water Infrastructure Act. AWIA reauthorizes the CWSRF fund with increased program funding for the first time in 30 years and increases assistance to struggling communities. In addition, AWIA reauthorizes the WIFIA program through 2024 and the Sewer Overflow and Stormwater Reuse Municipal Grants program and creates the Clean Water Infrastructure Resiliency and Sustainability Program. The bills are currently pending full senate and presidential approval. As appropriations are provided for various provisions, there may be some potential funding opportunities for the cesspool project.

In addition, Congress is discussing a potential COVID-19 Stimulus Package Phase 4 for release in late July/August 2020. While there is some uncertainty on the exact programs to be funded, it is anticipated that a future bill will include funding for public infrastructure projects with a focus on projects that help to kick start the economy, modernize infrastructure, and help build resilience to future crises. It is anticipated that funding provided through a potential stimulus bill will focus on shovel ready projects, be provided on a first come first serve basis, and are projects that help to kick-start a state's or the nation's economy. The Council of Infrastructure Financing Authorities has proposed the 2020 Save, Accelerate, Fill and Expedite (S.A.F.E.) Water Infrastructure Action Plan which proposes recommendations for the potential COVID-19 Stimulus Bill #4 including an allocation for Hawaiʻi's S.A.F.E. SRF Project Pipeline for Drinking Water projects at $32 million and Clean Water projects at $85.6 million and provides for program allowances including that the Clean Water and Drinking Water SRF programs be provided increased flexibility to achieving goals of the bill by waving requirements for state match for any stimulus funding and the 2020 capitalization grant to allow federal funding to flow immediately. However, the mechanism for disbursement of potential stimulus funding is yet to be determined.

While future legislations both target wastewater infrastructure funding, there is some uncertainty in the ultimate bill and appropriations and neither legislative can be relied upon as a mechanism to fund the entire cesspool conversion program but should be considered as one potential source of funding for the project.

1.9 Summary and Next Steps

The following section provides an overall summary, recommendations, and next steps.

1.9.1 Summary

In light of the lack of dedicated funding mechanism for the conversion of individual cesspool systems, a suite of financing sources has often been utilized in other states. These sourced have included self-financing (either from savings or bank loans), state incentives, and federal/state and local grant/low-interest loan funding. Some states have developed creative approaches for funneling federal and state low-interest loan and grant monies to individual homeowners. State tax credit or potential rebate programs may also provide another financing option for near-term cesspool conversion projects. In addition, some states have established a state-wide, fiscally sustainable funding mechanism for the financing of cesspool conversions.

While the costs of previous efforts to convert LCCs in the state were primarily borne by businesses, the current focus is on the replacement of individual homeowner cesspools which will require financing options that are available to private individuals and can be balanced with household affordability concerns. This TM focuses on potential funding mechanism and models for this purpose.

Financing options for the conversion of cesspools to approved OSWT systems will likely be comprised of a hybrid of financing options depending on several factors including, cost of selected OSWT system, priority of cesspool conversion, stakeholder feedback, and other factors that still need to be identified and assessed. The ideal cesspool conversion financing program would be one that will:

1. **Consider equitability and affordability issues.** Given the high cost of living in Hawaiʻi, the cesspool conversion finance program needs to account for affordability challenges and overall fairness within the community.
2. **Incentivize individual homeowners to convert existing cesspools.** The overall program will be more successful if cesspool owners have an incentive to convert. This process should be coordinated with the public outreach work task.
3. **Provide funding support for upfront cesspool conversion costs.** Homeowners may need funding support to even begin the cesspool conversion process. Consider funding mechanisms that mitigate a homeowner's need to pay all costs upfront.
4. **Consider the funding recipient.** Consider resources that can be paid directly to a homeowner vs. those that must be provided to a public agency, nonprofit, or financial institution and then provided to the homeowner. Financing options which are paid directly to the individual homeowner include

state incentives such as tax credits or rebates, grants from state/federal programs and non-profits and potential new programs modeled after current green energy infrastructure funding models. Financing options where resources must be directed to a public agency, non-profit, or financial institution, include grants and low interest loans from various state/federal programs to be administered by public agencies or non-profits, as well as property-based options including CFDs and SIDs.

5. **Balance the need for immediate, near-, and long-term expenditures.** The time horizon for implementation will also impact the available funding options. In the near-term, pursuit of available federal, state, and local funding sources, e.g. grants and loans, is likely more viable while the reliance on state, county, EPA, or CWSRF funded financing program is recommended for the long-term.
6. **Potentially fund a variety of OSWT options.** In coordination with the cesspool conversion technologies work, the funding may need to support a range of technical, site-specific solutions and a significant range of costs.
7. **Minimize the administrative burden on DOH while providing support to existing or new local agencies.** The funding program will need to account for the additional technical and financial service support to homeowners for cesspool conversions. Consider additional funding for state and local government to administer the program.

Identification of stable revenue sources will be helpful to fund the cesspool conversion program. Potential revenue sources to may include (where applicable):

- Developer fees
- Nutrient impact fees
- Permit fees
- Property taxes
- Recreational or license fees
- Resort taxes/fees
- General excise tax
- Special assessments
- Traditional municipal repayment sources (including user fees and tax/utility revenues)

In Hawaiʻi, adoption of legislation to provide funding, governance, authority, and institutional direction to fund cesspool conversion options has been numerous. However, there is a need to coordinate these legislative initiatives around administration and enforcement policies. Other states, in addition to addressing cesspool funding options, have been successful at passing legislation mandating cesspool conversions under various conditions including in real estate transactions and due to existing cesspool failures.

Based on a review of financing mechanisms utilized by ten other states to incentivize its individual homeowners to convert failing septic or cesspool systems, the key takeaways are as follows:

- The conversion process is a long-term effort that is slow moving and requires the establishment of a comprehensive and extensive public outreach effort.
- The long timeline for implementation also required that states established a sustainable financing mechanism including sources and revenue streams to cover program administration and other costs.
- The most common upgrade and conversion mechanisms instituted by states was the upgrade of the cesspool at the time of a property sale, or if a system failed during inspections or through a blanket phase-out program (as is being implemented in Hawaiʻi).

- Those states with the highest success had implemented extensive outreach programs that educated individual residents on the public health and water quality benefits of converting and provided information on incentives and state programs to help pay for these conversions.
- While each state varied in its program, most provided low interest loans to individual homeowners utilizing CWSRF or other state funds through a conduit/pass through mechanism. Utilizing this approach, the CWSRF programs were able to funnel funding to individual homeowners through a "conduit" or intermediate agency which assumed the loan as well as conducted all required program administrative activities – thereby reducing demands on the state's CWSRF program. Conduit agencies included other state programs, financial institutions or non-profit organizations.

Several financing models implemented in other states may prove to be a good fit in Hawaiʻi, including:

1. Financing program in which DOH CWSRF program partners with another State agency and shares program responsibility.
2. Financing program in which DOH creates a Conduit Lending/Pass Through Program with a public entity (such as the county or an eligible non-profit) in which DOH CWSRF staff are still involved with the disbursements. However, the pass-through entity is responsible for all program administrative activities (loan application, loan processing, project selection, repayments, loan close out etc.).
3. Financing program in which a new financing agency is established to handle the financing (and perhaps other aspects) of the cesspool upgrades and conversion.

In addition, several less traditional funding models have been used in Hawaiʻi by other infrastructure systems (e.g. energy) that may be applicable for cesspool conversions including: on-bill financing (used by HGIA); and Development of CFDs or SIDs which can levy taxes and assessments and issue bonds to provide infrastructure in communities.

Federal and state funding options for cesspool conversions for individual homeowners to finance OSWT systems are limited due to program priorities, and the requirement that the recipient of funding be a public entity or a qualified non-profit. Current funding options for individual homeowners include: Hawaiʻi Cesspool Tax Credits; Office of Hawaiian Affairs Malama Loans; Hawaiʻi Cesspool Remediation and Conversion Program (pending); Hawaiʻi Rural Water Association; and the Hawaiʻi Rural Community Assistance Corporation. In addition, EPA's WIFIA program and Hawaiʻi DOH CWSRF and NPS programs, may be potential funding sources, if a public entity were to be the loan recipient and then funnel loan monies to individual homeowners. Federal programs including USDA's Water and Waste Disposal Loan and Grant and Rural Housing Services Programs, as well as the HUD Non-Entitled Counties in Hawaiʻi Community Block Grants and Economic Development Administration should be further evaluated as potential funding programs as well. These later programs are targeted at rural or low-income communities.

1.9.2 Next Steps

The selected funding mechanism for the cesspool conversions will depend on the overall cesspool conversion program and strategy (e.g. prioritized areas, schedule of conversions, cost of technology to be used), who the funding recipient will be (individual vs a subdivision vs homeowners' association), DOH financial and staffing resources, and other factors. The prioritized list will provide an indication of the schedule of conversions and when dollars will be needed. Ultimately, any funding option will also need to include consideration of affordability since many of the cesspools are in areas of limited income.

The next steps in the initial evaluation of potential funding mechanisms that Carollo is scoped to complete includes:

1. Evaluate affordability issues as well as the equitable distribution of funds (TM02).

2. Present funding options to the DOH to solicit input, identify preliminary list of preferred financing mechanism, and identify considerations/concerns.

Recommendations and potential next steps to support cesspool conversions include:

1. Coordination of legislative efforts, such as:
   a. Extension of Act 120 tax credits beyond 2020 or creation of a rebate program.
   b. Creation of legislation to require that cesspools are disclosed as part of real estate property inspections/transactions.
   c. Evaluation of legislation for establishment and funding of a long-term cesspool conversion financing program.
   d. Evaluation of potential federal legislative actions.
2. Work towards the identification of potential viable financial mechanism through the following actions:
   a. Conduct additional research into preferred options identified by the CCWG.
   b. Outreach to federal/state funding programs to confirm applicability and program requirements, timing, etc.
   c. Follow-up with financing programs to discuss program details to understand the "nuts and bolts" of the programs. As well as identify lessons learned, successes and failures, and what program elements could work in Hawaiʻi.
3. Identify and contact potential agencies, non-profits and financial institutions within the state to determine technical expertise, ability and willingness to conduct administrative activities, what financial mechanisms they could help implement, and other functions they can perform.
4. Conduct discussions with DOH, CWSRF, counties, HUD, USDA, and other identified agencies/non-profits to assess and understand available resources (staff/financial), technical expertise, level of engagement/responsibility desired, and resource requirements.
5. Link preferred funding options to affordability and equitability distribution considerations to provide a complete picture of options and affordability mitigation measures.
6. Work with public outreach subgroup to develop strategies for presenting technology and financing options to groups of affected cesspool owners to solicit input.

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Appendix A

MECHANISMS TO FUND CESSPOOL CONVERSIONS TO CENTRALIZED AND DECENTRALIZED SYSTEM

Pay-As-You-Go-Funding

PAYGO financing involves collection of payments from customers within the utility's jurisdiction through user charges, capital charges, and other sources, for funding future capital improvements. All or a portion of these revenues are accumulated in a capital reserve fund and are used for capital projects in future years. PAYGO financing could be used to finance 100 percent or only a portion of a given project, depending on several factors.

Overall, total costs are substantially lower when employing a PAYGO financing approach due to the avoidance of interest payments incurred from bond funding, along with the associated transaction costs (e.g., legal fees, underwriters' discounts, etc.). However, it is often challenging to employ this funding approach for large new or replacement projects, due to the high amount of capital that is needed on-hand in reserves, or from rate-based cash flow. If the program is reserve funded, the agency must already have sufficient cash-on-hand designated for such a project. If the program is rate funded, it could significantly increase the agency's rates and fees if the program represents a sizeable increase in capital needs. This funding approach also doesn't recognize the inter-generational nature of water and wastewater utility assets which typically provide long-term benefits to multiple generations of ratepayers.

The PAYGO financing mechanism is not a viable mechanism by which to fund the cesspool conversions, as OSWTs will not fall under the jurisdiction of a utility. However, if a cesspool property were to be connected to an existing sewer system for centralized treatment, this may be an option to further explore.

Debt Financing

There are several options for debt financing of wastewater projects, ranging from the issuance of short- or long-term bonds.

Revenue Bonds

Revenue bonds are historically the principal method of incurring long-term debt. This method of debt obligation requires specific non-tax revenues such as user charges, facility income, and other funds, to be pledged to guarantee repayment of bonds. There is often no legal limitation on the amount of authorized revenue bonds that may be issued, but from a practical standpoint, the size of the issue must be limited to an amount where the net revenues available for annual debt service (interest and principal payments) are sufficient to meet bond covenant requirements. Revenue bond covenants generally include coverage provisions, which require that revenue from user fees minus operating expenses be greater than debt service costs by factors typically ranging from 10 to 25 percent, i.e. debt service coverage per the bond covenant is expected to range from 1.10 to 1.25 times.

General Obligation Bonds

General obligation (GO) bonds are municipal securities secured by the issuer's pledge of its full faith, credit, and taxing power. GO bonds are backed by the general taxing authority of local governments and are often repaid using utility revenues when issued in support of a sewer or water enterprise fund. In the event that GO bonds are issued for the cesspool project, the agency must have the necessary taxing capacity to issue the bonds.

Certificates of Participation

Certificates of participation provide financing through a lease agreement that does not require voter approval. The legislative body of the issuing agency is required to approve the lease arrangement by a resolution. The lessee (the public entity) would be required to make payments typically from revenues derived from the operation of the facilities. The amount financed may include reserves and capitalized interest for the period that facilities will be under construction.

Assessment District Bonds

Financing by this method involves initiating assessment proceedings. Assessment proceedings are documents in "Assessment Acts" and "Bond Acts." An assessment act specifies a procedure for the formation of a district (boundaries), the ordering, and making of an acquisition or improvement, and the levy and confirmation of an assessment secured by liens on land. A bond act provides the procedure for issuance of bonds to represent liens resulting from proceedings taken under an assessment act. Procedural acts include the Municipal Improvements Acts of 1911 and 1913. The commonly used bond acts are the 1911 Act and the Improvement Bond Act of 1915. The most prevalent procedure is a combination of the 1913 Improvement Act with the 1915 Bond Act. Charges for debt service can be included as a special assessment on the annual property tax bill. The procedure necessary to establish an assessment district may vary depending on the acts under which it is established and the district size.

The debt financing mechanism for the replacement of cesspools with OSWT is not a viable mechanism as most debt financing options require a public entity as the issuer and the issued must have a mechanism for repayment (e.g. annual property tax bills, utility revenues, etc.).

Grants and Loans

Federal, state and local grant and loan funding sources are available for the planning, design and construction of water, wastewater, and infrastructure projects. Grants and low interest loan funding programs, which are highly competitive, typically target specific types of project and/or have specific objectives that a project must achieve and often require projects to meet as many objectives as possible, including:

- Builds Regional partnerships.
- Incorporates integrated project benefits.
- Water conservation or efficiency.
- Protects groundwater resources.
- Renewable energy improvements or energy efficiency.
- Addresses risk and resiliency.
- Demonstrates consistency with the State and Regional policies and objectives.
- Demonstrates regional cooperation and partnerships with partners and stakeholders.
- Serves a DAC or severely DAC.
- Helps create both construction and post-construction related employment.

Federal and State low interest loans and grant programs have become more competitive due to an overall increased interest in alternate funding programs and federal and state budget constraints. Most programs require a public entity or agency be the applicant or serve as a conduit for funding to private entities. More so, as funds are limited and highly competitive; the programs require a challenging qualification process; may expire after a specified time; and are not typically a long-term funding solution.

Federal and State low interest loans and grants maybe a viable mechanism for the funding of some cesspool conversions, especially for those in the near-term if they fit a specific programs priority. However, in the longer term, these existing programs do not provide for a reliable steady source of funding of the cesspool conversions due to the competitiveness of the programs, the uncertainty in yearly appropriations and other factors.

Appendix B

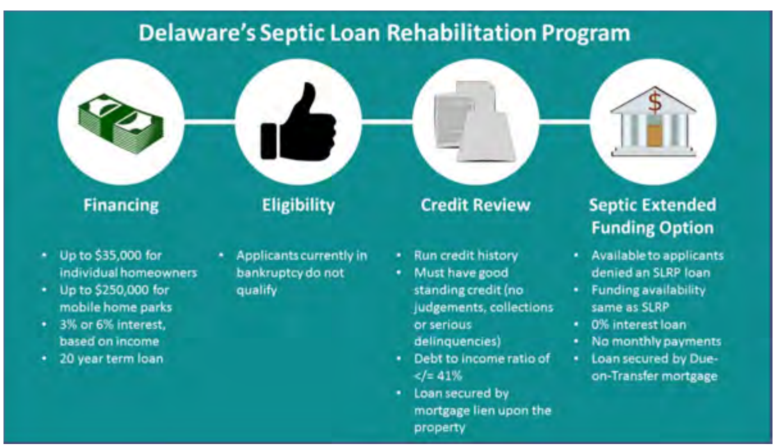
CESSPOOL FUNDING MECHANISMS IN OTHER STATES

Delaware (Program Type: Direct Lending)

Delaware is a coastal state with an estimated 70,000 onsite systems, 18 percent of which are estimated to be failing. Beginning in 2015, cesspools were banned and required to be replaced within one year of identification. The state has a goal to replace 6,074 septic and leach field systems by 2025. The Delaware CWSRF program, through the Delaware Department of Natural Resources and Environmental Control (DNREC), provides direct loans for the repair and replacement of privately owned decentralized wastewater treatment systems, to moderate to low income homeowners, under two programs: Septic Rehabilitation Loan Program (SRLP) and the Septic Extended Funding Option (SEFO).

Septic Rehabilitation Loan Program: The SRLP program provides low interest loans ranging from a minimum of $1,000 up to $35,000 to individual homeowners and $250,000 for mobile home parks. Individual loans have averaged $15,000. Eligible costs include site evaluation, OSWT system design, permits, construction costs and closing/recording costs. Eligible costs for central sewer projects include impact fees, connection fees, permit costs, electrical and abandonment of septic systems. Eligibility requirements include good standing credit (e.g. no judgements, collections or serious delinquencies), the applicant debt: income ratio is greater than or equal to 41 percent; and the loan must be secured by a mortgage lien upon the property. Applicants currently in bankruptcy do not qualify. Under the SRLP program, the loan term is 20 years and the interest rate is based on the applicant's income (ranges from 3-6 percent). There is no pre-payment penalty. Under the SRLP Extended Funding Option, the loan term is 20 years with a 0% interest rate and no monthly payments.

The DNREC established a partnership with the First State Community Action Agency (FSCAA) to assist with the SRLP. The FSCAA manages much of the administrative work associated with providing financial assistance directly to individual borrowers to reduce the burden on CWSRF staff resources, which has been a critical element to the SRLP attaining their goal of replacing 100 failing septic systems each year.



Septic Extended Funding Option – SEFO loans are offered to applicants that are denied an SRLP loan- typically due to poor credit or high debt to income ratio. The SEFO, is funded by an annual CWSRF allocation of $500,000 that comes from a 1 percent fee charged on CWSRF municipal wastewater loans. As with the SRLP program, applicants currently in bankruptcy do not qualify. This program provides the same funding and similar loan terms as the SRLP, however the interest rate is 0 percent and there are no monthly payments. Eligible costs include site evaluation, design, permits, construction costs and closing/recording costs. The eligibility requirements are similar except the loan is secured by Due-on-Transfer mortgage. While the loans are forgiven after 20 years; if the property is sold or the mortgage refinanced, the principal must be re-paid immediately.

Community Septic System Outreach Program: This program was developed as a partnership between the Community Action Agency and the Delaware Environmental Finance Office to identify low and moderate income homeowners that may need financial assistance to replaced failed and/or failing OSWT systems.

Washington (Program Type: Pass Through/Conduit Lending)

The State of Washington's, Department of Ecology provides funding to local governments to set up low-interest loan programs to repair or replace failing onsite sewage systems through two programs: the RLP), as well as the LLP. Funding for these programs is provided by two sources: Washington's CWSRF and the Centennial Clean Water Fund. SRF funding is used as the primary source of loan financing, while the Centennial Clean Water Fund is used to cover administrative costs, loan losses and grants/subsidies to low-income individuals.

Local Loan Program: The CWSRF program, utilizing a pass-through program mechanism, provides funding to 15 counties or local health departments in the Puget Sound and Marine counties, as well as the Spokane Conservation District through the Local Loan Program. Currently, two counties/ conservations districts act as "pass-through entities" providing sub-loans to individual homeowners for the repair and replacement of septic systems. The county or its health department is responsible for local loan servicing, collecting payments, and payment tracking (but may contract these services to a lending institution). The pass-through entity (county or conservation district) also approves or denies loan requests and establishes the terms of the sub-loans to residents. The pass-through entity is responsible for submitting quarterly progress reports to the CWSRF program providing schedules for project completion, loan marketing activities, data on loan applications and closures, and a final list of local loans provided to homeowners and small commercial enterprises.

Regional On-site Sewage System Loan Program: The RLP, launched in 2016, is a partnership between the Department of Ecology, the Department of Health, local counties and health departments, and Craft3 (a non-profit third-party lender). The RLP program is managed by Craft3, a non-profit financial institution, who was contracted by the Department of Ecology to manage the lending activities on behalf of local governments. Craft3 works with the local authorities to ensure that the proposed repair or replacement is approved, and is responsible for the approval or denial of loan requests, establishing loan terms, the loan servicing, collection of payments, payment tracking, submittal of quarterly reports, loan marketing activities, providing data on loan applications and closures, etc. Ultimately, Craft3 assumes the financial risk associated with lending, and is obligated to repay the CWSRF funds.

Through this program, Craft3 provides Clean Water Loans to both residential and commercial owners to repair or replace failing onsite sewage systems or to abandon systems and connect to the sewer. To be eligible for a loan the septic system must be failing, and funding cannot be used for new developments. The 15-year loan can cover the full cost of designing, permitting, installing and maintaining a septic system and includes a reserve for ongoing inspections and repairs. The loan rates (1.99-4.99 percent) and terms (no monthly payment, monthly interest only or monthly principal plus interest) vary based on the annual household income and occupancy. There are no income restrictions on eligibility, however more favorable rates/terms are provided for lower incomes. There is an option to extend the loan upon the loan maturing. If a property is sold or transferred, the loan balance if due on sale or maybe transferred to the new owner upon approval. Since the program inception in 1990, $15 million in CWSRF has been provided to the program.

Rhode Island (Program Type: Sub-State Revolving Fund)

Rhode Island is a coastal state and had an estimated 25,000 cesspools (2007) when the state passed a cesspool act to replace the 1,400 highest priority cesspools. It is unclear how many cesspools remain in Rhode Island, however as of 2015, almost 21,000 AIE technologies had been installed (many in new homes). Rhode Island passed the Rhode Island Cesspool Act of 2007 to better protect coastal water quality, groundwater and improve upon wastewater disposal methods. The act required that the state replace cesspools within 200 feet zones near tidal water, drinking water reservoirs and wells. However, the efforts to replace the cesspools was very slow. Ultimately, in 2016, the state passed a cesspool phase out program requiring for the replacement of cesspools on all properties subject to sale or transfer.

To facilitate the identification of priority conversion areas, the EPA awarded the state a $3 million State and Tribal Assistance Grant to create a cesspool conversion strategy/plan or comprehensive wastewater management plan. The state provides town with funds (State Bond funds, federal non-point source fund grants or EPA grants) to develop Onsite Wastewater Management Plans. Upon development of the plan, the town is eligible to apply for the Community Septic System Loan Program.

Community Septic System Loan Program

The State of Rhode Island's CSSLP, launched in 1999, provides low-cost financing to residential property owners for the repair or replacement of substandard or failing septic systems or to replace cesspools when the homeowner wishes to upgrade to a septic system. The program is funded via the Rhode Island Infrastructure Bank (RI I-Bank) which utilizes federal dollars recycled from previous CWSRF loans to provide the source of funds for the CSSLP. Municipalities apply to the Rhode Island I-Bank for a "lending facility", the proceeds of which can be utilized to make direct loans to homeowners. Residents of participating communities can then access the funding through their municipality via RI Housing. When a community has depleted its funding, the community re-applies to the Rhode Island I-bank for additional funds.

Rhode Island Housing serves as the loan servicer the homeowner loans and is responsible for the required administrative activities including: accepting and reviewing home homeowner applications from eligible communities; coordinating payments to septic system installers/homeowners;

collecting loan repayments from homeowners; crediting the homeowner repayments to the principal payment responsibility of the local governmental unit; and providing monthly reports to both the CWSRF program and the local governmental unit.

Under the CSSLP program, both residents and non-owner occupants may borrow up to $25,000 in interest free financing to pay for engineering and system replacement costs for failing septic systems. The CSSLP loan term is for up to ten years. There are no income limits for program participants, however applicants are required to have a debt to income ratio of no more than 45%. The homeowner is responsible for a $300 loan origination fee and a 1 percent annual servicing fee on the outstanding loan balance which is split between RI Housing and Rhode Island I-bank to cover costs associated with servicing the loan. For a homeowner to be eligible for CSSLP funding, a prerequisite is that the community within which the homeowner resides must have an On-Site Wastewater Management Plan which is approved by the Rhode Island Department of Environmental Management (DEM). In addition, the municipality must be on DEM's Project Priority List and be issued a Certificate of Approval. *To date the CSSLP program has provided $12.4 million in loans from since 1999. The program has issued 783 loans with an average loan amount of $15,435.*

Sewer Tie-in Loan Fund Program (STILF)

The Sewer Tie-in Loan Fund program provides homeowners in participating communities a low-cost loan to connect to the local sewer system and abandon their individual septic system or cesspool. Under the STILF program, the Rhode Island I-Bank provides interest free loans of up to $150,000 to sewer system owners. The sewer system owner then directs STILF funds to individual homeowners through RI Housing. The maximum loan for an individual property owner is $10,000, with a term of up to 5 years. Funds cannot be used to connect newly connected homes to sewers or to repair/replace or upgrade existing sewer connections. Upon notification by the sewer system owner that an individual property owner qualifies for the program, RI Housing will process the loan application, cut vendor checks, and process the loan repayments. *To date the STILF program has closed 49 loans for a total of $197,782. The average loan amount was $3,552.*

New York (Program Type: Septic System Replacement Fund)

New York passed the State's Clean Water Infrastructure Act in 2017 which provided $2.5 billion in funding for aging infrastructure and included $75 million to be provided over five years for the State's Septic System Replacement Fund.

Septic System Replacement Fund:

The Septic System Replacement Fund, administered by the EFC, provides funding to participating counties with an annual allocation of funds to replace cesspools and septic systems in New York State. Participating County Health Departments are responsible for the overall administer of the program and work directly with individual residential owners on the application process and grant awards. Counties may provide grants for projects that replace a cesspool with a septic system; installation/ replacement or upgrade of a septic system; or installation of enhanced treatment technologies. Individual property owners are reimbursed for up to 50 percent of eligible project costs (up to a maximum of $10,000) which include design, installation and system costs. Eligibility requirements include: a septic system project must be in a participating county and within a priority geographic area; Single family, two family and small businesses with an existing design sewage flow not exceeding 1,000 gallons per day (gpd); and seasonal or secondary homes may be eligible. New construction on vacant lots are not eligible and the property cannot have any outstanding or open real property tax liens. The property must be a valid certificate of occupancy or equivalent. Grants are provided on a reimbursement basis, therefore property owners are initially responsible for the total cost of their septic system project.

Each county's Health Departments are responsible for reviewing and evaluating the individual homeowner applications and determining financial assistance awards based on the program criteria. Considerations include: property's location in relation to a water body, impacts to groundwater used as drinking water, and the condition of the property owner's current septic system. Upon notification of grant eligibility, property owners work with the County to submit the application, secure design approval and on contractor selection. Upon completion of construction activities, the Health Department is responsible for verifying the project and authorizing payment.

In addition to the State's Septic System Replacement Fund, individual counties have developed county level funding programs to further entire individual residential owners to transition to the use of new technologies/OSWT systems. Suffolk County, located along the coast, has an estimated 252,000 cesspools and 108,000 other onsite disposal systems. The county identified the need to convert/replace almost 2,600 onsite systems per year based on home sale and developed the Septic Improvement Program to support this effort.

Septic Improvement Grant and Loan Program.

Under the Reclaim Our Water Septic Improvement Program, homeowners who decide to replace their cesspool or septic system with new technologies will be eligible for a grant of up to $30,000 from Suffolk County and New York State to offset the cost of one of the new systems. In addition to the grant, homeowners can qualify to finance the remaining cost of the systems over 15 years at a low 3 percent fixed interest rate. The loan program is administered by Community Development Corporation of Long Island Funding Corp, with financial support from Bridgehampton National Bank, in the amount $1 million and financial commitments from several philanthropic foundations. Eligibility criteria include: residence must be served by an existing OSWT system or cesspool; not be located within a proposed sewer district; not be new construction; have a valid certificate of occupancy and the applicants income should be verified. Suffolk County has approved approximately 550 AIE systems. Currently, the County can award up to 200 grants per year but plans to increase to 1,000 per year.

Maryland (Program Type: Credits and Linked Deposit)

Maryland is a coastal state with an estimated 420,000 septic systems (2009), with 52,000 of these systems being located within critical land areas. With nitrogen being the most serious pollutant in the Chesapeake Bay and Maryland waterways, Senate Bill 320 was passed to upgrade onsite septic systems to remove nitrogen. The emphasis is on the replacement of cesspools and septic systems with AIE technologies that remove nitrogen. Maryland has multiple funding programs for cesspool conversions including the BRF, the Water Quality Trading Program (WQT), and the Linked Deposit Program.

Bay Restoration Fund:

The BRF, created with the passage of Senate Bill 320 in 2004, creates a dedicated fund to finance the improvement of nitrogen, phosphorus, ad nutrient levels. Maryland utilizes two mechanism to fund the program. All municipal sewer customers are charged a fee of either $2.50 or $5 per month (depending on location) which is deposited into an interest earning fund. In addition, for each user served by an OSWT system they are charged a $60 annual fee. The income of the ODSDF is

$27 million per year and 60 percent of the funds o to septic system upgrades and the remaining funds are used for cover crops. BRF funds can be used to finance wastewater treatment plants upgrades to the best available technology for nitrogen removal or to connect existing dwellings to sewer, where public sewer is available. The grants are limited to $20,000 per household and the property owner is responsible for any additional costs over the grant amount. Grants can be applied toward capital facility, user connection, and master plumbing charges. The Clean Water Commerce Act (CWCA) passed in 2017 and expanded the use of BRF to include the costs related to the purchase of cost effective nitrogen, phosphorus, or sediment loading reductions. The amount used for funding is not to exceed $10 million per year in the fiscal year (FY) 2020 and 2021.

Water Quality Trading Program:

The Water Quality Trading Program creates a public market for nitrogen, phosphorus, and sediment requirements. It is a voluntary program that's a collaborative effort between the MDE and the Maryland Department of Agriculture (MDA). The purpose is to accelerate the restoration and protection of the Chesapeake Bay and local waters by promoting upgrades of OSWT systems to generate credits and meet National Pollutant Discharge Elimination System (NPDES) permit requirements. Each county has a specific total maximum daily load goal and can reach these goals by upgrading OSWT systems.

Linked Deposit Program:

The Linked Deposit Program, funded by the Maryland Department of Environment, provides a source of low interest financing for private landowners and water system owners to implement capital improvements to reduce nutrient delivery to the Chesapeake Bay. "Linked" refers to the relationship between below-market rate of interest agreement provided to a participating lender by MDE's WQFA. The below-market rate of interest loan is passed on to the borrower to fund water quality and drinking water capital projects. Participating lenders are accountable for processing, underwriting, and servicing the loan. The bank will evaluate the credit worthiness of an applicant according to the lenders underwriting criteria. The bank assumes all risk of default and the State and MDE are not liable to reimburse a participating bank for any loses or expenses associated with loans from this program. The loan agreement is also between the lender and the applicant, not the State or MDE.

MDE's septic upgrade program annually receives an estimated $8 million in funding, enough to cover about 600-700 septic upgrades per year. An average septic system upgrade, plus five years of maintenance, costs approximately $10,000-$13,000. Since 2006, the State has awarded approximately $19 million to homeowners and counties for upgrading septic systems.

Massachusetts (Program Type: Pass through Lending, Direct Loans, and Tax Credits)

Massachusetts is a coastal state. The number of OSWT systems in Massachusetts is not readily available. In 1996, the Massachusetts Department of Environmental Protection (DEP) recognized failing cesspools and septic systems as a leading cause of water pollution and drinking water contamination.

Community Septic Management Program

Massachusetts established the Community Septic Management Program, in 1996, to provide low cost loans to communities to devise local inspection and septic management plans. The Community Septic Management Program provides communities with low interest loans of up to $200,000 to devise a Community Inspection Plan or a Septic Management Plan. The Local Inspection Plans are intended to protect environmentally sensitive areas from contamination; while Septic Management Plans identify areas that need monitoring and maintenance. Both plans must include a provision of financial assistance to homeowners through betterment agreements.

Communities, through the local Board of Health, may then provide financial assistance to eligible homeowners for the repair, replacement, or upgrade of failed septic systems or the connection to an existing sewer through a Betterment Agreement. A Betterment Agreement channels loans from the CWSRF program through a municipality to individual property owners for the repair or replacement of septic systems. The interest rate ranges between 3-5 percent based on affordability. Funds may be used to cover all costs necessary to repair or replace a failed septic system, hook up to existing sewer system, or to replace traditional septic systems with alternative systems. To be eligible for funding, a project must be placed on a community's priority list and screened based on environmental/public health impacts, income and funding needs. In general, betterment loans, together with accrued interest, are repaid through the Community's tax collection – as a line item in the property tax bill. If the property is sold, the payments is assumable by the buyer of a property. The municipality can place a municipal lien on property if the homeowner defaults on the loan.

The Community Septic Management Program was funded through a loan from the State Revolving Fund which was offered at 0 percent interest rate to communities via the Massachusetts Water Pollution Abatement Trust. The Massachusetts Clean Water Trust provides up to $5 million a year from the CWSRF program assets to fund municipalities' needs. There is also a $20,000 grant available for first-time communities entering the Program to provide additional funds to assist with administrative costs. The community also has an option to set aside up to 2.5 percent of the loan funds to obtain consulting services to administer the Program. Each community executes an agreement with the Trust describing the terms and conditions of the SRF Loan. The community subsequently re-loans these funds to homeowners. The interest charged on the betterment loans to homeowners provides positive cash flow and additional security for the community. Each community assumes full responsibility for repaying monies borrowed from the Trust. However, the repayment obligation is secured with the betterment agreements made with homeowners.

Homeowner Septic Loan Program

The program is a bank loan program providing low interest loans to eligible homeowners through the Massachusetts Housing Program. The Massachusetts DEP allocated $14 million for financing home septic repairs. The program provides funding to owners with up to 4 family homes in the amount of $1,000 to $25,000 for a loan term of 3-20 years. Interest rates range from between 3-5 percent based on family size, income and market area. The minimum monthly payment is $27. The loans are backed by mortgage security. All loans are due in full upon sale, transfer or refinancing of the first mortgage.

Tax Credit:

The Commonwealth also provides a tax credit of up to $6,000 over 4 years to defray the cost of septic repairs to a primary residence. The tax credit is available for all septic systems and cesspool upgrades and repairs that occurred after January 1, 1997. Forms are provided through the Department of Revenue for homeowners to claim the tax credit.

Since the implementation of the Community Septic Management Program, more than 4,000 systems have been replaced, repaired, or upgraded. Over $22 million in low interest loans have been approved by the Massachusetts Clean Water Trust and the Massachusetts CWSRF program to communities. In addition, repayment through the property tax assessments is a creative revenue source for funding a nontraditional *project. The overall effectiveness of the Community Septic Management Program's implementation depends largely on the initiative of local officials.*

New Jersey (Program Type: Direct Loan and Linked Deposit)

New Jersey Department of Environmental Protection's (NJDEP) Environment Infrastructure Financing Program is now known as the New Jersey Water Bank (NJWB). It is a partnership between the NJDEP and the New Jersey Environmental Infrastructure Trust (Trust). The purpose is to provide low cost financing for the design, construction, and implementation of projects that help protect and improve water quality. NJWB financing comes from the Trust and the NJDEP. The Trust issues revenue bonds that are used in combination with zero percent interest funds to provide very low interest loans for water infrastructure projects. The NJDEP uses a combination of federal State Revolving Fund (SRF) capitalization grants and State's matching funds, loan repayments, State appropriations, and interest earned on such funds. To receive funds through the NJWB, a public sponsor must develop a septic management district.

The New Jersey CWSRF Green Project Reserve program and the Municipal Grant Program (MGP) may also provide funding for septic systems. The CWSRF green project reserve is a federally funded program and both public and private owned projects are eligible for financial assistance. Eligible projects include decentralized wastewater treatment solutions including septic tanks. The MGP provides grants from the state to eliminate septic systems and finance new sewer connections. Assistance is available for up to $500 per property and can only be used to assist with the physical cost of connection to the system. New Jersey is in the process of developing a program to invest unexpended capital funds from its CWSRF and put the money to homeowners through a Link Deposit Program. This is similar to the program in Maryland in which the CWSRF program purchases a reduced rate certificate of deposit from a private institution, and the institution then loans out the deposited funds to individuals for smaller scale water quality projects.

Because cesspools must be upgraded during real estate transactions, there is an opportunity for funds to come through the Department of Community Affairs (DCA) community block grants or USDA rural development housing grants.

Ohio (Program Type: Direct Financing)

In 2013, the Ohio Department of Health estimated that 31 percent of septic systems were failing. There are several funding mechanisms available to help fund the conversion of the state's septic systems including: the Water Pollution Control Loan Fund (WPCLF), the Water Resource Restoration Sponsor Program (WRRSP), the State's CWSRF, and the Un-Sewered Area Assistance Program. The Ohio EPA offers three options for direct funding assistance which include: a linked deposit program, a local loan capitalization program, and the Principal Forgiveness loans to the Local Health Districts (LHDs).

Water Pollution Control Loan Fund:

This fund is offered by the Ohio EPA to assist low to moderate income households to repair and replace failing on site treatment systems. WPCLF provides below-market interest loans. Small borrowers are usually eligible for indirect loans through linked deposit programs, while public and large private borrowers are able to secure direct loans. Local government entities can create their own RLF or linked deposit program using a WPCLF loan. In 2019, $10.1 million was provided for the repair and replacement of failing septic systems.

Water Resource Restoration Sponsor Program (WRRSP):

Another program offered by the Ohio EPA, the WRRSP offers communities very low interest rate for wastewater treatment plant improvements as long as the community also sponsors projects to protect or restore water resources. The philosophy of the program is that wastewater treatment plans improvements and water resource restoration efforts are complementary efforts.

Ohio Clean Water State Revolving Fund (CWSRF):

The CWSRF program provides a linked deposit program for individual homeowners that need to upgrade or replace a decentralized system through low-interest loans. The state works with local banks to provide financial assistance at a reduced rate, and the borrower is able to secure a loan at under market rate.

Un-sewered Area Assistance Program:

The Ohio Water Development Authority developed this program to provide grants for the construction of a publicly owned sewer system for areas that are un-sewered and have failing on site treatment systems. This program is available to state and county and public agencies with the authority to manage wastewater or water management facilities in un-sewered areas.

Principal Forgiveness to LHD:

Principal Forgiveness loans are similar to grant funds and are the most popular amongst homeowners in the State. Since 2016, the Ohio EPA has awarded nearly $50 million to Ohio LHDs to be disbursed to eligible homeowners. Annual awards to Local Health Districts range from $150,000 to $300,000. LHDs are responsible for setting area priorities and determining eligibility of residents based on income and the failing on site treatment systems. Homeowners can qualify for 50 percent to 100 percent in principal forgiveness depending on income and status.

Florida (Program Type: Incentives)

Florida is a coastal state which has an estimated 2.6 million onsite septic systems in operation, serving as a means of wastewater disposal for 30 percent of Florida's population. Florida represents approximately 12 percent of the United States' septic systems. The state has shallow groundwater and has had significant water quality issues. In 2008, legislation was passed that mandated the development of a comprehensive nitrogen reduction strategy for on-site systems.

Septic Upgrade Incentive Program

In 2016, the Florida Department of Environmental Protection (DEP) was authorized to issue funds for its Septic Upgrade Incentive Program (Program) pursuant to the Florida Springs and Aquifer Protection Act and resulting Basin Management Action Plans (BMAPs) to develop an incentive program to encourage homeowners to voluntarily remediate existing conventional septic systems and cesspools to include nitrogen reducing enhancements. Eligible enhancements include retrofitting septic tanks with advanced pre-treatment, recirculating aerobic treatment units, or replacing traditional septic tanks with upgraded nutrient-reducing technology.The incentive program offers subsidies, only in designated priority focus areas within a county, in amounts up to $10,000 per system and are designed to offset homeowner costs. Funds are available on a first come first served basis, until funding is exhausted. The subsidies are available for payment directly to septic system installers and licensed plumbers retained by homeowners to update existing conventional systems with enhanced nitrogen reducing features and must be pre-approved by DEP prior to the commencement of work. The Program is contingent upon appropriation by the

Legislature and, if required, an authorized release of the funds by the Legislative Budget Commission. DEP anticipated that program funding would be exhausted by April 17, 2020, for the current FY. It is anticipated that new funding will be available at the start of the new FY beginning on July 1, 2020.

In addition, the Governor's budget includes an earmark for $7.6 million specifically for septic upgrades for homeowners in rural areas where sewer systems are not available.

Texas

Texas is a coastal state with 25-35% of its population served by OSWT systems and approximately 45,000 new onsite systems installed every year. The state has developed a rigorous approval process for propriety and non-standard onsite treatment systems. Most of the current grant programs in Texas do not provide assistance to individual homeowners, however some do fund local and regional projects that may include septic system assistance. Some programs include:

Texas On-Site Sewage Facility Grant Program (TOGP):

TOGP gives competitive grants to support applied research and projects for on-site wastewater treatment technology and systems. This grant is funded from a fee collected for each on-site sewage facility (OSSF) permit issued.

319 Nonpoint Source Program:

This program cleans and prevents pollution caused by runoff from urban and nonagricultural nonpoint sources. Nonprofit organizations and state agencies are eligible, but individuals may not apply for direct funding.

Supplemental Environmental Projects (SEPs):

The SEPs are from the Texas Commission on Environmental Quality that includes programs that help homeowners with septic systems among other environmental projects. Project types can either be a contribution where the respondent contributes to a pre-approved SEP performed by a third party, custom where the respondent performs the project using their resources, or compliance where an eligible local government may correct the violation alleged in the enforcement or remediate environmental harm.

Minnesota (Program Type: Conduit Lending)

Small Community Wastewater Treatment Program

The Minnesota Public Facilities Authority (PFA) administers the Small Community Wastewater Treatment Program to provide financing to replace non-complying septic systems and straight pipes with new individual or cluster subsurface sewage treatment systems that are publicly owned, operated and maintained. To be eligible for financing, applicants must be a city, county, township, sanitary district or other governmental subdivisions that has a project ranked on the Minnesota Pollution Control Agency's (PCA's) Project Priority List (PPL). Projects are funded in priority order, as established by the PCA. The entity receiving financing must own the subsurface sewage treatment systems (SSTS) systems built under the program. Each property owner seeking to participate in the program must provide a utility easement to the entity to allow access to the system for maintenance and repairs.

Program funding, appropriated from the State's Clean Water Fund, via the Clean Water, Land and Legacy Amendment, provides for:

1. Technical Assistance Grants - Technical assistance grants of up to $60,000 are available to communities to contract with licensed SSTS professionals, counties, the University of Minnesota on-site sewage treatment program, or qualified nonprofit organization to: conduct preliminary site evaluations and prepare feasibility reports, provide advice on possible SSTS alternatives, and help develop the technical, managerial, and financial capacity to build, operate, and maintain SSTS systems.
2. Construction Loans/Grants - Construction financing is available for costs (design, construction, land acquisition and related legal fees) associated with replacing a non-complying system with publicly owned subsurface sewage treatment system. PFA will provide construction financing of up to $2 million per year at a 1% interest rate and grants of up to 80 percent based on affordability criteria. Disadvantaged communities may also qualify for 50 percent principal forgiveness (grant). The construction loan term is for up to 20 years, but not to exceed the design life of the systems. Loan repayments must begin no later than two years after the loan is awarded.

All unsewered communities seeking CWSRF funding for decentralized systems are required to establish a user charge system to pay for operation and maintenance costs associated with the system including development of:

- Financing Plan that provides a dedicated source of revenue for debt service and operation and maintenance (typically special assessments or user charges).
- Management Plan including a schedule for inspections, pumping, repair and replacement activities.

Alternatives analysis using the Wastewater Treatment Hierarchy "Wastewater Hierarchy" where the focus is on small, acute problem areas before deferring to a larger infrastructure solution to correct environmental or public health issues.

Appendix C

POTENTIAL FEDERAL AND STATE FUNDING SOURCES FOR HAWAIʻI

Current funding options for cesspool conversions for individual homeowners or groups of homeowners to finance OSWT systems are limited and typically consist of property assessments, tax credits and low-interest loans and grants from various Federal, State and community-based agencies. The following is a summary of federal and state funding options that can be used to fund cesspool conversion projects, but many require a public entity be the primary applicant.

Federal Funding

There are several highly competitive federal grant and low loan programs that provide financial resources that may be viable opportunities.

Environmental Protection Agency

Clean Water State Revolving Fund Programs

The CWSRF program is a federal-state partnership that provides communities with a source of low-cost financing for a wide range of water quality infrastructure projects. With the passage of the WRRDA Amendments, the CWSRF program eligibilities were greatly expanded, including the ability of the CWSRF program to provide financial assistance for the construction, repair and rehabilitation or replacement of decentralized wastewater treatment systems, as well as the ability for the program to provide financial assistance to any qualified non-profit entity, as defined by the administrator, to provide assistance to owners and operators of small and medium publicly owned treatment works. In addition, CWSRF programs may now provide assistance for the construction, repair or replacement of decentralized wastewater treatment systems that treat municipal wastewater or domestic sewage. CWSRF funding can be provided to public entities, such as municipalities, county governments, and state agencies, private and non-profit organizations.

CWSRF Loan Assistance Programs have considerable flexibility in their funding mechanisms and can set the conditions for loan assistance, an authority that can be exceptionally helpful in financing nontraditional eligibilities, such as cesspools, including:

- Loan maturities can range up to 30 years or useful life of the project.
- Repayment schedules can be structured to meet the needs of the borrower.
- Interest rates can vary from market rates to zero percent.
- Ability to target lower interest rates to DACs to incentivize a variety of goals such as nonpoint source projects, green projects, and the use of innovative technologies.
- Source of repayment does not have to be the project itself, any dedicated source of revenue can be used to repay a NPS loan.

The CWSRF program can be used to finance a variety of projects through various funding mechanisms. Selection of the mechanisms is based on the type of project, repayment source and depends on decisions made by State programs. The federal EPA delegates the CWSRF program authority to each State.

Water Infrastructure Finance and Innovation Act

The EPA's WIFIA established in 2017 provides a new financing mechanism for water and wastewater infrastructure projects. WIFIA provides low interest rate financing for the planning/design and or construction of large dollar-value water and wastewater projects. Eligible projects include:

- CWSRF and Drinking Water SRF eligible projects.
- Projects for enhanced energy efficiency at drinking water, wastewater and recycled water facilities.

- Brackish or seawater desalination project, an aquifer recharge project, water recycling project.
- Acquisition of property if it is integral to the project or will mitigate the environmental impact of a project.
- Bundled SRF projects submitted under one application by an SRF program.
- A combination of projects secured by a common security pledge.

Projects must cost no less than $20 million (or $5 million for small community projects) or an entity may bundle a group of projects together totaling a minimum of $20 million. The program provides a maximum loan not exceeding 49 percent of the project costs. The interest rate is equal to the US Treasury rate of a similar maturity plus a point. The loan term is for 35 years, with the option to defer repayment by 5 years. Unlike the SRF program, the WIFIA program has an "application fee" which ranges on average from $300,000-$500,000, which reconciles the cost associated with processing the loan.

The WIFIA application process is a two-step process, agencies are asked to submit a Letter of Interest which is reviewed by the EPA and evaluated based on the program priorities and on a set of scoring criteria. The EPA will invite selected project applicants to submit a formal application package. It is with the formal application that the applicants are requested to provide an initial application fee of $100,000 and upon entering a financing agreement borrowers are asked to reimburse the EPA for processing costs.

Non-Point Source Section 319 Grants

Under section 319 of the Clean Water Act, EPA provides grants to states to control nonpoint sources of pollution from a variety of sources such as agricultural runoff, mining activities, and malfunctioning onsite septic systems. The EPA encourages each state to use the funds to restore and protection the priority water body types including surface and groundwater. While all Section 319(h) funding decisions are made by the states, projects must be identified in the state's non-point source management plan. States submit their proposed funding plans to EPA. Some, but not all, states use these grants to construct, upgrade, or repair onsite systems. Note that individual homeowners are not eligible to directly receive grant assistance through this program, as the grants are typically provided to watershed organizations that are actively implementing watershed-based plans to restore impaired waterbodies. The federal appropriations vary year to year. In FY 2019, the total appropriation for the program was $165.4 million was allocated for the program. States are required to use 50 percent of their allocation for watershed projects, and the remaining funds can be used for non-point source projects. Recipients of the grant are required to provide a 40 percent non-federal match and projects must be completed within 5 years of grant award.

In Hawaiʻi, non-point source grants are administered through Hawaiʻi's Clean Water Branch Polluted Runoff Control Program, which is under the Hawaiʻi State Department of Health. In the 2015-2020 Hawaiʻi Nonpoint Source Management Plan, cesspool wastewater was identified as a source of non-point source runoff impacting the state's resources and identified the need to develop statewide strategies that address water quality protection and runoff from cesspools, agriculture and urban areas. The PRC Program typically issues a Request for Proposal on an annual basis. Grant recipients are required to provide a 25 percent non-federal match. The State has recently invested in cesspool replacement projects in Kauaʻi (Hanalei Bay watershed) with Section 319 funding, and there are plans to invest in additional cesspool replacement projects in the following years.

United States Department of Interior, Bureau of Reclamation

The USBR WaterSMART program, Reclamation provides cost shared financial assistance to states, tribes and local governments to help them plan and implement projects to increase water supply through investments to modernize existing infrastructure. WaterSMART funding opportunities include: Title

XVI/WIIN grants, Water and Energy Efficiency Grants, Drought Program, Basin Study, Desalination, and CWMPs.

United States Department of Interior, Bureau of Reclamation – Title XVI Program (Title XVI Authorized and WIIN Authorized Projects)

Reclamation administers funds for recycled water feasibility, demonstration, and construction projects through the Water Reclamation and Reuse Program authorized by the Reclamation Wastewater and Groundwater Study and Facilities Act of 1992 (Title XVI) and its amendments. The program provides as much as 25 percent of construction costs with a maximum of $20 million. To meet eligibility requirements a project must have a feasibility study, comply with environmental regulations, and demonstrate the ability to pay the remainder of the construction costs. Projects are authorized by Congress and recommended in the President's annual budget request by the USBR. Congress then appropriates funds and the Bureau ranks and prioritizes projects and disburses the money on a competitive grant basis each year. Prioritized projects are those that postpone the development of new water supplies, reduce diversions from natural watercourses, and reduce demand on federal water supply facilities, or that have a regional or watershed perspective.

United States Bureau of Reclamation - Drought Resiliency Program

Reclamation administers two grant programs under the Drought Resiliency Program.

- **Drought Contingency Planning:** Provides grant funds for the development of Drought Management Plan or for an agency to update an existing drought plan with grant awards of up to $200,000.
- **Drought Resiliency Projects:** USBR provides funding for the implementation of projects that build long-term resiliency to drought and reduce the need for emergency response actions that are identified in a Drought Management Plan. Projects eligible for funding should address at least one the following: serve to increase the reliability of water supply; improve water management; implement systems to facilitate voluntary water sales, transfers, or exchanges; and provide benefits for the environment are eligible. Types of projects include moving pipelines, small recycling, storage reservoir construction, and projects that increase flexibility in drought. The Drought Resiliency Grants provide as much as 25 percent of construction costs with a maximum of $300,000 for projects completed in two (2) years and $750,000 for projects that are completed in three (3) years. $20 million. To meet eligibility requirements a project must have a drought management plan, comply with environmental regulations, and demonstrate the ability to pay the remainder of the construction costs.

United States Bureau of Reclamation WaterSMART Small-Scale Water Efficiency Projects

Under the WaterSMART grants program, Reclamation provides a dedicated source of funding to fund small on the ground implementation projects to support water planning. USBR anticipates making $2 million available in Federal funding available in 2019. The total project cost should be capped at $150,000 and grant funding will include a 50/50 cost share with the total Federal funding limit of $75,000. Projects need to be completed within 2 years of grant award.

United States Bureau of Reclamation - WaterSMART: Water and Energy Efficiency

Through the WaterSMART Water and Energy Efficiency Grants program, Reclamation provides a 50/50 cost share funding to irrigation and water districts, Tribes, States, and other entities with water or power delivery authority. Eligible projects include projects that result in quantifiable and sustained water savings, increase renewable energy use and improve energy savings, and support broader water quality sustainability benefits. Projects that benefit endangered and threatened species, support water sustainability benefits, or implement activities to address climate related impacts on water may apply. Projects are selected through a competitive process and the focus is on projects that can be completed within 24 months that will help sustainable water supplies in the western United States. There are two funding limits for the program: $300,000 (typically for projects completed within a year; and up to $1,000,000 (for projects to be completed in 3 years). The total earmarked for this program in FY 2019 was $34 million.

United States Department of Interior, Bureau of Reclamation – Cooperative Watershed Management Program

Through the CWMP, Reclamation provides funding to watershed groups to encourage stakeholders to form local solutions to address water management needs. Funding is provided on a competitive basis for:

Watershed Group Development and Watershed Restoration Planning: This funding provides funding for the development of watershed groups, watershed restoration planning, and watershed management project design (Phase I). Eligible applicants include states, Indians, tribes, local and special districts, local government agencies and non-profit organizations. As part of Phase I activities, applicants may use funding to develop bylaws, a mission statement, complete stakeholder outreach, develop a watershed restoration plan, and watershed management project design. For this funding program, Reclamation will award up to $50,000 per year for a period of up to two years (total of $100,000) with no non-Federal cost-share required.

Implementation of Watershed Management Projects: Under this program, Reclamation provides cost-shared financial assistance to established watershed groups to implement watershed management projects. These on-the-ground projects, collaboratively developed by members of a watershed group, address critical water supply needs and water quality concerns, helping water users meet competing demands and avoid conflicts over water. Reclamation will award up to $300,000 per project. Applicants must contribute at least 50 percent of the total project costs.

United States Department of Commerce – Economic Development Administration

Public Works and Economic Adjustment Assistance Programs

The EDA provides grants for public works projects provide grant funding for public works projects, including wastewater and stormwater projects that promote economic development. The EDA through its Public Works and Economic Adjustment Assistance Program will provide support assistance with up to 50 percent in matching funds (up to $3 million) based on the number of permanent jobs created by the implementation of the proposed project. For every full-time job created, the EDA will provide $10,000 in EDA assistance. In order to apply a community, County or region must have a current Comprehensive Economic Development Strategies plan. The public entity would have to provide an economic impact statement demonstrating the anticipated growth associated with the project implementation as part of the application process. All construction projects are expected to be completed within 5 years from the date of award. Applications are accepted on a rolling basis. The EDA has published the FY 2020 Public Works and Economic Adjustment Assistance Programs Notice of Funding Availability and is soliciting applications in rural and urban areas. There are no submission deadlines and applications will be accepted until all funds have been expended.

United States Department of Agriculture

Water & Waste Disposal Loan and Grant Program

The USDA provides funding directed at low-income and or small water/wastewater utilities. USDA provides Predevelopment Planning Grants which assist low-income communities with the initial planning and development of applications required for USDA Development Program requirements include: 1) Population must be less than 10,000 people; and 2) Median household income below the poverty line or less than 80 percent of the statewide non-metropolitan median household income. Maximum grant amount of

$30,000 or 75 percent of the predevelopment planning costs. Twenty-five (25) percent cost share from applicant or third-party sources.

The Water and Waste Disposal Loan and Grant Program provides direct loan/grant and loan guarantees for clean and reliable drinking water systems, sanitary sewage disposal, sanitary solid waste disposal, and stormwater drainage. Eligible applicants include most state and government entities, private non-profits and federally recognized tribes. Eligible areas include rural areas and town with populations of 10,000 or less. Funds may be used to finance the acquisition, construction or improvement of sewer collection, transmission, treatment and disposal systems. Loans have a 40-year payback period, based on the useful life of the facilities. The interest rate is based on the need for the project and the median household income of the area to be served.

Rural Housing Service

Under the Rural Housing Service Program, USDA offers a variety of programs to build or improve housing and essential community facilities in rural areas. To ensure decent, safe and affordable housing remains available, USDA Rural Development can provide assistance through home repair loans and grants to remove health and safety hazards or make a home accessible for household members. Funds can be used to repair or replace furnaces, appliances, electrical, foundations, siding, roofing windows, plumbing, wells, septic systems and other health and safety hazards. Loans are available up to $20,000 at a one percent fixed interest rate for up to 20 years. Seniors age 62 and older, who do not have repayment ability for a loan, may be eligible for a loan and grant combination to make needed repairs and improvements. The maximum lifetime grant amount is $7,500. Funds can cover all upfront and construction costs, including septic system designs, permits and installations. Program eligibility is based on household income that cannot exceed 50 percent of the area median income and the property must be located in a rural community.

Rural Economic Development Loan and Grant Program

The Rural Economic Development Loan and Grant program provides funding for rural projects through local utility organizations. USDA provides zero-interest loans to local utilities which they, in turn, pass through to local businesses (ultimate recipients) for projects that will create and retain employment in rural areas. The ultimate recipients repay the lending utility directly. The utility then is responsible for repayment to USDA. USDA provides grants of up to $300,000 to local utility organizations which use the funding to establish RLFs. Up to 10 percent of the grant funds may be applied toward operating expenses over the life of the RLF. Loans are then made from the RLFs to project sponsors (up to 80 percent of project costs). First time loans are provided at 0 percent interest, subsequent loans may incorporate interest rates or administrative loan fees. When the RLF is terminated, the grant is repaid to USDA. Program eligibility is based on household income that cannot exceed 50 percent of the area median income and the property must be located in a rural community.

United States Department of Housing and Urban Development – Community Development Block Grants (CDBG)

The HUD awards discretionary funding through various programs including the CDBG program. The CDBG program, authorized under Title 1 of the Housing and Community Development Act of 1974, provides grant funding to communities to develop viable urban communities by "providing housing and a suitable living environment, and by expanding economic opportunities". HUD provides annual funding to states, which then allocates money to local communities in the form of CDBGs.

CDBG Entitlement Program

The Entitlement Community CDBG Program provides federal funding to entitled cities and counties to carry out a wide range of community development activities directed at revitalizing neighborhoods, economic development, and providing improved community facilities and services. Entitled communities are defined as those cities with a population of greater than 50,000 and counties with populations of greater than 200,000. Funding is provided to entitled communities to meet housing and community development needs. Entitlement communities develop their own programs and funding priorities. However, maximum feasible priority must be provided to projects that benefit low- and moderate- income persons. In addition, funding maybe allocated for activities, if the grantee certifies that the activities meet other community development needs having a particular urgency because existing conditions pose a serious and immediate threat to the health or welfare of the community where other financial resources are not available to meet such needs.

CDBG Non-Entitled Counties in Hawaiʻi Program

HUD administers the Non-Entitled CDBG Program in for the state of Hawaiʻi and allocates funds on a formula basis using population, poverty and housing overcrowding as a basis for allocating funds. The FY 2004 Appropriations Act requires that HUD administer the program in Hawaiʻi in the same manner that it administers the CDBG Entitlement Grant Program. The Non-Entitled CDBG Grants in Hawaiʻi offer a source of funding to benefit community needs in but not limited to economic development, housing rehabilitation, public facilities, construction or installation for the benefit of low- to moderate-income persons. HUD's Honolulu Field Office directly administers the CDBG Program for non-entitlement counties in the State of Hawaiʻi.

In Hawaiʻi three counties qualify for this program - Hawaiʻi, Kauaʻi and Maui. Non-entitled communities are defined as cities with a population of less than 50,000 and counties with populations less than 200,000. Many of the programs are similar to that of the entitlement program with grants for community development activities directed at neighborhood revitalization, infrastructure, economic development and improved community facilities and services. Like the entitlement project, eligible activities include construction of public facilities and improvements, such as water and sewer facilities, and streets, public services, activities related to energy conservation and renewable resources, etc. No less than 70 percent of the funds must be used for activities that benefit low- and moderate-income persons over a period specified by the state, not to exceed 3 years. In order to receive CDBG funds, non-entitlement CDBG grantees must submit a Consolidation Plan (the jurisdictions comprehensive planning document) to the Honolulu field office. *To utilize this program, the County's would need to agree to use their CDBG funds towards this purpose.*

Section 108 Loan Guarantee Program

Section 108 Loan Guarantee Program (Section 108) provides CDBG recipients the ability to leverage their annual grant allocation to access low-cost, flexible financing for economic development, housing, public facility, and infrastructure projects. Communities can use Section 108 guaranteed loans to either finance specific projects or to launch loan funds to finance multiple projects over several years. Section 108 can fund economic development, housing, public facilities, infrastructure, and other physical development projects, including improvements to increase resiliency against natural disasters. Section 108 assistance can be deployed in two ways:

- Directly by the community or its governmental or non-profit partner to carry out an eligible project
- Indirectly with a community or its partner re-lending (or, in limited circumstances, granting) the funds to a developer or business to undertake an eligible project

The loan amounts are based on the entities latest CDBG amount received and capped at five times the amount minus any outstanding Section 108 commitments. The maximum loan repayment period is 20 years and the interest rate varies based on the treasury yield.

State Funding Options

The following is a summary of current and potential state funding options for cesspool conversions. The focus of the funding options review was limited to those options available for individual homeowners or groups of homeowners to finance OSWT systems and typically consist of property assessments and low-interest loans and grants from various State and community-based agencies. Funding options to connect to a county of private wastewater system are not included below.

Hawaiʻi State Department of Health Clean Water State Revolving Fund Program

The CWSRF Program has existed since 1988 when the State legislature passed Act 365 which was superseded by HRS Chapter 342-D Part V. This program provides financing for the construction of water pollution control projects necessary to prevent contamination of groundwater and coastal water resources and to protect and promote the health, safety and welfare of the citizens of the State of Hawaiʻi. It also provides low interest loans to county and State agencies to construct point source and nonpoint source water pollution control projects. Loan terms for this program include terms of no more than 30 years; annual interest rate of 0.25 percent and a semi-annual loan fee of 0.5 percent. Terms are fixed over the life of the loan and proceeds can be used for planning, design and construction activities. Loan proceeds fund up to 80 percent of project costs and require a 20 percent non-federal match.

Since the program was established in 1988, approximately $875.40 million in low interest loans have been provided to counties in the State to fund water quality improvements. In Federal Fiscal Year (FFY) 2019, the State was expected to receive $12.3 million for additional loans. The program includes a Green Project Reserve of 10 percent which is reserved to fund green infrastructure. For FY 2019, this set aside was approximately $1.23 million.

This fund has been used to support the closure of LCCs in the State and DACs are specifically targeted for this program. The requirements for the fund have been modified to address the needs of individual cesspool owners, homeowner associations and nonprofit organizations so that they have access to loans to fund new decentralized systems to replace cesspools.

Applicability for Cesspool Conversions: This a viable funding program for cesspool conversions, however the administrative workload on CWSRF staff will need to be addressed.

Hawaiʻi Rural Community Assistance Corporation (RCAC)

Public agencies, tribal governments, and nonprofits in the State are eligible to apply for this program which has been in existence for 35 years. Eligible projects include water, wastewater, solid waste and storm water facilities that primarily serve lower-income rural communities. Individual homeowners will likely need to create SIDs to apply for this source of funding. "Green lending" includes a prioritization component whereby applicants indicate water and energy savings giving them higher funding priority.

Feasibility, pre-development, and construction projects are eligible. Feasibility efforts are typically not more than $50,000 and a typical term is 1 year. Pre-development projects such as engineering, legal and bond counsel efforts are typically not to exceed $350,000 and the term is 1 year. Maximum loans for construction funding is $3M. Loan terms are up to 20 years; 5.0 percent for the first 10 years and subject to change for longer term loans. Loan fees are 1.0 percent.

RCAC has funded water projects on Maui and Oʻahu.

Applicability for Cesspool Conversions: This a viable funding program for cesspool conversions for lower income rural communities.

Hawaiʻi Rural Water Association (RWLF)

The State association is a chapter of the Rural Water Association and provides funding to infrastructure projects targeted at replacing equipment, providing system upgrades and completion of small projects including energy efficiency, sustainability and disaster recovery projects. Current loan terms include interest rates of 3.0 percent and a repayment periods of 10 years. Loan amounts are typically less than $100,000 or 75 percent of total project costs, whichever is less. There are no administrative fees. Eligible systems must be public entities (municipalities, counties, special purpose districts, Native American Tribes, non-profit corporations and cooperatives) serving up to 10,000 people.

Applicability for Cesspool Conversions: This a viable funding program for rural communities. However individual homeowners will likely need to create a SIDs to apply for this source of funding.

Proposed Hawaiʻi Cesspool Remediation and Conversion Loan Program

State SB 2850/HB2540/SB 221 introduced legislation in 2018 that would create a specific program for cesspool remediation and conversions. This program is envisioned to provide low-interest loans to cesspool owners for the upgrade or conversion of cesspools to aerobic treatment unit systems in each county. The loan program would include an on-bill financing option supported by funding from the water pollution control revolving fund. In 2019 SB 221 was passed to establish a similar loan program, effective July 2019. This program was to be implemented through the Counties in coordination with DOH.

Applicability for Cesspool Conversions: It is not clear whether this program has been implemented.

Office of Hawaiian Affairs Malama Loans

The mission of the Office of Hawaiian Affairs (OHA) is: "To enhance access for all persons of Native Hawaiian ancestry to credit, capital and financial services and skills so as to create jobs, wealth, and economic & social well-being for all the people of Hawaiʻi." To support their mission OHA provides loans and grants for Native Hawaiian businesses and individuals.

The Malama Home Improvement Loan is available in amounts ranging from $2,500-$100,000. Loans over $20,000 must be secured by non-real estate assets. Current terms are 5-6 percent interest and up to a 7-year loan period. Loan applications must include: Proof of Hawaiian ancestry and Hawaiʻi residency; Contractor's estimate of the work; 2 years federal tax returns and W-2s; and 1 month current pay stubs.

While this program has limited eligibility, i.e. not all cesspool homeowners are Native Hawaiian, it may be a financing option for those who do qualify. The state may consider evaluating funding options tied to Native Hawaiian ancestry through organizations like Bishop Estate and the Department of Hawaiian Home Lands to assist the native Hawaiian community. This approach could already be available through Federal programs such as HUD.

Hawaiʻi Cesspool Tax Credits, State Income Tax Credit (Act 120)

Hawaiʻi currently provides a state income tax credit for qualified cesspool owners upgrading to a septic system, aerobic treatment unit, or connecting to a sewer. Qualified cesspools are cesspools that are: located within 500 feet of a shoreline[14], perennial stream or wetland[15], or within a source water assessment program area[16]. A list of cesspools (identified by tax map key and county) that already meet the criteria of Act 120 is available on the DOH website[17].

A taxpayer may apply for a tax credit of up to $10,000 for documented expenses associated with upgrading each qualified cesspool. Under the current law, tax credits are available for five years (tax years 2016-2020), ending on, December 31, 2020. The state provided a maximum of $5,000,000 of credits that are available for each tax year. Any taxpayer who has upgraded a qualified cesspool but is not eligible to claim the credit in a taxable year because the cap has been reached shall be eligible to claim the credit in the subsequent years. As of February 2020, House Bill 1723 which extends the tax credit from December 31, 2020 to December 31, 2025 was progressing through the legislature, passing the Second Reading and referred to committee for further deliberations.

While this program has several financial advantages for those homeowners who file state income taxes, there are likely many homeowners who are below the threshold for filing state income taxes and therefore are not able to take advantage of this option. Given that only 47 applications have been filed for this credit[18], this incentive may have limited appeal and application to current cesspool owners. This challenge will be addressed in the Affordability Analyses in a subsequent TM.

While the tax credits help to offset some construction costs associated with the conversion, it does not provide:

- Relief for the on-going maintenance and management of the new OSWT option.
- Relief to low-income customers who do not earn enough to qualify for this credit.
- Relief in upfront costs to retain assistance from a licensed civil engineer.

In addition, depending on the selected OSWT, the credit may only cover a fraction of the cost borne by the homeowner. Pending legislation may extend the term of this program, however an assessment of the accessibility by all homeowners to this incentive should be considered and other mechanisms identified.

[14] Hawaiʻi Administrative Rules §13-222-2
[15] Hawaiʻi Administrative Rules §11-54-1
[16] As determined by the Department of Health based on a two year time of travel from a cesspool to a public drinking water source
[17] https://health.hawaii.gov/wastewater/home/taxcredit/
[18] Number of filings from 2015-2017.

Appendix D

POTENTIAL CWSRF FUNDING MECHANISMS FOR NON-TRADITIONAL PROJECTS

The following is a summary of potential mechanisms by which the State CWSRF programs can provide financial assistance through the counties or other public entities to individual residential owners.

Direct Loans:

CWSRF programs are able to make direct loans to any municipality, inter-municipal, interstate, or state agency for construction of publicly owned treatment works. Additionally, in some cases, CWSRF programs can make direct loans to private borrowers under certain circumstances.

Co-Financing:

Local communities can use a variety of state and federal funding sources to help co-finance infrastructure improvements. Funding sources, such as the EPA, USDA, USBR, HUD, and other State funding programs, often offer opportunities to co-fund projects with the CWSRF program. Co-financing projects is useful for large projects that cannot be entirely funded by the State's CWSRF program, or if there are project costs that may not be eligible under CWSRF but are eligible under other programs.

CWSRF programs can also enter into a co-financing arrangement with other state agencies and programs, allowing the program to leverage existing relationships and mechanisms by which to award and disburse funding. Several states have used this approach to reach borrowers for NPS projects by partnering with state agricultural offices that already have an existing relationship with landowners.

Partnerships:

Many types of partnerships are possible in the CWSRF program, which can allow the program to extend the reach of the program to fund projects that might otherwise not be in a position to receive CWSRF assistance. The Delaware CWSRF has entered into master lease/purchase agreement with another state agency to fund necessary infrastructure improvements including a wetland remediation. The CWSRF is the lessor and the state agency is the lessee under a memorandum of understanding with the CWSRF loan provided in the form of a lease paying project and repayments are in the form of rental payments.

Conduit/Intermediary Lending

The following is a summary of two mechanisms for conduit/intermediary lending.

Pass through Lending

Pass-through lending distributes CWSRF funds through a conduit entity/agency to an end borrower. Conduit entities include state agencies, counties, conservation districts and local municipalities. The benefits of a pass-through lending approach includes:

- Conduit entity (e.g. county) is frequently able to bundle several sub-loans and complete the CWSRF application requirements for all of them, reducing the administrative burden on individual end borrowers as well as the CWSRF program.
- As the conduit organization is the loan guarantor, a pass-through arrangement provides a more secure financial capability assurance for the CWSRF program as opposed to making loans directly to the small, untested end borrowers.
- A pass-through structure makes it possible for CWSRF subsidies, such as principal forgiveness, to reach non-municipal, nontraditional projects via the eligible public pass-through partner, who can then channel the savings through to a private or nonprofit end-user.

Linked Deposit

Linked deposit financing takes advantage of a provision in the CWSRF authorizing statute allowing CWSRF funds to be used "to earn interest on fund accounts". In a linked deposit arrangement, a state CWSRF program purchases a reduced-rate certificate of deposit from a private financial institution. The financial institution then loans out the deposited funds (at a slightly lower interest rate) to individuals for smaller-scale water quality projects. Other states have used linked deposits to successfully fund projects such as septic replacements, agricultural best management practices, or environmentally friendly forestry equipment. This mechanism allows the individual end borrowers to work directly with their own financial institutions instead of the CWSRF program. Financial institutions earn a fee that compensates them for administrative the loans. The financial institution is responsible for reviewing and approving applications from the end borrowers (as well as collecting payments), removing much of the administrative burden that would otherwise fall to the CWSRF program.

Sponsorship Lending

CWSRF programs can combine assistance to both traditional and nontraditional projects in the same loan agreement (e.g. traditional public treatment works project with a non-point source project). This allows user fees from the traditional portion of the project to serve as a repayment stream for the nontraditional project. Typically, a municipality receives a loan with a reduced interest rate as compensation for undertaking/ "sponsoring" a nontraditional project thus allowing municipalities to address pressing watershed restoration or water quality protection priorities without placing a repayment responsibility on NPS projects. For added incentive, a CWSRF could further reduce the interest rate so that the municipality would save money rather than break even.

Programmatic Financing

Programmatic financing shifts traditional project-specific lending strategy to one that is designed to fund the utility's entire capital improvement plan (CIP) (or any portion thereof) so long as the projects are eligible and in compliance with CWSRF program requirements. This can also encompass non-point source projects (stormwater, green infrastructure, and restoration projects) that are eligible and included as part of the CIP. The focus is on the schedule and pace of disbursements for a "package" of projects on an annual basis under a single loan agreement. With programmatic financing, if a project in the CIP is delayed or falls through, the funding can be directed towards other eligible project activities in the CIP. This approach has been used successfully in Minnesota and Rhode Island for a number of years, and is currently being implemented in Hawaiʻi.

Portfolio Lending

Portfolio Lending is a strategy to commit funding over time to one or several projects identified in a CIP or watershed management plan. Both options can easily accommodate nontraditional projects. Portfolio lending requires careful cash-flow management to ensure that program funds are not over-extended, but can provide a valuable level of certainty to a CWSRF program's project pipeline. While the borrower must still complete the CWSRF application process to receive a loan each year, they have the assurance that the state revolving fund (SRF) will have the financial capacity to fund the project.

Capital Improvement Plans

With CIP Portfolio Lending, the CWSRF program commits to fund a certain portion (or all) of a municipality or utility's CIP over time, assuming each project meets eligibility and priority criteria. This helps to develop borrowing relationships to ensure stable demand for CWSRF funds and contributes to the municipality's long-term planning efforts. If nontraditional projects are included in the CIP, they can be financed at the same time instead of trying to finance as standalone projects.

Watershed Management Plan

With a Watershed Management Plan approach, there is a higher priority placed on funding projects that address water quality on a watershed basis. The planning and implementation activities associated with watershed management projects lend themselves well to a portfolio funding approach that encompasses numerous projects in various stages through a multi-year lifespan.

Intermunicipal Lending

In Intermunicipal Lending, an intermunicipal agency is established by two or more municipalities, which is then eligible for CWSRF assistance. The agency can facilitate cross-jurisdictional coordination and funding support for regional solutions to water quality problems. The assistance recipient could be a single entity within the agency or the agency itself and would be ultimately responsible for the implementation of the portfolio of projects eligible for CWSRF assistance. It is also important to note that a CWSRF can provide authorized assistance to intermunicipal agencies, including loan guarantees for "sub-state revolving funds." However, the cooperation and coordination required in the development, funding and implementation of "joint' projects might be a challenge.

For example, the Missouri CWSRF provided a $1 million loan to the MACOG to capitalize the Missouri On-Site Wastewater Improvement Grant-Loan program. This pass-through arrangement provides financing for homeowners to repair or replace on-site wastewater treatment systems. The program provides a 50 percent/50 percent low-interest loan and grant for low-income homeowners or a 60 percent/10 percent/30 percent low-interest loan/grant/homeowner match for non-low-income homeowners. While MACOG coordinates the entire program and holds the loan agreement with the CWSRF program, the program is administered by the nineteen individual regional planning commissions and councils of government throughout Missouri for customers in their jurisdictions.

Planning and Design Lending

CWSRF programs can also provide planning and design low interest loans and grants. In some states, the planning and design loan becomes interest-free or is forgiven if the borrower pursues CWSRF construction financing. Loan forgiveness is particularly helpful to nonpoint source projects. For example, in the state of Arizona, the WIFA administers the CWSRF program and uses a portion of their fee revenue to fund a planning and design program aimed at providing much needed assistance to communities with limited resources who need help in completing this kind of work. This funding is capped at $35,000 per project with a 40 percent local match.

Purchasing Local Debt Obligations

Clean Water Act Title VI allows states the opportunity to provide assistance through the purchase or refinancing of local debt obligations. For example, States may purchase general obligation or revenue bonds issued by municipalities, inter-municipalities, and interstate agencies at or below market rates, so long as such debt obligations were incurred after March 7, 1985. In terms of financing nontraditional projects, the purchase of local debt presents a viable alternative for intermunicipal borrowers, interstate agencies, public private partnerships (P3), and nontraditional projects with longer useful life expectancies including, but not limited to, land purchases, conservation easements, and watershed restoration efforts.

Credit Enhancements

With a credit enhancement program, a highly-rated CWSRF program guarantees third-party debt (such as a bond issue) for a municipality or utility with a weaker credit rating. The guarantee agreement between the CWSRF and the assistance recipient results in more favorable borrowing terms for the recipient, allowing the entity to take advantage of interest rates similar to what it might receive on a traditional CWSRF loan. At the same time, this arrangement allows the CWSRF program to stretch its assistance capabilities further since a guarantee does not require the same cash outlay as a traditional loan. This form of assistance has not been widely used among CWSRF programs.

CWSRF Bond Issuance

The following are two types of bonds that could be issued by the CWSRF program to help finance the cesspool conversions.

Traditional Bonds

The sale of bonds by or on the behalf of the CWSRF programs has produced a tremendous boost in the assistance provided by SRF programs. Since 1989, 29 CWSRF programs have leveraged their programs in this manner, issuing approximately $42 billion in bonds to finance eligible projects. CWSRF bonds can be sold to finance traditional projects, nontraditional projects, or both. There is not a lot of experience in the marketplace for the sale of bonds to finance only non-traditional projects. To issue bonds, the CWSRF program must have the capacity (e.g., free cash flows and debt service reserve if necessary) to enter into debt, secure it, and make debt service payments. Equally important is a sufficient pipeline of projects that are ready to proceed; therefore, the demand for nontraditional projects should be carefully assessed along with their readiness to proceed before bonds are issued.

Green Bonds

"Green Bonds" are municipal bonds issued with a commitment to direct proceeds exclusively toward environmentally beneficial purposes. Although the terminology is new (coined in 2008 by the World Bank), the concept is tried-and-true for CWSRF programs that have leveraged funds, since the proceeds from leveraged bonds have always been used for projects benefitting the environment. For the most part, Green Bonds are typically issued with the same pricing and terms as the issuer's standard bonds, but may be marketed to different investors

Appendix B

Technical Memorandum 2:
AFFORDABILITY EVALUATION FOR CESSPOOL CONVERSIONS
(November 2020)

Hawai`i State Department of Health
Cesspool Conversion Finance Research

Technical Memorandum 2
AFFORDABILITY EVALUATION FOR CESSPOOL CONVERSIONS

FINAL | November 2020

carollo
in association with Harris & Associates

Hawai`i State Department of Health
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Abbreviations

ACS	American Community Survey
ALICE	Asset Limited, Income Constrained, Employed
ATU	aerobic treatment unit
Carollo	Carollo Engineers, Inc.
CBG	census block group
CCWG	Cesspool Conversion Working Group
COVID-19	Coronavirus Disease 2019
DOH	Department of Health
FPL	Federal Poverty Level
GIS	Geographical Information Systems
HM	hours of minimum wage
Legislature	Hawai'i State Legislature
mgd	million gallons per day
MHI	median household income
O&M	operations and maintenance
OSWT	onsite wastewater treatment
TM	technical memorandum
USEPA	United States Environmental Protection Agency
UV	ultraviolet
WWTP	wastewater treatment plant

Technical Memorandum 2

EXECUTIVE SUMMARY

ES.1 Introduction

Throughout the State of Hawai‘i, there are approximately 88,000 cesspools, releasing an estimated 53 million gallons per day (mgd) of wastewater to the environment. Most of the existing cesspools provide wastewater disposal for single family residences, as opposed to large-capacity systems serving multiple residences or commercial areas. Given that over 90 percent of the state’s drinking water supplies are from groundwater sources, cesspools pose a potential environmental and public health risk.

In 2017, the Hawai‘i State Legislature (Legislature) passed Act 125, which states that by January 1, 2050 all cesspools in the state, unless granted exemption, shall upgrade or convert to a septic or aerobic treatment unit (ATU), or connect to a sewer system (Act 125, 2017). The Legislature then passed Act 132 in 2018, which established a Cesspool Conversion Working Group (CCWG) to develop a long range, comprehensive plan and commission a statewide study of sewage contamination in nearshore marine areas (Act 132, 2018). The CCWG retained Carollo Engineers, Inc., (Carollo) to provide expertise on onsite wastewater treatment (OSWT) technologies as well as cesspool conversion funding, finance options, and affordability.

As a result of Act 125, cesspool owners will be required to upgrade their existing cesspools to an OSWT technology that complies with environmental and public health regulations. The cost associated with cesspool conversions will likely be a financial burden to many residential owners in a state where the cost of living is already high. The Legislature tasked the CCWG to develop a strategy to aid the funding and financing of the cesspool upgrades. The purpose of this technical memorandum (TM02) is to evaluate the affordability issues associated with the requirements of Act 125. A previous TM (TM01) summarized potential funding mechanisms that may be applicable to provide financial support to homeowners for their cesspool upgrades.

ES.2 Purpose and Limitations

The purpose of this TM is to evaluate the potential financial impacts on cesspool homeowners that must upgrade to an approved OSWT system. In addition, this TM provides an evaluation of the overall affordability of cesspool conversions based on industry standards and local financial measures.

It should be noted that this is a preliminary affordability evaluation, and that the CCWG is engaged through other focus areas, such as public outreach where valued feedback is considered. This evaluation was completed based on publicly available information and did not include public input. Future public outreach and education are planned as a part of the overall cesspool conversion strategy development under separate contracts.

Other considerations that may have impacts to the affordability evaluation include exemptions to cesspool conversion (at the discretion of the Department of Health [DOH] per Act 125), or changes to the priority areas and definitions. Ongoing efforts under separate contracts are underway to study available cesspool data validation and prioritization. If new information or guidance on cesspool priority areas is developed, the affordability evaluation should be revisited.

ES.3 Potential Financial Impact of Cesspool Conversions on Homeowners

This TM considers the potential monthly financial impacts of cesspool conversions on individual homeowners. Many homeowners will require some type of financial assistance to convert their cesspools to an approved OSWT technology. Depending on the financing option and OSWT technology selected, the cesspool conversion project could result in financial impacts to the residents ranging from approximately $94 to $339 per month as shown in Table ES.1. The table summarizes the potential costs to homeowners for a range of cesspool upgrade options. The "low" scenario represents the simplest and most straightforward cesspool upgrade to a septic tank system. The "average" and "high" scenarios represent typical and more complex cesspool upgrades, respectively for the purposes of this affordability analysis.

Table ES.1 Summary of Potential Monthly Financial Impacts to Cesspool Homeowners

Cost Description	Cesspool Conversion Cost Scenarios		
	Low	Average	High
Installation Cost(1)	$10,000	$23,000	$38,000
Monthly Installation Repayment Cost(2)	$61	$139	$230
Monthly O&M Cost(3)	$33	$71	$109
Estimated Total Monthly Cost	$94	$210	$339

Notes:
(1) Based on historical installation costs for septic tank and ATU treatment and disposal systems from DOH. The low costs represent the 10th percentile, and the high costs represent the 90th percentile. All conversion costs are site specific and these costs may not be representative for more complex sites/installations.
(2) Based on 20-year loan at 4.0 percent interest rate.
(3) Monthly operations and maintenance (O&M) costs are estimated with the low cost representing septic tank operations costs. The high cost represents a higher level of treatment with ATU + UV disinfection + seepage pit. The average operations cost is the average of the low- and high-end values.

The total low costs are comparable to the monthly sewer bill for a customer connected to a centralized public wastewater system in the state.[1] However, most homeowners will be required to pay more than the comparable monthly sewer bill to convert a cesspool to an alternative OSWT technology.

ES.4 Affordability Analysis

The affordability analysis compared the range of cesspool conversion costs to various measures of affordability, including federal poverty, and median household income (MHI) levels.

In addition, the analysis includes a scenario evaluating the potential impacts of a hypothetical $10,000 rebate program. This scenario was included to evaluate how some level of financial relief would improve the affordability of cesspool conversions. Certainly, there are many more scenarios of financial relief that can be evaluated in coordination with future policy decisions. This scenario was intended to be only one example.

The affordability analysis used total cesspool conversion costs, which include the cost to replace the cesspool with an approved OSWT technology and the cost to operate and maintain the new OSWT. The analysis does not net out any maintenance costs (e.g. routine pumping) that a homeowner currently incurs for an existing cesspool.

Although there are a number of methodologies that have been suggested as guidance for affordability of water and/or wastewater services (some of which are described herein), this analysis primarily relies on the

[1] The typical monthly sewer bill for an average household ranges from $40 to $111 depending on the location within the state.

traditional financial capability assessment guidelines established by the United States Environmental Protection Agency (USEPA). Under this guidance, a household is considered "cost burdened" when wastewater services exceed 2 percent of household income (USEPA, 1997). These households who will be required to convert to an alternate OSWT technology with income below the Federal Poverty Level (FPL) were also identified and considered.

Figure ES.1 illustrates the estimated number of residents financially burdened by the cesspool upgrade cost by county without and with a $10,000 rebate based on the USEPA 2 percent criteria. This analysis shows that 97 percent of residents with cesspools across the state would be financially burdened by the need to fund cesspool conversion and maintain the new OSWT. This decreases to 85 percent if each cesspool homeowner could receive a $10,000 rebate for conversion.

Hawaiʻi County has the greatest projected financial impact, with the costs of cesspool conversion without a rebate exceeding 2 percent of the MHI for all census block groups containing cesspools. Hawaiʻi County also has 48,303 cesspools, more than three times as many as any other county in the state.

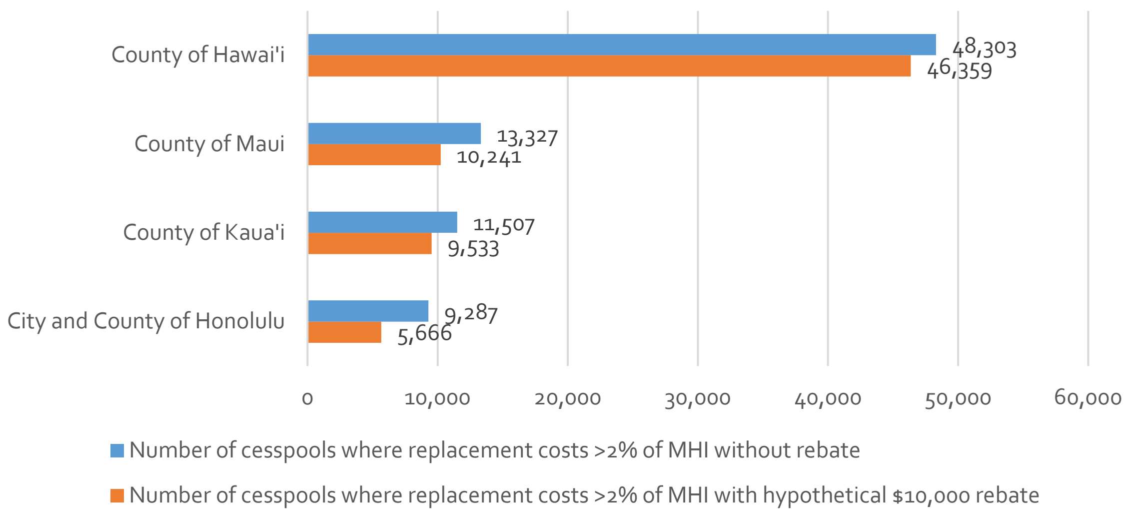

Figure ES.1 Number of Residents with Cesspools Projected to be Financially Impacted by Cesspool Conversion Costs with and without the Rebate(1)(2)(3)

Notes:
(1) Assumes average cesspool conversion cost scenario of $210 per month.
(2) Assumes all homeowners can obtain a hypothetical rebate of $10,000.
(3) MHI = median household income

Figure ES.2 shows the income distribution for residents with cesspool by county, based on the median household income for Census Block Group of the cesspool. The same affordability threshold amounts are shown as previously described along with the FPL. Looking at the county level, significant disparities appear in the income distribution. Hawaiʻi County, which has the largest share of cesspools, has 69 percent or 33,185 residents with cesspools with an income between $40,000 and $80,000 per year. By comparison, over 80 percent or 8,903 residents with cesspools in the City and County of Honolulu have an income above $80,000 per year. Residents with cesspools with incomes greater than $80,000 encompass 53 percent (6,444 residents with cesspools) for Maui County and 48 percent (6,479 residents with cesspools) for Kauaʻi County.

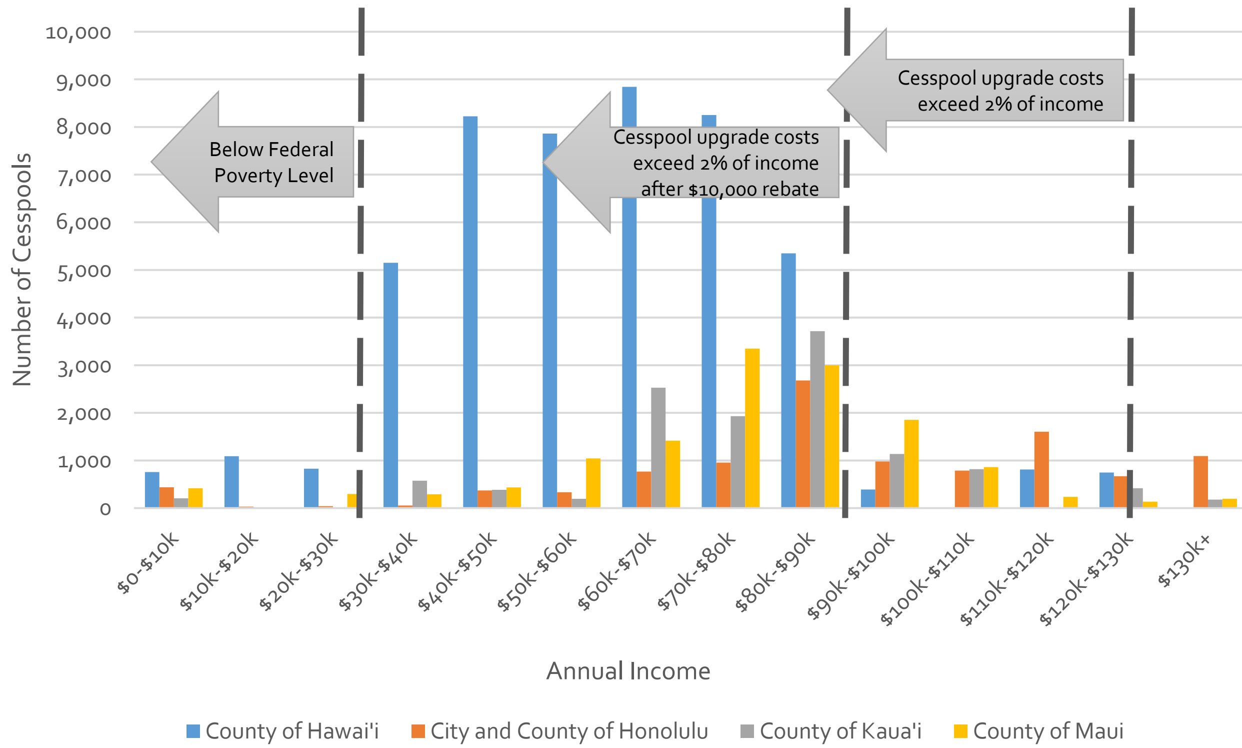

Figure ES.2 County Median Household Income Levels and Estimated Conversion Cost as Percent of Annual Income(1)

Notes:
(1) Assumes average cesspool conversion cost scenario of $210 per month.

ES.5 Summary and Conclusions

Many residents with a cesspool will struggle to afford the conversion and ongoing system O&M costs required by Act 125. These challenges appear to be most acutely felt in Hawai'i County, where income and poverty levels indicate the greatest number of households projected to need assistance. However, these challenges are also felt by a significant number of residents with cesspools across the state as well.

There are two basic ways to increase affordability: 1) either through reducing the monthly cost; or 2) providing direct funding support. The state could investigate both options as ways to increase the number of cesspools replaced as part of this program. To reduce monthly costs, low-interest loan programs can help households with a stable but insufficient income to afford cesspool upgrades. Households living below the FPL have the greatest need for direct funding support. The number of residents with cesspools in these categories are shown in Table ES.2 by county and statewide. Table ES.2 also shows the number of residents with cesspools that fall below the 2 percent MHI threshold with and without a hypothetical rebate. To address environmental and public health concerns, direct funding could also be prioritized for cesspools located in high priority, sensitive ecological, or drinking water source areas. This will enhance the effectiveness of the program and help reach established environmental goals.

Table ES.2 Summary of the Residents with Cesspools by County Based on Key Affordability Criteria(1)

Affordability Measure	County of Hawai'i	County of Kaua'i	County of Maui		City and County of Honolulu	Statewide
			Maui	Moloka'i		
Number of Households with Cesspools Below Federal Poverty Level(2)						
Below Federal Poverty Level	3,254	204	416	297	512	4,683
Number of Households with Cesspools Where Conversion Cost Exceeds 2 Percent Median Household Income(2)						
With $10,000 Rebate	46,359	9,533	9,000	1,241	5,666	71,799
Without $10,000 Rebate	48,303	11,507	11,888	1,439	9,287	82,424

Notes:
(1) Affordability analysis was for the average scenario with $23,000 cesspool upgrade costs, and monthly costs of $210 if the cesspool conversion is financed over 20 years at 4 percent interest.
(2) Federal poverty level is $30,718 annual income.
(3) The 2 percent of median household income threshold is $126,125 annual income based on the USEPA definition of "cost burdened".

To determine the amount of financial assistance that may be needed, it is also important to consider the portion of the cesspool conversions costs that *can* be afforded by homeowners. With the exception of those with estimated annual income below the FPL, it was assumed that homeowners could afford to privately finance an amount that results in a monthly payment less than or equal to 2 percent of their estimated monthly income less the average monthly maintenance cost for the selected replacement technology. If that amount is less than the average of conversion costs, it is assumed the difference would require financial aid. Table ES.3 summarizes the estimated amount of conversion costs that can be afforded or privately financed versus the amount of financial aid that may be required. It is anticipated that more than $900 million in financial aid is required to support cesspool conversions for homeowners who are financially burdened.

Table ES.3 Estimated Private Financing and Financial Aid Required for Cesspool Conversions(1)

Priority	Total Private Financing(2) ($ million)	Total Financial Aid Required(3) ($ million)
1	$89.8	$106.5
2	$94.2	$239.3
3	$164.7	$256.3
4	$557.6	$440.1
Totals	**$906.3**	**$1,042.2**

Notes:
(1) Based on average conversion cost of $23,000.
(2) Assumes residents can afford up to 2 percent of estimated household income for cesspool conversions, financed at 4 percent interest over 20 years.
(3) Assumes cesspool conversion costs in excess of 2 percent of estimated household income will require financial aid. Residents with income levels below the federal poverty limit are assumed to require financial support for all conversion costs.

Technical Memorandum 2

AFFORDABILITY EVALUATION FOR CESSPOOL CONVERSIONS

2.1 Introduction

Based on the 2004 *Clean Watersheds Needs Survey Report to Congress*, 62 percent of the residents in the state of Hawaiʻi are served by centralized wastewater treatment facilities, and the remaining 38 percent are served by decentralized or OSWT systems. There are approximately 110,000 OSWT systems, including 88,000 cesspools and over 21,000 septic systems in the state.

The USEPA defines a cesspool as an underground excavation that receives sanitary wastewater from bathrooms, kitchens, and washers. Figure 2.1 is a schematic diagram of a typical cesspool. Cesspools are designed to capture wastewater solids but are not designed to provide wastewater treatment or nutrient removal. The structure usually has an open bottom and perforated sides. Domestic wastewater flows into the structure and the solid waste collects at the bottom, while the liquid waste flows out to percolate into the subsurface that may be hydraulically connected to groundwater and surface water.

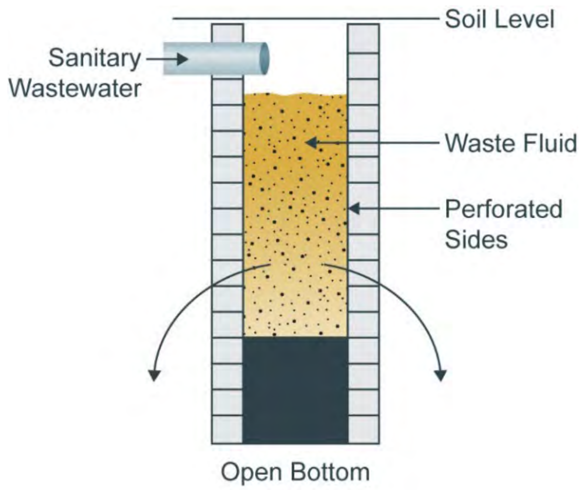

Figure 2.1 Cesspool Schematic

Most of the existing cesspools in Hawaiʻi serve single family residential units and are spread out through the state. Table 2.1 summarizes the estimated number of cesspools by county, as well as the estimated total wastewater discharged by cesspools. Of these, 43,000 cesspools have been identified as posing a risk to the state's water resources, with 31,000 of these located within the perennial watersheds on the counties of Hawaiʻi, Kauaʻi, Maui, and Molokaʻi (DOH, 2018).

Table 2.1 Estimate of Cesspools and Total Anticipated Discharge by Island(1)

Island	Estimated Housing Units	Estimated Number of Cesspools	Estimated Cesspool Effluent (mgd)
Hawaiʻi	82,000	49,300	27.3
Kauaʻi	29,800	13,700	9.5
Maui(2)	65,200	12,200	7.9
Molokaʻi(2)	3,700	1,400	0.8
Oʻahu(3)	336,900	11,300	7.5
Total	**517,600**	**87,900**	**53.0**

Notes:
(1) Confirmation of the actual number of cesspools, locations, and priorities is being conducted under a separate task of the CCWG.
(2) Maui and Molokaʻi are within Maui County.
(3) Oʻahu includes all the City and County of Honolulu.

In total, these cesspools are estimated to discharge 53 mgd of untreated sewage to the groundwater system and coastal waters. Untreated wastewater from cesspools contain nutrients (nitrogen and phosphorous) and pathogens such as bacteria, protozoa, and viruses, which can have an impact on drinking water, water quality in streams, rivers, and other receiving water bodies, and the health of the state's reefs and the health of Hawaiʻi's residents and visitors.

In 2017, the Hawaiʻi State Legislature passed Act 125, which states that by January 1, 2050 all cesspools in the state of Hawaiʻi, unless granted exemption, shall upgrade or convert to a septic system or aerobic treatment unit (ATU), or connect to a sewer system (Act 125, 2017).

To incentivize "early adopter" cesspool conversion, the state of Hawaiʻi established a temporary tax credit program in 2016 under Act 120. Act 120 provided a $10,000 tax credit to homeowners for the upgrade of qualifying cesspools and is set to expire on December 31, 2020.

Act 132 was passed in 2018 to establish the CCWG to develop a long range, comprehensive plan and commission a statewide study of sewage contamination in nearshore marine areas (Act 132, 2018). Act 132 directed the DOH to evaluate residential cesspools in the state, develop a report to the legislature that includes a prioritization method for cesspool upgrades, and work with the Department of Taxation on possible funding mechanisms to reduce the financial burden on homeowners. The CCWG retained Carollo to provide expertise on cesspool conversion technologies and funding and finance options.

As a result of Act 125, homeowners will be required to upgrade their existing cesspools to approved technologies. The CCWG recognized that the cost associated with the conversion will be a significant financial burden to individual residential owners. One of the complex challenges tasked to the CCWG is to develop a strategy to aid the funding and financing of the cesspool conversions.

Figure 2.2 shows a stepwise approach to guiding cesspool homeowners through the conversion process. The CCWG and key advisors are developing the overall strategy to the cesspool conversion program, including public outreach, treatment technologies, data validation and prioritization, and finance research. The information on funding mechanisms provided in TM01 and the information on the affordability of cesspool conversions for homeowners provided in this TM02 is intended to support step #5 shown in Figure 2.2. However, there is a significant amount of strategy, planning, and coordination that will be completed by the CCWG and others over the next few years.

Figure 2.2 Stepwise Approach to Cesspool Conversions for Homeowners

Historical costs to upgrade a cesspool to an approved OSWT and disposal system (e.g. septic system or ATU followed by soil absorption system) range widely from approximately $9,000 to $60,000 or more depending on system capacity, technology, location or site constraints, and size of dwelling unit[2]. With 88,000 cesspools requiring upgrades, total upgrade costs could range between $880 million to more than $5.3 billion.

While there are low-interest loan and grant funding opportunities from federal, state, and local financing sources, these sources combined fall significantly short of what is required to fully fund all conversions. In addition, most of the financing programs are available only to government entities, such as state agencies or counties, and are not targeted and in most cases unavailable to private, residential property owners. This is further complicated by the fact that state agencies and the counties do not currently have the staff or the administrative capabilities to receive grant or loan funds; review and process individual homeowner applications; disperse the funds to the homeowners; and, in the case of loans, conduct follow-up payment collection.

Incentivizing residents to convert existing cesspools will be challenging. Despite the benefits of improving public health and the environment, there are currently no immediate state mandates[3] or regulatory drivers to incentivize conversions and there are few financial incentives for homeowners to convert or upgrade their systems. Cesspools are generally very low-cost and there are minimal maintenance requirements. Significant challenges to the successful conversion of the state's cesspools includes:

- Identification of individual residential incentives.
- Identification of sustainable funding mechanisms for the financing of capital expenditures, long-term costs associated with the maintenance and management of OSWT systems, and overall program administration.
- Identification of funding mechanisms that consider homeowner affordability as well as DOH and/or county administrative workload.

In addition to financial incentives, there is a need to identify and quantify the benefits (e.g., economic, environmental, water quality, etc.) to be gained from converting cesspools that can be communicated to individual homeowners to further incentivize the homeowners to convert.

[2] Based on cost data from DOH. See Appendix A.
[3] The cesspool conversion deadline in Act 125 is January 1, 2050.

2.1.1 Method of Cesspool Conversion

There are generally three options for cesspool conversions:

- **Connection to existing or new centralized sewer systems.** In the large municipal areas of Hawaiʻi, homes and businesses are connected to county or privately-owned sewer collection and treatment systems, where wastewater flows to a centralized facility for treatment and disposal. Centralized sewer collection and treatment systems are generally cost efficient because of economies of scale. These facilities treat the wastewater either for discharge or for water reuse applications. However, new connections typically must pay significant capital investment fees required by counties or private developers to connect to the centralized system, and connections to centralized systems may not be feasible for many cesspool conversions.
- **Connection to decentralized sewer systems.** Decentralized sewer systems (also "cluster" wastewater systems) are similar to centralized sewer systems, but typically have a smaller collection system service area and wastewater treatment facility. Decentralized treatment can range from passive treatment with soil dispersal to more sophisticated, mechanical treatment, such as membrane bioreactors.
- **Conversion of cesspools to approved OSWT and disposal systems.** Approximately 38 percent of the households in Hawaiʻi are served by decentralized or OSWT and disposal systems, including cesspools (USEPA, 2008). Since many of the cesspools are in rural areas without centralized or decentralized wastewater systems, conversion to approved OSWT and disposal systems may be the most cost-effective option for some homeowners compared to centralized and decentralized treatment options.

2.1.2 Purpose and Limitations

The purpose of this TM is to evaluate the potential financial impacts on cesspool homeowners that must upgrade to an approved OSWT system. In addition, this TM provides an evaluation of the overall affordability of cesspool conversions based on industry standards and local financial measures.

It should be noted that this is a preliminary affordability evaluation, and that the CCWG is engaged through other focus areas, such as public outreach where valued feedback is considered. This evaluation was completed based on publicly available information and did not include public input. Future public outreach and education are planned as a part of the overall cesspool conversion strategy development under separate contracts.

Other considerations that may have impacts to the affordability evaluation include exemptions to cesspool conversion (at the discretion of DOH per Act 125), or changes to the priority areas and definitions. Ongoing efforts under separate contracts are underway to study available cesspool data validation and prioritization. If new information or guidance on cesspool priority areas is developed, the affordability evaluation should be revisited.

The affordability analysis in this TM includes a scenario assuming all cesspool homeowners can utilize a hypothetical $10,000 rebate to reduce cesspool conversion costs. It is acknowledged that additional funding and alternatives scenarios can be evaluated to determine what policy decisions would assist homeowners with cesspool conversion affordability. To streamline this affordability evaluation, two approaches to defining cesspool conversion affordability were used. However, there are many ways to define affordability thresholds as it relates to wastewater services and cesspool upgrades. Other affordability definitions and thresholds can be considered in future evaluations.

2.2 Potential Financial Impacts of Cesspool Conversions on Homeowners

Traditional water and wastewater infrastructure projects generally involve significant expenditures which provide benefits to a community which share in those costs. Cesspool conversion is a significant expenditure with limited, immediate benefit to an individual homeowner. Nevertheless, families are likely to bear the cost of conversion and on-going maintenance without any way to help recover these costs. While addressing affordability of the cesspool conversions for homeowners it is important to clearly understand not only the cost of the conversion, but also the potential impacts of financing options. A previous TM (TM01) evaluated potential alternative financing mechanisms. The affordability analysis is based on a single financing approach.

The cost of cesspool conversion includes up-front construction/installation and ongoing O&M costs. Cesspool conversion costs to an approved OSWT system (e.g., septic tank system, ATU, or other approved technology) have ranged from $9,000 to $60,000 with an average of $23,000, based on historical installation costs provided by DOH (see Appendix A). These large cost ranges illustrate that there are many factors involved in the cost of a cesspool retrofit which can include type and size of the system, different site conditions (soil type, access, slope, etc.), different material costs, and different market conditions (e.g. number of available contractors). Such data show that it is challenging to come up with a "typical" cost, because there are so many variables – basically each project is different and generalizing costs is very difficult.

Depending on wastewater treatment and disposal options, the annual O&M cost can vary from $400 (septic tanks) to $1,300 (ATU, ultraviolet (UV) disinfection, and seepage pit). Annual O&M costs for septic tanks includes inspection and pumping of the septic tank approximately once per year. The upper range of annual O&M costs include power and maintenance costs for ATU + UV disinfection + seepage pit (Babcock et al, 2019).

Table 2.2 summarizes anticipated monthly homeowner financial impacts using the mid-range financing terms for a home equity loan. The ranges are based on the average cost of $23,000 for installation, with low and high cost scenarios of $10,000 and $38,000 based on the 10th and 90th percentile cost estimates, respectively (see Appendix A). O&M costs are based on a range from $400 to $1,300 per year, with an average of $850. There can be variations in the financing term and interest rates that are possible, however, the installation costs are assumed to be financed over 20 years at 4.0 percent, based on current market rates for home equity loans as of July 2020.

The costs shown in Table 2.2 are total cesspool conversion costs, which include the cost to replace the cesspool with an alternative OSWT technology and the cost to maintain the new OSWT. Any existing maintenance costs that a cesspool owner pays on the existing cesspool have not been considered.

Table 2.2 Summary of Potential Monthly Financial Impacts to Cesspool Homeowners

Cost Description	Cesspool Conversion Cost Scenarios		
	Low	Average	High
OSWT Installation Cost (total)(1)	$10,000	$23,000	$38,000
Interest rate (percent)(2)	4.0	4.0	4.0
Loan Term (years)(2)	20	20	20
OSWT Installation Cost (monthly)(2)	$61	$139	$230
Estimated O&M Cost (monthly) (3)	$33	$71	$109
Estimated Monthly Cost	**$94**	**$210**	**$339**

Notes:
(1) Based on historical installation costs for septic tank and ATU treatment and disposal systems from DOH. The low-end costs represent the 10th percentile, and the high-end costs represent the 90th percentile. All conversion costs are site specific and these installation costs may not be representative for more complex sites/installations.
(2) Installation costs are assumed to be financed over 20 years at 4 percent based on market rates for home equity loans as of July 2020.
(3) O&M costs are based on $400 (assuming a septic tank) to $1,300 per year (assuming ATU + UV disinfection + seepage pit), with an average cost of $850/year.

2.3 Affordability Analysis

An affordability analysis was performed for the cesspool conversion program. This analysis is intended to estimate the relative financial impact of cesspool upgrades on homeowners. Figure 2.3 is a schematic of the data sources, costs, and affordability measures that were used in the analysis. Each of these components are summarized in the following sections.

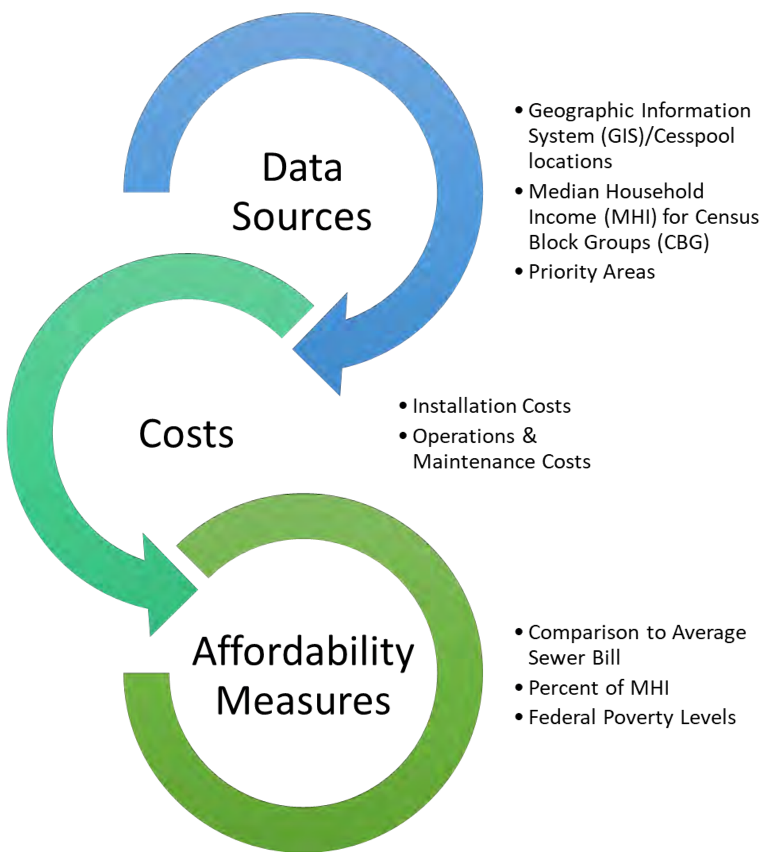

Figure 2.3 Data Sources, Costs, and Affordability Measures included in the Affordability Analysis

2.3.1 Data Sources and Collection

The primary data sources for the affordability analysis included:

- Geographic Information System (GIS) shapefiles for Hawai'i, Kaua'i, Maui, Moloka'i, and O'ahu showing individual cesspools, gathered from the Hawai'i Statewide GIS Program[4].
- GIS shapefiles for Cesspool Upgrade Priority Areas (DOH, 2018).
- MHI and number of households living in poverty for each census block group, collected from the American Community Survey (ACS) for 2018 from the U.S. Census Bureau (ACS, 2018). A census block group is the smallest geographical unit for which demographic data is available. Census block groups generally follow geographic and infrastructure boundaries such as rivers, railroads, and streets, and as a result tend to follow neighborhood boundaries. Census block groups typically cover an area with 600 to 3,000 people.[5]

2.3.2 Data Processing

The following sections describe the data processing for household demographics, and cesspool conversion prioritization and costs, monthly sewer bill comparisons, and affordability measures.

2.3.2.1 Household Demographic Data

A geospatial analysis of the Hawai'i cesspool locations was performed to assign economic and prioritization data to each cesspool site. For each household with a cesspool, a corresponding MHI and number of households living in poverty for the census block group from the ACS 2018 data was assigned. The ACS 2018 demographic data serves as a useful estimate for the income and poverty of each property owner with a cesspool in the data. Poverty data was gathered from the ACS 2018 data and assigned this to each cesspool based on its census block group.

2.3.2.2 Cesspool Conversion Prioritization

As identified in the 2018 Legislature Report, the cesspools were sorted by the priority upgrade areas. These priority upgrade areas were developed with the goal of funding a conversion program for low-income property owners. The priority upgrade categories are as follows (DOH, 2018):

- **Priority 1:** Significant risk of human health impacts, drinking water impacts, or draining to sensitive waters.
- **Priority 2:** Potential to Impact Drinking Water.
- **Priority 3:** Potential Impacts on Sensitive Waters.
- **Priority 4:** Impacts Not Identified.

If funding is limited, these priority areas represent a useful metric when allocating grants, loans, and other funding offsets to property owners. The CCWG is currently reviewing the priority areas and definitions as a part of the overall strategy development via the data validation and prioritization subgroup.

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[4] http://geoportal.hawaii.gov/

[5] For more information regarding Census Block Groups, please refer to the US Census Bureau, please see https://www.census.gov/programs-surveys/geography/about/glossary.html#par_textimage_4

2.3.3 Terminology & Definitions

Throughout this TM, there are several financial terms and other definitions used to describe the analysis. Key terms and definitions are summarized as follows:

- **Affordability.** Throughout this TM, "affordability" refers to the ability for a household to pay for wastewater services without facing economic hardship. For cesspool conversion costs to be considered affordable, households would not need to consider forgoing medically necessary prescriptions or doctors' visits, sacrifice meals, face the inability to pay for childcare, energy bills, or rent/mortgage, for example (Raucher et al, 2019).
- **Financially burdened.** Those that are financially burdened would have to sacrifice essential expenses, such as those listed for affordability, to be able to pay for cesspool conversions.
- **Living wage.** A living wage is the amount of income that a household needs to pay for essential living expenses. The living wage developed by the Massachusetts Institute of Technology accounts for essential expenditures in several categories, including food, housing (including utility costs), transportation, medical care, childcare, and taxes[6].
- **Federal Poverty Level.** The FPL provides a benchmark for determining what households can be considered "impoverished" and thus qualify for assistance and support programs, but there is often a large segment of households that are above this threshold but struggle to make ends meet with their income[7].
- **Homeowner or cesspool owner.** Ultimately, it is the responsibility of the homeowner or the persons that own the property with the cesspool to meet the cesspool conversion requirements outlined in Act 125. However, some of the properties with cesspools may be rented to another resident.
- **Resident.** The resident lives at the property with the cesspool and the resident may or may not own the property. It is the resident's income level that is shown in the median household income dataset, which is a key assumption of the affordability analysis described herein. It is acknowledged that the cesspool conversion costs may or may not be passed from the homeowner to the resident (if rented).

2.3.4 Affordability Methodology

The affordability analysis included evaluation of various measures of affordability and financial impact for the cesspool conversion to answer the following questions:

- What percent of income should a typical household be expected to spend on cesspool conversion?
- How likely is it that a cesspool owner either lives below the poverty level or is significantly income-constrained?
- How does the conversion cost compare to a wastewater connection to a public system and monthly service cost for sewered areas?

Cost impacts to homeowners were previously described in Section 2.2. For installation costs, it was assumed that the conversion would be financed through a home equity loan over 20 years at 4.0 percent. There are several methodologies that have been suggested as guidance to define affordability for water and/or wastewater services. Those that have been considered herein include percent of median household income,

[6] https://livingwage.mit.edu/

[7] https://www.census.gov/topics/income-poverty/poverty.html

federal poverty and Asset Limited, Income Constrained, Employed (ALICE) levels, labor hours at minimum wage, and comparison to local sewer bills. Each is described in the following sections.

2.3.4.1 Percent of Median Household Income

Historically, affordability for water and wastewater service has been benchmarked as a percentage of MHI. The USEPA has advanced this metric in the past, stating that wastewater should be less than 2 percent of income to be considered "affordable" (USEPA, 1997). For most analysts, median household income for the municipality, zip code, or some other geographic boundary is readily available, and as a result, the percent of MHI approach has been broadly accepted as a crude measure of affordability for decades, with some going higher or lower than 2 percent. For instance, Fitch Ratings has published guidance that it generally views rates above 1 percent of MHI as "financially burdensome" for customers (Fitch Ratings, 2016).

Despite the broad use of this metric, the water and wastewater industry has sought alternatives over the last several years. Several authors have advanced new benchmarks to measure affordability in response. While percent of MHI is now a useful starting point, the same water and wastewater bill will have a much greater relative impact on a low-income household than a median income household. Affordability measures should therefore reflect this relative impact.

Much of MHI's shortcomings as an affordability measure stem from the fact that it is often used to cover too broad of a geographic area. The MHI for an entire state or even a county or zip code encompasses an extremely broad range of income levels and is likely to be representative of a relatively small subset of households.

In contrast, the MHI for a census block group is likely to more closely reflect the income levels of most residents because the block group tends to follow neighborhood boundaries and is likely to include less socioeconomic stratification. While the MHI for the entire state of Hawai'i represents the income distribution across approximately 1.4 million people, the MHI for a block group represents at most 6,000 people. Therefore, the percent of MHI for each block group was used for this analysis. It was assumed that the median household income for the block group is approximately representative of the individual cesspool owners.

There are still challenges and shortcomings to this approach. First, the census block group MHI does not differentiate between renters and homeowners, which may provide further levels of income stratification. Renters may report income that is then reflected in the census data but ultimately, they may not be directly paying for the cesspool conversion.

Second, even when using the median income of a small block group, there still may be substantial income stratification within the group. It is unlikely that this group will be perfectly homogeneous from a socioeconomic perspective. As a result, the MHI analysis focuses on a typical household, and does not reflect the lower end of the income distribution where affordability challenges are greatest.

The threshold where the average cesspool conversion and O&M costs are less than 2 percent of MHI is $126,125 per year for the average cost scenario ($210 per month).

2.3.4.2 Federal Poverty and ALICE Levels

Affordability challenges naturally begin at the lower end of the income distribution. Households with incomes below a "living wage" face the greatest difficulty paying for basic services like water and wastewater. A living wage is the amount of income that a household needs to pay for essential living expenses. The living wage developed by the Massachusetts Institute of Technology accounts for essential expenditures in several categories, including food, housing (including utility costs), transportation, medical care, childcare, and taxes. Several different measures were reviewed in this analysis to observe the baseline level of poverty. While these measures do not measure the affordability of the cesspool conversion costs (they do provide a benchmark for affordability), they do highlight where income constrained census block groups overlap with cesspool locations.

The census block group data includes an estimate of the number of households living in poverty. For 2018, the U.S. Census Bureau defined poverty level as a family with an income of less than $30,718.[8] The FPL provides a benchmark for determining what households can be considered "impoverished" and thus qualify for assistance and support programs, but there is often a large segment of households that are above this threshold but struggle to make ends meet with their income. In fact, the FPL is so low for most states, that many references to the FPL are in terms of multiples of FPL, e.g. 200 percent of FPL or 400 percent of FLP. "The FPL, with its minimal and uniform national estimate of the cost of living, far underestimates the number of households that cannot afford to live and work in the modern economy." (ALICE Report, 2020)

ALICE is one measure used to define households who may not qualify for aid under FPL measures but still have significant challenges making ends meet. ALICE household budgets are intended to provide a more realistic estimate of how much income is necessary to both live and work in each geography. This economic indicator has been in existence for about a decade. The 2018 ALICE household survival budget for a family of four in Hawaiʻi is estimated at $90,828 per year (United for ALICE, 2020). This compares to the FPL for a family of four estimated at $28,870 in 2018. There have been 3 reports published based on 2016, 2017 and 2018 data. It typically takes about 2 years to analyze the data. Therefore, the current 2020 ALICE report is based on 2018 data.

While ALICE indicators are prepared for each state through census data, approximately 20 states[9] actively support additional economic research in their respective states to further understand the drivers of economic challenges in their communities. This research is led by a 27-person national advisory committee that represents the various states, including Hawai'i and is tasked with making sure that the data and research are applied independently and consistently towards the development of ALICE models and tools.

The ALICE budget is comprised of the following categories: housing, childcare, food, transportation, health care, technology, taxes, savings, and miscellaneous (10 percent of budget).

The main conclusions of the most recent ALICE report for Hawai'i indicate a troubling trend. Despite strong economic growth until Coronavirus Disease 2019 (COVID-19) impacts hit the state in March 2020, the number of ALICE households rose from 22 percent in 2007 to 33 percent in 2018. The total number of households in Hawaii is estimated at 455,100. This trend is exacerbated by the recent COVID-19 impacts with the ALICE report estimating that an additional 35,000 households would become ALICE households by the end of 2020.

2.3.4.3 Hours of Labor at Minimum Wage

Some water utility affordability scholars have argued in support of using hours of labor at minimum wage as a measure of affordability (Teodoro, 2018). This metric puts the water and sewer bill in terms of how many hours a person would have to work at the local minimum wage in order to pay for sewer service. The minimum wage across the state is $10.10 per hour[10].

[8] For more information regarding the U.S. Census Bureau's poverty measures, please see https://www.census.gov/topics/income-poverty/poverty/guidance/poverty-measures.html
[9] AK, CT, FL, HI, ID, IL, IN, IO, LA, MA, MI, NJ, NY, OH, OR, PA, TN, TX, VA, WA and WI
[10] Effective January 1, 2018. See https://labor.hawaii.gov/wsd/minimum-wage/

2.3.4.4 Comparison to Centralized Wastewater Collection and Treatment

Many communities across the United States are served by centralized wastewater collection and treatment systems. While these are less prevalent in Hawai'i compared to other states, there are wastewater treatment plants (WWTP) across the state that can offer a comparative monthly cost for residential households. While comparing cesspool conversion costs with WWTP service charges does not measure affordability (as the monthly sewer bills may exceed 2 percent of income for some customers), it does provide a local benchmark for alternative cost.

Figure 2.4 shows typical average monthly sewer service charges for wastewater collection and treatment for the various counties compared to the monthly cost for cesspool conversion for the low, average, and high cost scenarios.

Hawai'i County has the lowest monthly wastewater bill at $40 per month on average, while City and County of Honolulu has the highest at $111 per month. As a percent of MHI for each county, the monthly wastewater bills range from 0.8 percent (Hawai'i County) to 1.6 percent (City and County of Honolulu).

Figure 2.4 Typical Monthly Sewer Bill Compared to Monthly Cesspool Conversion Costs for Average Scenario(1-4)

Notes:
(1) County of Hawai'i – single family monthly flat rate of $40.00
(2) City and County of Honolulu – based on estimated single family water usage at 9,000 gals/month. Wastewater bill is 80 percent of water usage*$4.63/kgals + base fee of $77.55 = $110.89
(3) County of Kaua'i – single family monthly flat rate of $60.09
(4) County of Maui – based on estimated single family water usage at 9,000 gals/month. Wastewater bill is based on all water usage up to 9,000 gals at $4.50/kgals + base fee of $32.50 = $73.00

2.4 Affordability Analysis Results and Discussion

To streamline the affordability analysis, this effort focused on the cesspool conversion costs relative to the percent of median household income levels by census block groups and federal poverty levels statewide and for each of the counties individually. Because the minimum wage is uniform across the state, this measure was not included with the county-level results. Affordability analyses using the ALICE household budget level are included in Appendix B for reference. Appendix C summarizes the affordability analyses by county and legislative district.

2.4.1 Statewide

The following sections summarize the affordability analysis for the state of Hawaiʻi, considering the percent of census block group median household income and federal poverty levels.

2.4.1.1 Census Block Group Median Household Income

Figure 2.5 shows the number of cesspools statewide by census block group MHI. The dashed black lines indicate the affordability threshold previously defined as 2 percent of MHI ($126,125 per year for the average cost scenario or $210 per month and $89,766 per year for the adjusted average cost scenario [after rebate] or $150 per month for cesspool conversion costs). The number of cesspools and MHI levels to the left of the dashed line are projected to have affordability challenges with the cesspool upgrades. By this definition, approximately 82,424, or 97 percent of all cesspool owners in the state will be financially burdened by cesspool upgrade costs without financial assistance. The FPL is shown for reference.

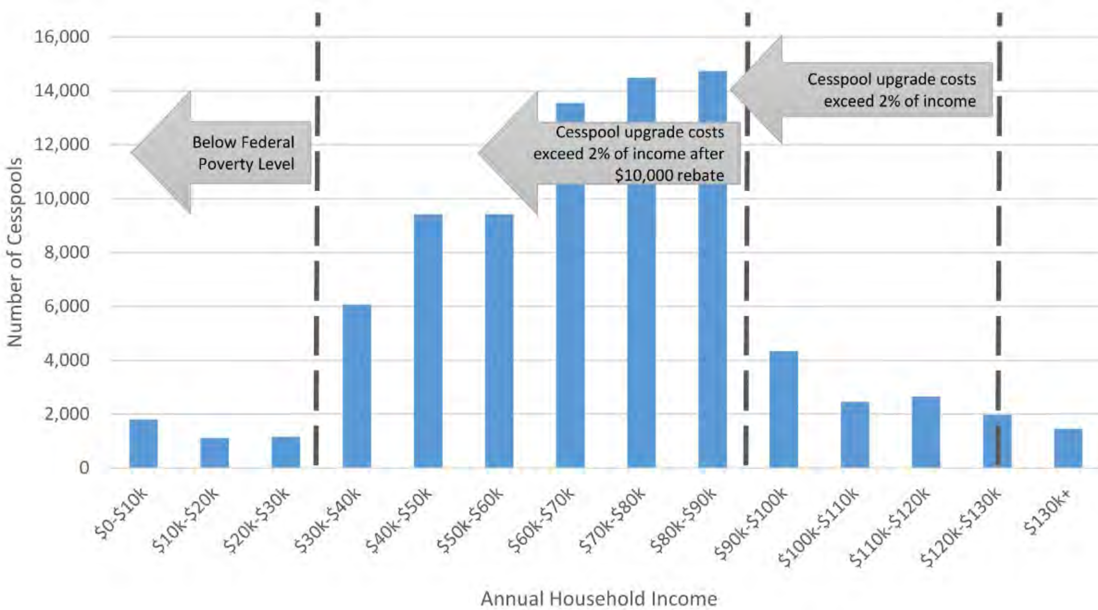

Figure 2.5 Statewide Number of Cesspool Homeowners Relative to Median Household Income Levels(1)

Notes:
(1) Assumes average cesspool conversion cost scenario of $210 per month.

Figure 2.6 shows the same information broken down by county relative to MHI levels and the affordability threshold. Assuming no financial assistance, an estimated 48,303 cesspools owners with affordability challenges are in Hawaiʻi County. The County of Maui has approximately 13,327 cesspool owners below the affordability threshold, followed by the County of Kauaʻi with approximately 11,507 homeowners impacted. Lastly, the City and County of Honolulu has the least number of homeowners impacted with approximately 9,287.

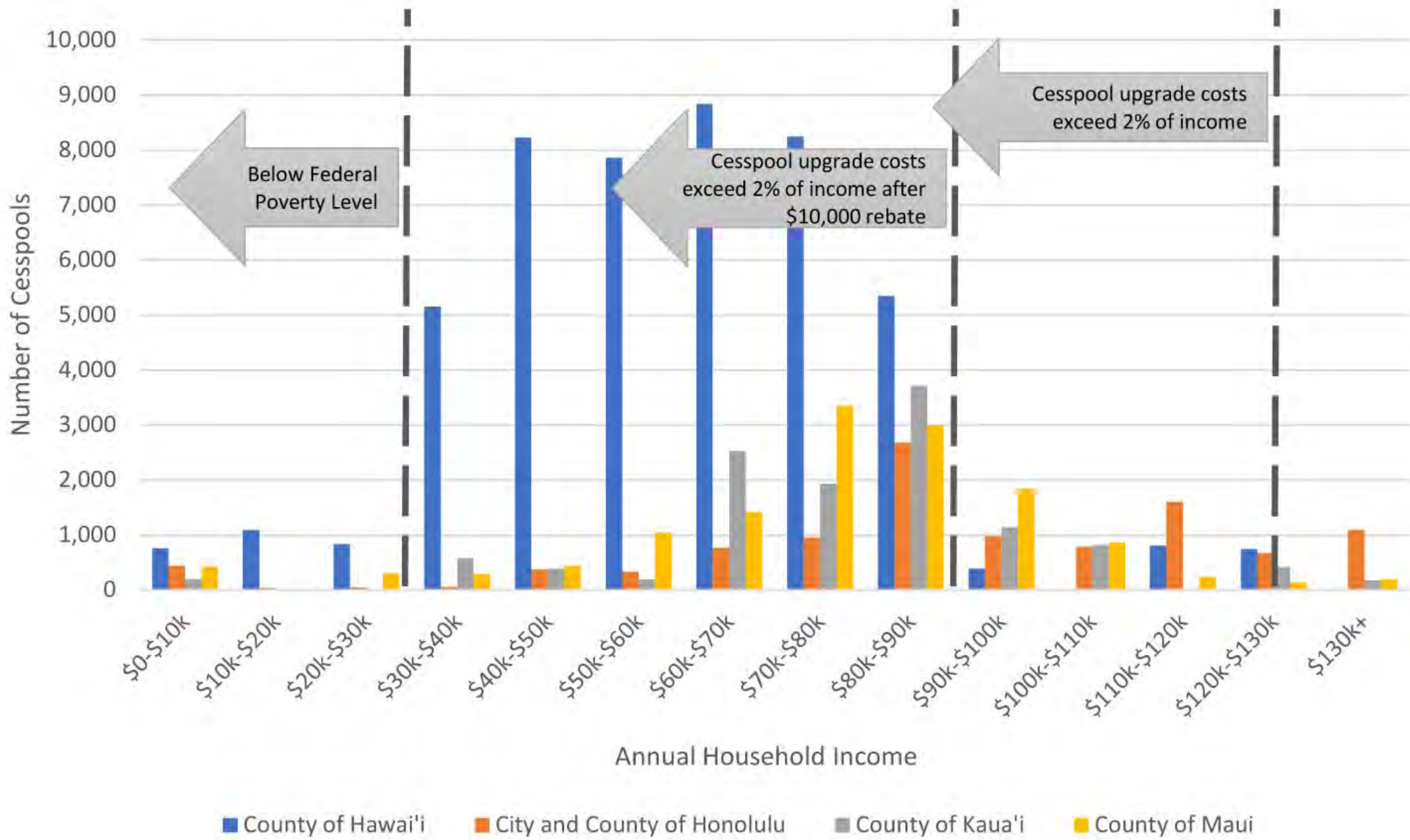

Figure 2.6 Number of Cesspool Homeowners Relative to Median Household Income Levels by County

Notes:

(1) Assumes average cesspool conversion cost scenario of $210 per month.

Table 2.3 shows the results of the affordability analysis considering census block group MHI by cesspool priority level. Assuming no financial assistance, the cost of cesspool conversions would exceed 2 percent of MHI for 97 percent of cesspool owners (all priority categories). It is estimated that 99 percent of the Priority 1 cesspool owners will have difficulty affording cesspool conversions. If the high cesspool conversion cost scenario is assumed (estimated cost of $339 per month), virtually all cesspool homeowners would be financially burdened by the conversion.

These results show that cesspool conversion costs would be a significant burden for most Hawaiʻi residents. Given that a vast majority of the cesspool homeowners are likely to find the conversion unaffordable even when costs are financed over 20 years, significant affordability challenges should be expected for the program, absent additional funding.

Table 2.3 Statewide – Number of Households Expected to Exceed 2 Percent of Income

Priority Categories	Number of Cesspools(1)	Number of Households Projected to Spend >2 percent of Income on Cesspool Conversion(2)		
		Low Cost	Average Cost	High Cost
1	8,532	341	8,434	8,532
2	14,500	5,048	14,321	14,500
3	18,306	3,121	17,717	18,306
4	43,379	16,759	41,952	43,358
Totals	**84,717**	**25,269**	**82,424**	**84,696**

Notes:
(1) Number of cesspools are based on GIS data and may not align exactly with the 2018 DOH report.
(2) Based on the median household income for the census block group where the cesspool site resides.

2.4.1.2 Poverty Levels

Across the state, it is estimated that 4.8 percent or 4,104 households with cesspools have incomes below the federal poverty level or $30,718.

Figure 2.7 shows the percent of cesspool homeowners by county and statewide that fall in various categories relative to the FPL ($30,718), including:

- Below FPL.
- Between 100-200 percent of FPL ($30,718-$61,436).
- Between 200-300 percent of FPL ($61,436-$92,154).
- Between 300-400 percent of FPL ($92,154-$122,872).
- Above 400 percent of FPL (>$122,872).

The County of Hawaiʻi has the most residents with cesspools located in block groups where the MHI is both below the FPL and between 100 and 200 percent of FPL, with 1,867 and 15,640 cesspools, respectively. The City and County of Honolulu, County of Maui, and County of Kauaʻi follow, with 489, 460, and 204 cesspools located in block groups where the MHI is below the FPL, respectively.

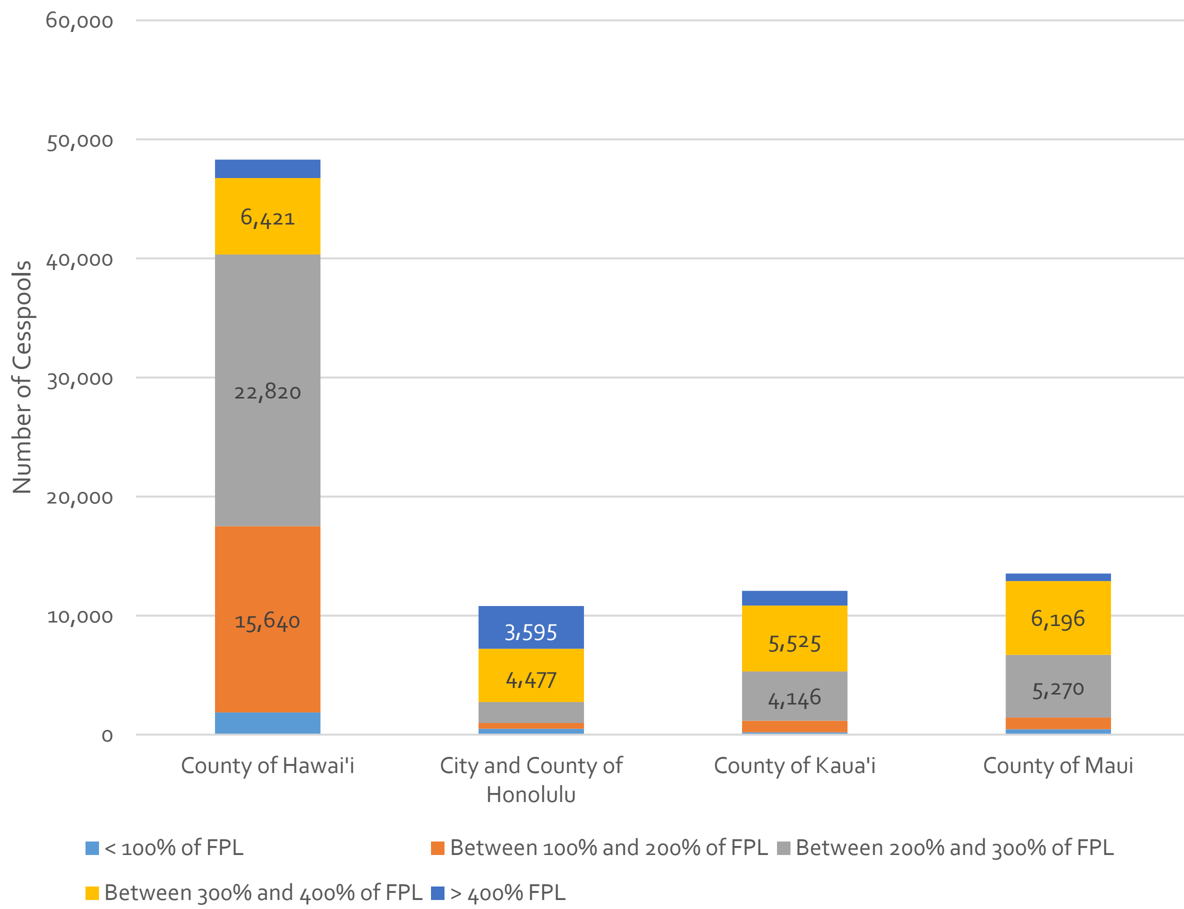

Figure 2.7 Number of Cesspool Homeowners by Federal Poverty Levels

2.4.2 County of Hawaiʻi

The following sections summarize the affordability analysis for the County of Hawaiʻi by percent of census block group MHI, and poverty levels. The County of Hawaiʻi has the largest number of cesspools (48,303), as well as the most residents facing affordability challenges. Hawaiʻi County also has the greatest proportion of households without centralized sewers than any other county (71 percent). This high percentage indicates that sewer mains are unlikely to be available for most properties. Without options to connect to existing centralized wastewater systems, the only option for many cesspool owners in Hawaii County is approved OSWT systems.

2.4.2.1 Census Block Group Median Household Income

Figure 2.8 shows the number of cesspools in the County of Hawaiʻi by census block group MHI. The dashed black lines indicate the affordability threshold previously defined as 2 percent of MHI (for full cost and adjusted cost after $10,000 rebate). As previously discussed, the County of Hawaii has the most significant cesspool conversion affordability challenges based on MHI data. Approximately 48,303 cesspools owners located in Hawaiʻi County (more than half of all cesspools in the state) are expected to face affordability challenges for conversions.

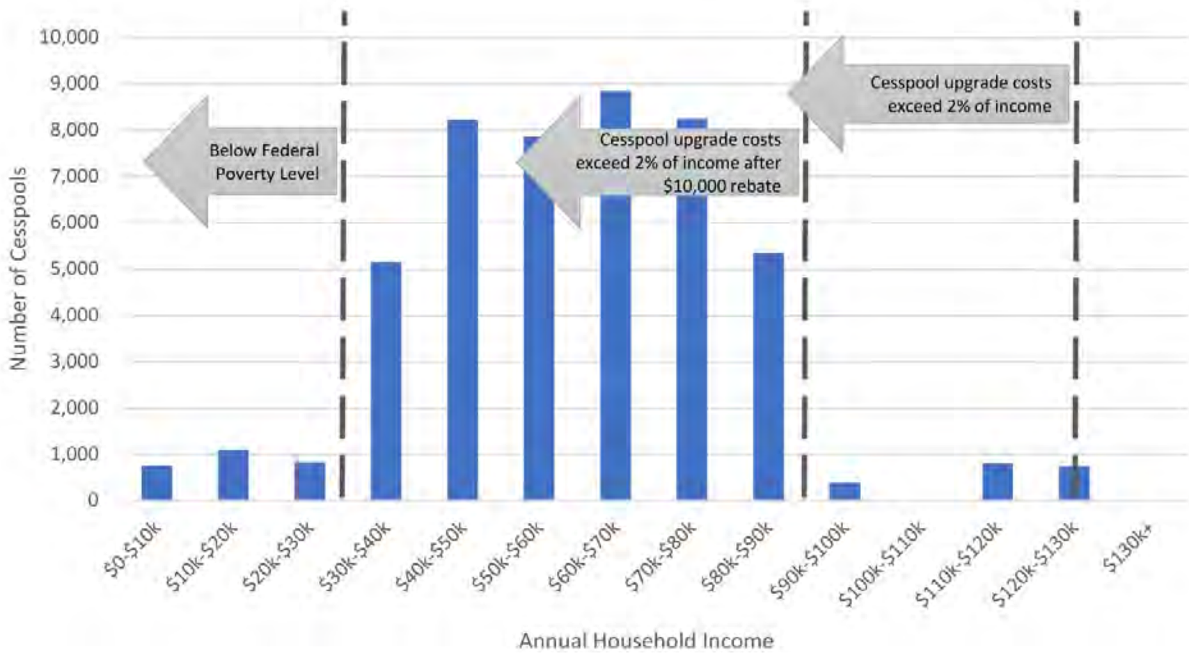

Figure 2.8 Hawai'i County – Number of Cesspools Relative to Median Household Income(1)

Notes:
(1) Assumes average cesspool conversion cost scenario of $210 per month.

Figure 2.9 shows the locations of the Hawai'i County's cesspools relative to median household incomes and priority upgrade areas. The Priority 2 area south of the Hilo Bay area shows that homeowners have MHI levels below the affordability threshold. Most homeowners in this area appear to have MHIs of less than $80,000 and MHI appears to decrease moving inland. The Priority 2 area near Hilo Bay shows a mixture of MHI with pockets of lower income levels ranging from $0 to $40,000. Other Priority 3 areas located on the Kona side and near Puako show MHIs ranging from $50,000 to $80,000, which is still below the affordability thresholds for cesspool conversions. MHI data for cesspools located outside of priority upgrade areas range widely. The highest MHIs are shown in the Waimea area. Lower MHI data are shown for more sparsely populated, coastal and inland areas.

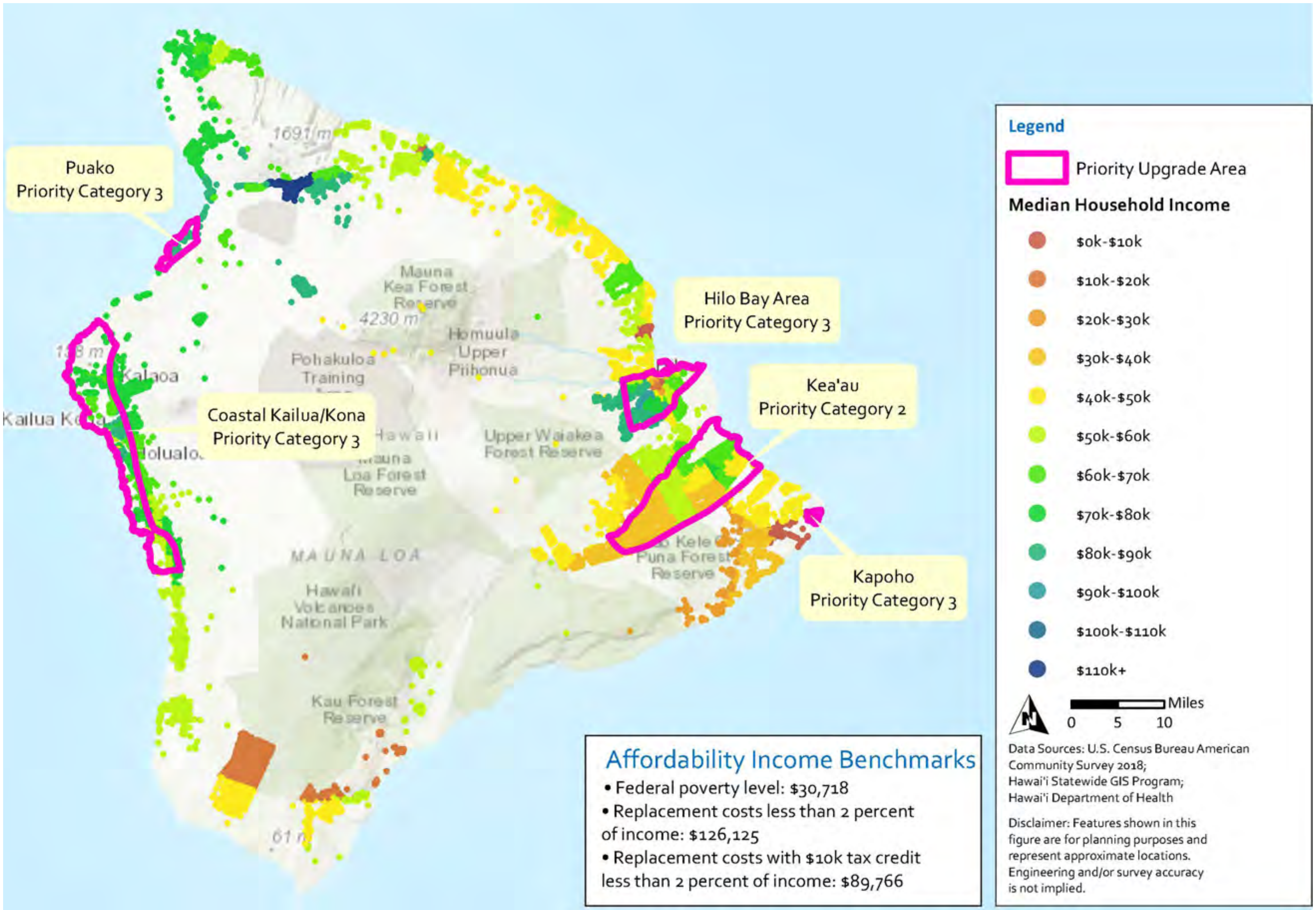

Figure 2.9 Hawai'i County Cesspools and Median Household Income Levels

Table 2.4 summarizes the number of cesspool owners expected to spend greater than 2 percent of their income on conversion broken down by low, average, and high conversion cost scenarios and by priority level. All County of Hawaiʻi cesspool homeowners fall below the affordability threshold for the average conversion cost scenario. Approximately 44 percent of cesspool homeowners would be unable to afford cesspool conversions under the low-cost scenario. A greater share of the County of Hawaiʻi's residents would face affordability issues for cesspool conversion compared with statewide metrics.

Table 2.4 Hawaiʻi County – Number of Households Projected to Exceed 2 Percent of Income

Priority Categories	Number of Cesspools	Number of Households Projected to Spend >2 percent of Income on Cesspool Conversion(1)		
		Low Cost	Average Cost	High Cost
1	0	NA	NA	NA
2	8,039	4,651	8,039	8,039
3	15,188	2,784	15,188	15,188
4	25,076	13,841	25,076	25,076
Totals	**48,303**	**21,376**	**48,303**	**48,303**

Notes:
(1) Based on the median household income for the census block group where the cesspool site resides. Assumes no financial assistance.
(2) NA = not applicable

2.4.2.2 Poverty

Like the state as a whole, the majority of the County of Hawaiʻi's cesspool homeowners have incomes above the FPL. Approximately 5.5 percent or 2,675 households with cesspools have incomes below the FPL.

2.4.3 City and County of Honolulu

The following sections summarize the affordability analysis for the City and County of Honolulu by percent of census block group MHI, and poverty levels. Most homeowners have sewer connections such that the City and County of Honolulu has the lowest percentage of households with a cesspool at 3 percent. There are an estimated 311,525 households and 10,805 cesspools in the City and County of Honolulu.

2.4.3.1 Census Block Group Median Household Income

Figure 2.10 shows the number of cesspools in the City and County of Honolulu by census block group MHI. The dashed black lines indicate the affordability threshold previously defined as 2 percent of MHI (for full cost and adjusted cost after rebate).

Honolulu's census block group MHI distribution is skewed more to the right than the other counties, but it also has a significant number of block groups at the far-left end of the distribution, with incomes below $10,000 per year. Therefore, while the county may not have the same broad affordability challenges that other counties will see, the households that will be unable to pay for conversion may be extremely challenged to do so.

Figure 2.11 shows the locations of the City and County of Honolulu's cesspools relative to median household incomes and priority upgrade areas. The Priority 1 area in Kahuluʻu shows MHIs ranging from $90,000-$110,000+ (on the border and above the affordability threshold). The Priority 3 area on the Windward side of the island near Waimanalo shows most MHIs ranging from $50,000-$100,000. Some homeowners in this area will require financial assistance with cesspool upgrades. The Diamond Head area of Oʻahu is a Priority 3 area with MHIs ranging widely from $0-$110,000+. Connection to the City and County of Honolulu's sewer system may be an option for these homeowners; however, sewer construction in this area may be challenging. Without a sewer connection, some homeowners may require financial assistance for upgrades.

The Priority 3 area in Ewa Beach shows higher MHIs ranging from $90,000-$110,000+. Many of these homeowners may be able to afford cesspool conversions without significant financial assistance. However, homeowners in the Priority 3 area near Waialua have MHIs ranging from $40,000-$80,000 (less than the affordability threshold) and may require financial assistance. There are some pockets of MHIs showing as greater than $110,000 in this area where homeowners may be able to afford the cesspool upgrades.

Table 2.5 summarizes the number of cesspools projected to spend more than 2 percent of income on the cesspool conversion in the City and County of Honolulu for the low, average, and high cost scenarios and by priority level. It is estimated that approximately 86 percent of City and County of Honolulu cesspool homeowners (9,287) fall below the affordability threshold for the average conversion cost scenario.

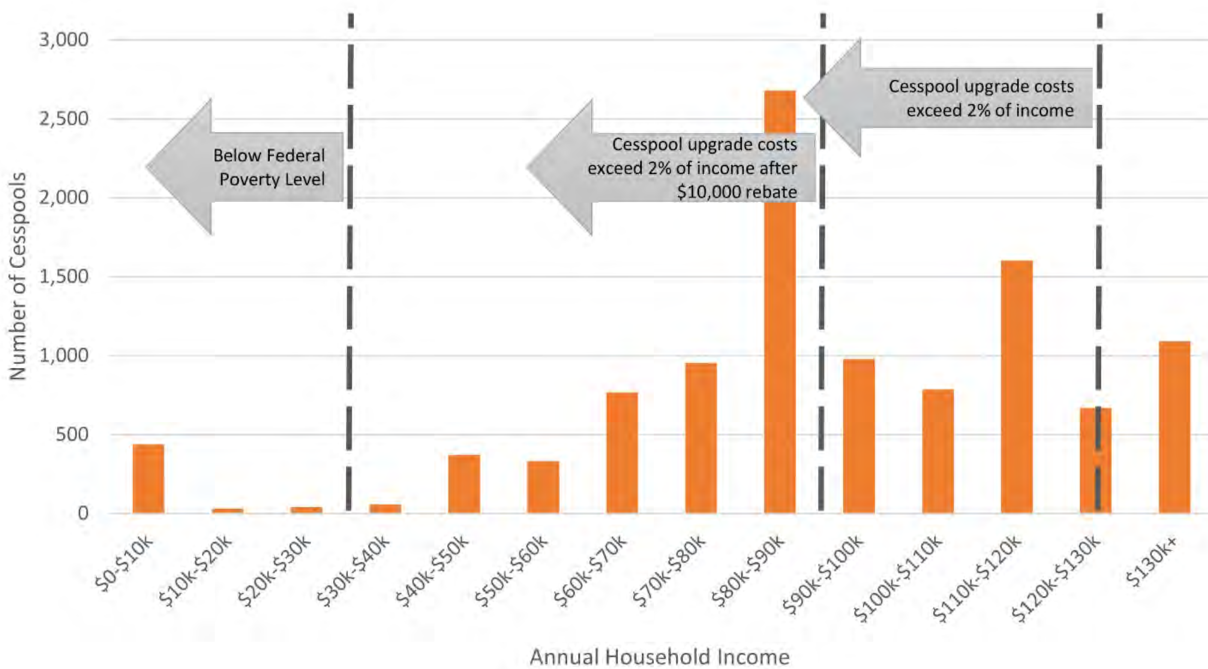

Figure 2.10 City and County of Honolulu – Number of Cesspools Relative to Median Household Income Levels(1)

Notes:
(1) Assumes average cesspool conversion cost scenario of $210 per month.

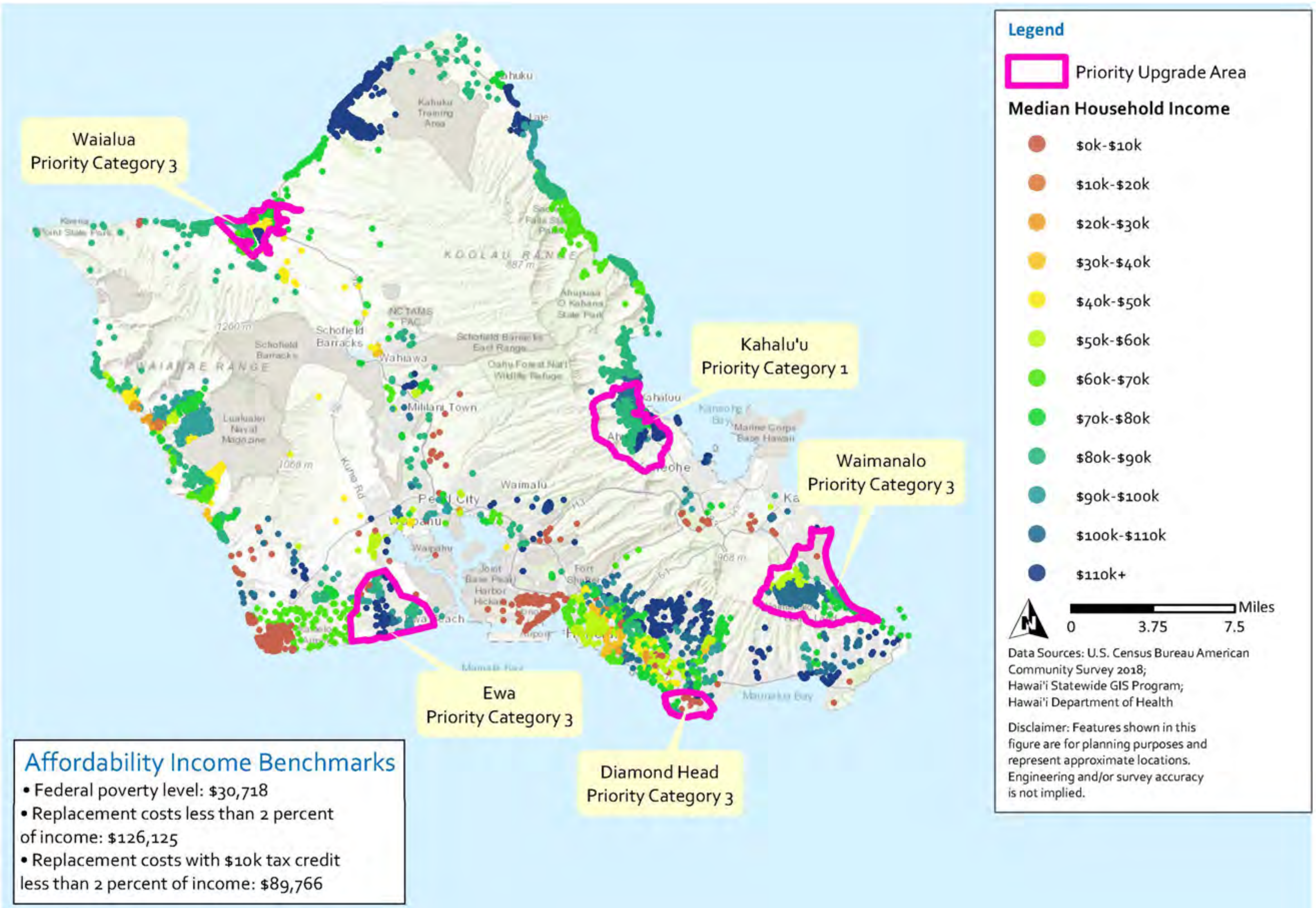

Figure 2.11 City and County of Honolulu Cesspools and Median Household Income

Table 2.5 City and County of Honolulu – Percent of Median Household Income by Priority Category

Priority Categories	Number of Cesspools	Number of Households Projected to Spend >2 percent of Income on Cesspool Conversion(1)		
		Low Cost	Average Cost	High Cost
1	656	NA	656	656
2	0	NA	NA	NA
3	2,924	147	2,335	2,924
4	7,225	1,027	6,296	7,204
Totals	**10,805**	**1,174**	**9,287**	**10,784**

Notes:
(1) Based on the median household income for the census block group where the cesspool site resides. Assumes no financial assistance.
(2) NA = not applicable

2.4.3.2 Poverty Levels

The City and County of Honolulu has approximately 4.7 percent or 512 households with cesspools that have incomes below the FPL.

2.4.4 County of Kauaʻi

The following sections summarize the affordability analysis for the County of Kauaʻi by percent of census block group MHI, and poverty levels. There are an estimated 12,085 cesspools and 22,524 households in Kauaʻi County, with approximately 54 percent of households having a cesspool.

2.4.4.1 Census Block Group Median Household Income

Figure 2.12 shows the number of cesspools in the County of Kauaʻi by census block group MHI. The dashed black lines indicate the affordability threshold previously defined as 2 percent of MHI (for full cost and adjusted cost after rebate). Approximately 11,507 cesspools owners located in Kauaʻi County, or 95 percent, are expected to face affordability challenges for cesspool conversions without financial assistance.

Figure 2.13 shows the locations of Kauaʻi County's cesspools relative to median household incomes and priority upgrade areas. The Priority 3 area near Hanalei Bay area shows that homeowners have MHI levels ranging from $20,000 to $70,000, which is below the affordability threshold. The Priority 2 level area near Kapaʻa/Wailua shows MHIs ranging from $40,000 to $100,000, just below the affordability threshold. Also, Priority 2 level area on the south side of Kauaʻi shows a range of $40,000 to more than $110,000 for MHIs.

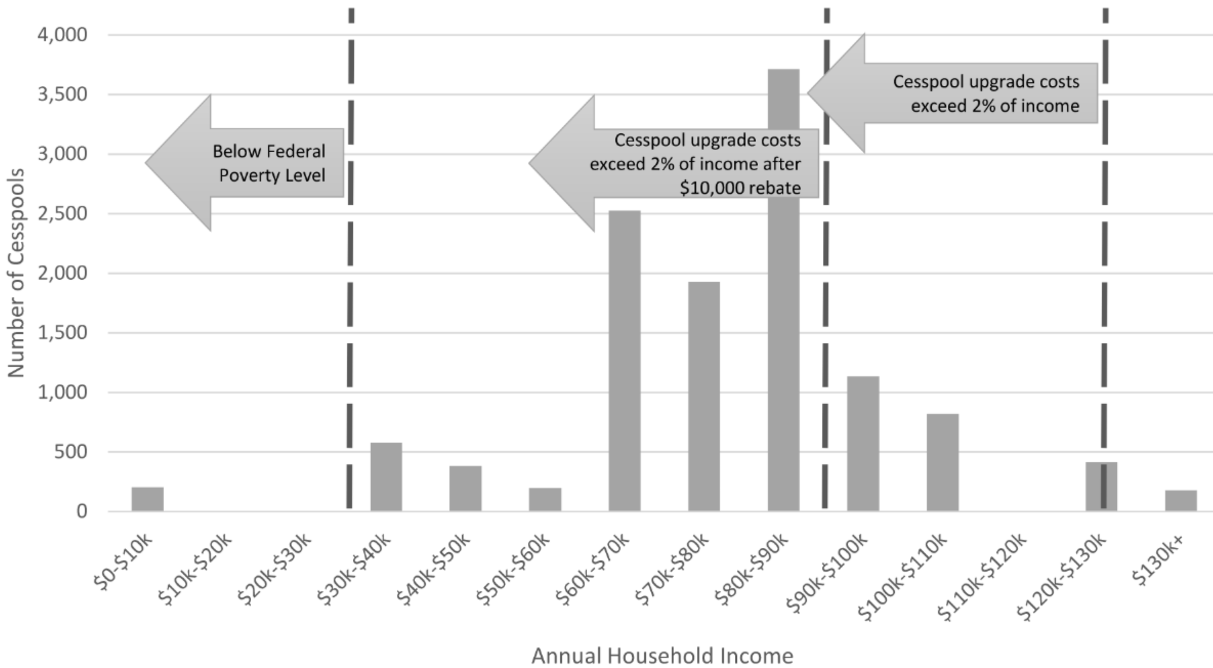

Figure 2.12 County of Kaua'i – Number of Cesspools Relative to Median Household Income Levels(1)

Notes:
(1) Assumes average cesspool conversion cost scenario of $210 per month.

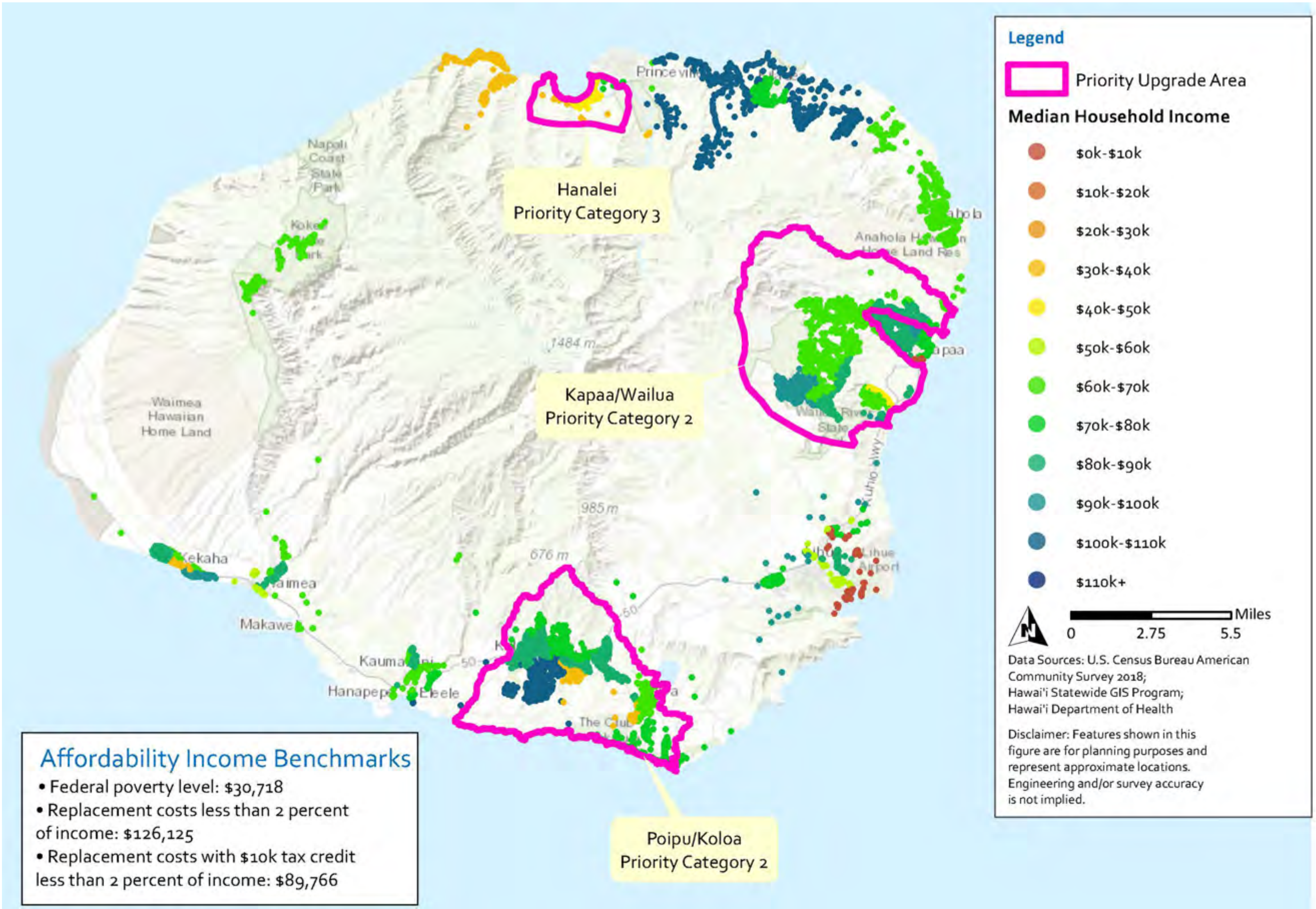

Figure 2.13 Kaua'i County Cesspools and Median Household Income

Table 2.6 summarizes the number of cesspools projected to spend more than 2 percent of income on the conversion in the County of Kauaʻi for the low, average, and high cost scenarios and by priority level. It is estimated that effectively 84 percent (11,507) of County of Kauaʻi cesspool homeowners fall below the affordability threshold for the average conversion cost scenario.

If the high cost scenario is assumed, all cesspool homeowners on Kauaʻi fall below the affordability threshold, while only 8 percent would fall under the same designation under the low-cost scenario. Compared with the statewide metrics, a slightly smaller share of Kauaʻi County cesspool homeowners is expected to face affordability issues for cesspool conversion.

Table 2.6 County of Kauaʻi – Number of Households Projected to Exceed 2 Percent of Income

Priority Categories	Number of Cesspools	Number of Households Projected to Spend >2 percent of Income on Cesspool Conversion(2)		
		Low Cost	Average Cost	High Cost
1	0	NA	NA	NA
2	6,461	397	6,282	6,461
3	194	190	194	194
4	5,430	605	5,031	5,430
Totals	**12,085**	**1,192**	**11,507**	**12,085**

Notes:
(1) Based on the median household income for the census block group where the cesspool site resides. Assumes no financial assistance.
(2) NA = not applicable

2.4.4.2 Poverty Levels

The County of Kauaʻi has the smallest share of households assumed to be living below the FPL across all counties in Hawai'i at 1.7 percent or 512 of residents with cesspools.

2.4.5 County of Maui

The County of Maui includes Maui, Molokaʻi, Lānaʻi, and Kahoʻolawe, of which Maui and Molokaʻi have cesspools included in this analysis. This section is divided between these two islands. There are an estimated 12,085 cesspools in Maui County, compared with 54,274 households. It is estimated that approximately 22 percent of households have a cesspool.

2.4.5.1 Maui

The following sections summarize the affordability analysis for Maui by percent of census block group MHI, and poverty levels.

Census Block Group Median Household Income

Figure 2.14 shows the number of cesspools in Maui by census block group MHI. The dashed black lines indicate the affordability threshold previously defined as 2 percent of MHI (for full cost and adjusted cost after $10,000 rebate).

Table 2.7 summarizes the number of cesspools projected to spend more than 2 percent of income on the cesspool conversions in Maui for the low, average, and high cost scenarios by priority level. It is estimated that approximately 98 percent of Maui cesspool homeowners (11,888) fall below the affordability threshold for the average conversion cost scenario without financial assistance.

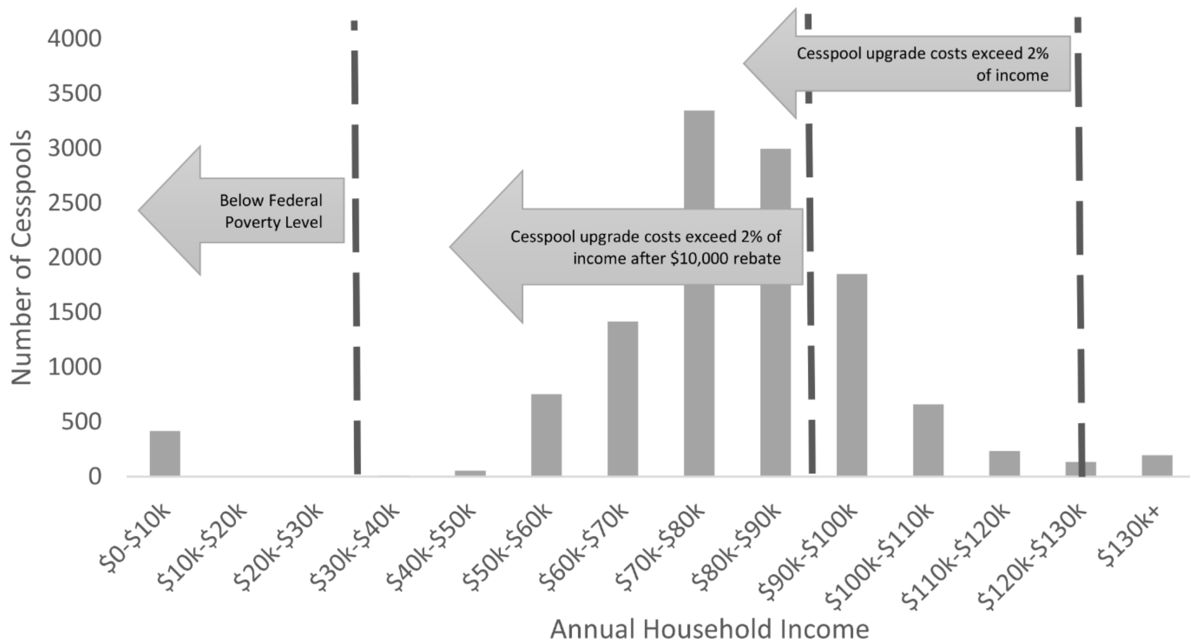

Figure 2.14 Maui – Number of Cesspools Relative to Median Household Income Levels(1)

Notes:
(1) Assumes average cesspool conversion cost scenario of $210 per month.

Table 2.7 Maui – Number of Households Projected to Exceed 2 Percent of Income

Priority Categories	Number of Cesspools	Number of Households Projected to Spend >2 percent of Income on Cesspool Conversion(1)		
		Low Cost	Average Cost	High Cost
1	7,876	341	7,778	7,876
2	0	NA	NA	NA
3	0	NA	NA	NA
4	4,209	231	4,110	4,209
Total	**12,085**	**572**	**11,888**	**12,085**

Notes:
(1) Based on the median household income for the census block group where the cesspool site resides. Assumes no financial assistance.
(2) NA = not applicable

Poverty Levels

It is estimated that 3.4 percent or 416 households with cesspools on Maui have incomes below the FPL.

2.4.5.2 Molokaʻi

The following sections summarize the affordability analysis for Molokaʻi by percent of census block group MHI, and poverty levels.

Census Block Group Median Household Income

Figure 2.15 shows the number of cesspools in Molokaʻi by census block group MHI. The dashed black lines indicate the affordability threshold previously defined as 2 percent of MHI (for full cost and adjusted cost after rebate).

Table 2.8 summarizes the number of cesspools projected to spend more than 2 percent of income on the cesspool conversions in Maui for the low, average, and high cost scenarios and by priority level. It is estimated that effectively all Moloka'i cesspool homeowners (1,439) fall below the affordability threshold for the average conversion cost scenario.

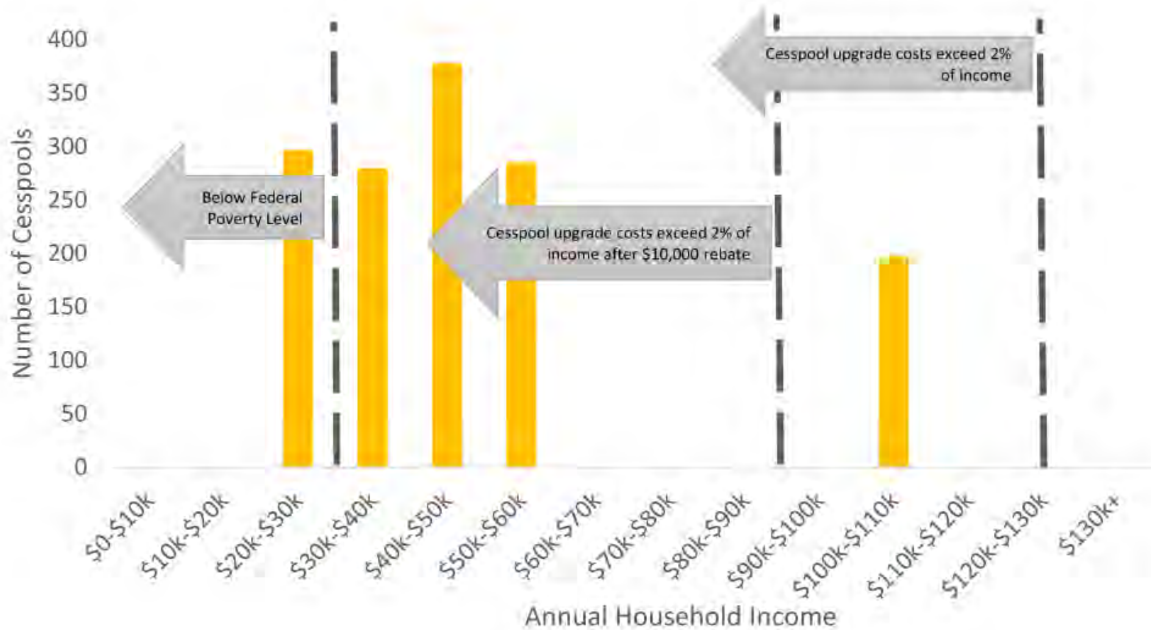

Figure 2.15 Moloka'i - Number of Cesspools Relative to Median Household Income Levels (1)

Notes:
(1) Assumes average cesspool conversion cost scenario of $210 per month.

Table 2.8 Moloka'i – Number of Cesspools Projected to Exceed 2 Percent of Income

Priority Categories	Number of Cesspools	Number of Households Projected to Spend >2 percent of Income on Cesspool Conversion(1)		
		Low Cost	Average Cost	High Cost
1	0	NA	NA	NA
2	0	NA	NA	NA
3	0	NA	NA	NA
4	1,439	955	1,439	1,439
Totals	**1,439**	**955**	**1,439**	**1,439**

Notes:
(1) Based on the median household income for the census block group where the cesspool site resides. Assumes no financial assistance.
(2) NA = not applicable

Poverty Levels

It is estimated that 2.2 percent or 297 households with cesspools on Molokaʻi are below the FPL. While the percent of households assumed to be below the FPL is relatively in line with the rest of the state, Molokaʻi has the largest share of residents living between 100 and 200 percent of the FPL, the highest among any island and more than double the next highest (Hawaiʻi County). This significant share of residents living slightly above the poverty level is likely to result in significant affordability challenges for Molokaʻi residents.

Figure 2.16 shows the locations of Molokaʻi and Maui's cesspools relative to median household incomes and priority upgrade areas. Molokaʻi has Priority 1, 2, or 3 areas. Median household incomes range from $0 to $60,000 (below the affordability threshold), with a concentration of $110,000+ MHIs located in the Kaunakakai area (above the affordability threshold). The Priority 2 location in Upcountry Maui shows a wide range of incomes from $0-$110,000+ with most incomes ranging from $60,000-$100,000 (just below the affordability threshold). Non-priority upgrade areas on Maui show varying MHIs.

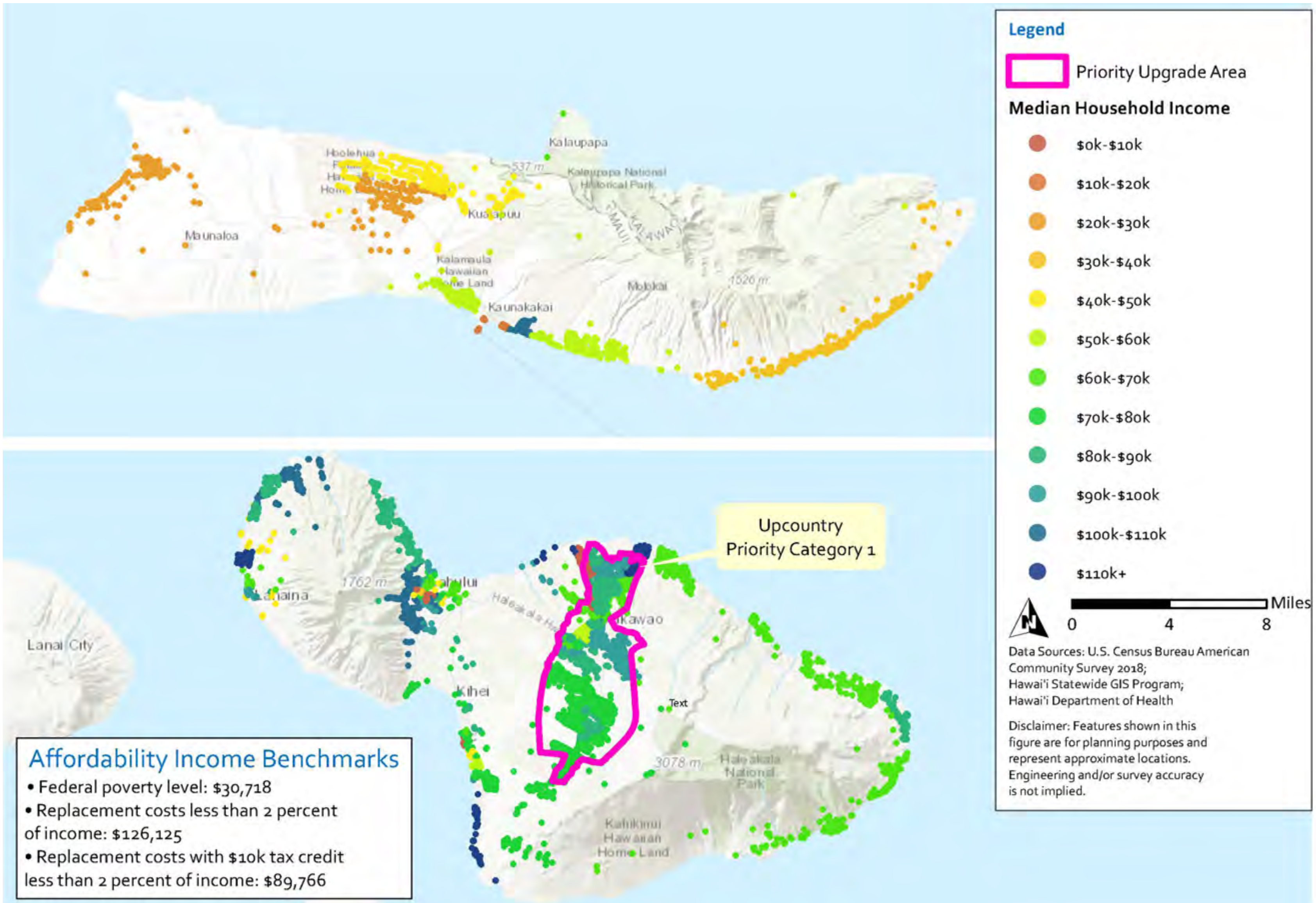

Figure 2.16 Maui and Moloka'i Cesspools and Median Household Income

2.5 Conclusions & Recommendations

The relative level of financial impact has important implications when allocating grants, loans, and other funding sources to cesspool conversion projects. Additional household level research is recommended prior to making decisions regarding allocation of these funds, but this analysis can guide the next steps as the state considers where to begin making investments and achieve the greatest affordability impact.

Significant affordability challenges are anticipated for cesspool conversions across the state. Table 2.9 summarizes the affordability analysis in terms of the number of cesspool homeowners based on key affordability criteria. It is projected that 97 percent of cesspool homeowners (82,424 homeowners) will pay more than 2 percent of their income for the cesspool conversions. This statistic decreases to 85 percent (71,799 homeowners) when assuming each cesspool homeowner could take advantage of a hypothetical $10,000 rebate. As a result, the conversions are likely to be a significant financial burden at the household level. Furthermore, measures of poverty and income-constraints show that most homeowners have little room in their household budgets for such a significant expense.

The analysis within this TM breaks down the cesspools by priority levels and households with the greatest financial needs. In combination with the funding mechanisms TM, the affordability analysis can be used to target priority areas and/or prioritize financial needs.

Following prioritization of cesspool upgrades, the state can evaluate how to best leverage any funding available to supplement the cost of conversions for households most impacted.

Table 2.9 Summary of the Cesspool Homeowners by County Based on Key Affordability Criteria[(1)]

Affordability Measure	County of Hawai'i	County of Kaua'i	County of Maui		City and County of Honolulu	Statewide
			Maui	Moloka'i		
Below Federal Poverty Level [(2)]	3,254	204	416	297	512	4,683
Below 2 Percent Median Household Income [(3)]						
With $10,000 Rebate	46,359	9,533	9,000	1,241	5,666	71,799
Without Hypothetical $10,000 Rebate	48,303	11,507	11,888	1,439	9,287	82,424

Notes:
(1) Affordability analysis was for the average scenario with $23,000 cesspool upgrade costs, and monthly costs of $210 if the cesspool conversion is financed over 20 years at 4 percent interest.
(2) Federal poverty level is $30,718 annual income.
(3) The 2 percent of median household income threshold is $126,125 annual income based on the USEPA definition of "cost burdened".

2.5.1 Funding Assistance Prioritization

With limited funds available to directly support conversions, it is important for the state to consider where the need for funds are concentrated. From an environmental standpoint, the priority upgrade locations identified in the 2018 Legislature Report are a useful starting point. From an economic standpoint, census block groups where average conversion cost is expected to exceed 2 percent of MHI is also useful.

Using the average conversion cost from Table 2.2, the estimated cost to replace all cesspools organized by 2 percent MHI thresholds and priority upgrade area is outlined in Table 2.10. The estimated conversion cost is provided based on the number of cesspools in each priority category and the affordability criteria. These cost data can be used for preliminary policy discussions and decisions by the CCWG and other advisors.

Table 2.10 Estimated Cost to Replace All Cesspools for Residents by Priority Category and Median Household Income

Priority Category	Number of Cesspools	Total Conversion Cost ($ millions)(1)
Below 2 percent Median Household Income Threshold(2)		
1	98	$2.3
2	179	$4.1
3	589	$13.5
4	1,427	$32.8
Subtotal	**2,293**	**$52.7**
Above 2 percent Median Household Income Threshold(3)		
1	8,434	$194.0
2	14,321	$329.4
3	17,717	$407.5
4	41,952	$964.9
Subtotal	**82,424**	**$1,895.8**
Total	**84,717**	**$1,948.5**

Notes:
(1) Based on average conversion cost of $23,000.
(2) Residents who may be able to afford cesspool conversions without financial assistance.
(3) Residents who are financially burdened by cesspool conversion costs and may require financial assistance.

2.5.2 Private Financing and What Can Be Afforded

To determine the amount of financial assistance that may be needed, it is also important to consider the portion of the cesspool conversions costs that *can* be afforded by homeowners. With the exception of those with estimated annual income below the FPL, it was assumed that homeowners could afford to privately finance an amount that results in a monthly payment less than or equal to 2 percent of their estimated monthly income less the average monthly maintenance cost for the selected replacement technology. If that amount is less than the average of conversion costs, it is assumed the difference would require financial aid. Table 2.11 summarizes the estimated amount of conversion costs that can be afforded or privately financed versus the amount of financial aid that may be required. It is anticipated that more than $900 million in financial aid is required to support cesspool conversions for homeowners who are financially burdened.

Table 2.11 Estimated Private Financing and Financial Aid Required for Cesspool Conversions(1)

Priority	Total Private Financing(2) ($ million)	Total Financial Aid Required(3) ($ million)
1	$89.8	$106.5
2	$94.2	$239.3
3	$164.7	$256.3
4	$557.6	$440.1
Totals	**$906.3**	**$1,042.2**

Notes:
(1) Based on average conversion cost of $23,000.
(2) Assumes residents can afford up to 2 percent of estimated household income for cesspool conversions, financed at 4 percent interest over 20 years.
(3) Assumes cesspool conversion costs in excess of 2 percent of estimated household income will require financial aid. Residents with income levels below the federal poverty limit are assumed to require financial support for all conversion costs.

2.6 References

Babcock, R., Barnes, M.D., Fung, A., Godell, W., and Oleson, K.L.L. 2019. Investigation of Cesspool Upgrade Alternatives in Upcountry Maui (Final Report). Prepared for the Hawaii Department of Health, Safe Drinking Water Branch.

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Appendix A

DOH OSWT AND DISPOSAL SYSTEM INSTALLATION COST DATA

OSWT Installation Costs from DOH

Average	$22,905.43
Median	$21,989.52
Max	$59,585.00
Min	$8,925.00
90th Percentile	$37,809.20
10th Percentile	$9,927.19

TMK	Address	Cost	Type	Bedrooms
141024003	41-890 Kakaina St., Waimanalo, Hawaii 96795	$21,204.18	ST	5
144023021	714 Old Mokapu Rd., Kailua, Hawaii 96734	$40,837.86	ST	5
146001030	46-047 Lilipuna Road, Kaneohe, Hawaii 96744	$38,972.00	ST	5
146017037	46-398 Holopu Place, Kaneohe, Hawaii 96744	$11,370.61	ST	5
146027028	46-426 Hololio Street, Kaneohe, Hawaii 96744	$30,062.00	ST	5
147014004	47-719 Kamehameha Hwy, Kaneohe, Hawaii 96744	$9,582.00	ST	5
147014004	47-719 Kamehameha Hwy, Kaneohe, Hawaii 96744	$9,582.00	ST	5
147014004	47-719 Kamehameha Hwy, Kaneohe, Hawaii 96744	$9,582.00	ST	5
147014004	47-719 Kamehameha Hwy, Kaneohe, Hawaii 96744	$9,582.00	ST	5
147014004	47-719 Kamehameha Hwy, Kaneohe, Hawaii 96744	$9,582.00	ST	5
147014030	47-121 Wailehua Road, Kahaluu, Hawaii	$38,221.76	ST	5
147046041	47-521 Melekula Rd., Kaneohe, Hawaii	$17,257.17	ST	5
153001016	53-133 Kamehameha Hwy, Hauula, Hawaii 96717	$28,803.00	ST	5
153002033	53-231 Kamehameha Highway, Hau'ula, Hawaii	$28,324.00	ST	5
153002046	53-215 Kamehameha Highway, Hauula, Hawaii	$32,971.62	ST	5
153003001	53-270 Kamehameha Hwy, Hauula, Hawaii 96717	$23,870.20	ST	5
154011038	56-233 Kamehameha Hwy, Hauula, Hawaii 96717	$21,989.52	ST	5
154012035	54-267 Kaipapau Loop, Hauula, Hawaii 96717	$22,000.00	ST	5
154018042	54-140 Kawaipuna Street, Hauula, Hawaii 96717	$22,700.00	ST	5
156001079	44-497 Kaneohe Bay Drive, Kaneohe, Hawaii 96744	$20,000.00	ST	5
157005003	57-477 Kamehameha Hwy, Kahuku, Hawaii	$26,476.24	ST	5
159003024	05-601 B Ke Iki Road, Haleiwa, Hawaii 96712	$24,432.72	ST	5
161012035	61-307 Kamehameha Hwy, Haleiwa, Hawaii 96714	$29,719.16	ST	5
166021020	66-437 Waialua Beach Road, Haleiwa, Hawaii 96712	$22,513.08	ST	5
167002021	67-631 Kahui Street, Waialua, Hawaii 96791	$19,750.00	ST	5
167008018	67-371 Kukea Circle, Waialua, Hawaii	$10,489.33	ST	5
167015044	67-007 Kahaone Place, Waialua, Hawaii 96791	$30,366.48	ST	5
168012009	66-136 Akule Street, Haleiwa, Hawaii 96791	$11,735.10	ST	5
168012017	68-147 Akule Street, Waialua, Hawaii 96791	$23,000.00	ST	5
223003063	2850 Omaopio Road, Kula, Hi 96790	$41,674.00	ST	5
235001007	310 Iao Valley Road, Wailuku, Hawaii 96793	$10,497.73	ST	5
235001105	11 Ua Place, Wailuku, Hawaii 96793	$14,698.15	ST	5
336010007	36-2270 Hawaii Belt Rd., Laupahoehoe, Hawaii 96764	$8,925.00	ST	5
413010033	8706 Kiowea Road, Kekaha, Hawaii 96752	$21,945.00	ST	5
424001026	2-3161 C Kaumualii Hwy, Kalaheo, Hawaii 96741 (Cesspool 1)	$25,965.00	ST	5
432003009	2461 Niumalu Road, Lihue, Hawaii 96766	$25,500.00	ST	5
432003009	2461 Niumalu Road, Lihue, Hawaii 96766	$25,500.00	ST	5
444002075	6611 Kipapa Road, Kapaa, Hawaii 96746	$27,297.00	ST	5
448013018	4721 Aliomanu Road, Anahola, Hawaii 96703	$35,070.00	ST	5
455001001	5069 Weke Road, Hanalei, Hawaii 96714	$22,510.87	ST	5
214005019	4933 Uakea Rd, Hana, Hawaii 96713	$59,585.00	ATU	5
455010067	5-5016 Kuhio Hwy, Hanalei, Hawaii 96714	$38,000.00	ST	5
424005037	2931 Wawae Road, Kalaheo, Hawaii 96741	$52,356.00	ST and 2	5
425006033	3641 Lawaiuka Rd., Lawai, Hawaii	$37,046.00	ATU	5
425006036	3644 Lawaiuka Road, Lawai, Hawaii 96765	$21,760.00	ATU	5
425006036	3644 Lawaiuka Road, Lawai, Hawaii 96765	$21,760.00	ATU	5
458012014	5-6920 Kuhio Highway, Wainiha, Kauai, Hawaii	$26,338.57	ATU	5
141005029	41-038 Manana Street, Waimanalo, Hawaii 96795	$28,248.00	ST	4

OSWT Installation Costs from DOH

Average	$22,905.43
Median	$21,989.52
Max	$59,585.00
Min	$8,925.00
90th Percentile	$37,809.20
10th Percentile	$9,927.19

TMK	Address	Cost	Type	Bedrooms
142103019	653 Manu Oo Street, Kailua, Hawaii 96734	$27,925.00	ST	4
144024060	68-505 Crozier Drive, Waialua, Hawaii 96791	$36,393.00	ST	4
158003089	58-034 Kapuai Place, Haleiwa, Hawaii 96712	$12,300.85	ST	4
159003042	05-605 Ke Iki Road, Haleiwa, Hawaii 96712	$31,308.89	ST	4
159004027	59-783 Kamehameha Hwy, Haleiwa, Hawaii 96712	$19,800.00	ST	4
159004027	59-783A Kamehameha Hwy, Haleiwa, Hawaii 96712	$19,800.00	ST	4
159004034	1931 Alaweo Street, Honolulu, Hawaii 96712	$45,550.00	ST	4
167006075	67-464 Haona St., Waialua, Hawaii	$21,170.68	ST	4
167006079	67-480 Haona Street, Waialua, Hawaii 96791	$11,050.76	ST	4
324021141	119 Likeke Street, Hilo, Hawaii	$9,786.65	ST	4
324061033	1621 Maunakai Street, Hilo, Hawaii, 96720	$11,826.58	ST	4
362010013	62-1148 Puahia Street, Kamuela, Hawaii	$10,692.19	ST	4
436008001	2922 Waa Road, Lihue, Hawaii 96766	$32,500.00	Presby	4
153014026	53-018 Pokiwai Pl., Hauula, Hawaii 96717	$20,000.00	ATU	3
167014030	67-003 Kaimanu Place, Waialua, Hawaii 96791	$24,159.58	Presby	3
199017039	99-118 Ululaau Place, Aiea, Hawaii 96701	$33,000.00	ST	3
214005023	4893 Uakea Rd, Hana, Hawaii 96713	$32,186.00	ST	3
235005038	3075 Alaneo Place, Wailuku, Hawaii 96793	$45,796.56	ST	3
321011001	39 Apapane Road, Hilo, Hawaii 96720	$10,500.00	ST	3
322019075	121 Barenaba Lane, Hilo, Hawaii 96720	$20,000.00	ST	3
323026057	277 Kaiulani Street, Hilo, Hawaii 96720	$14,789.62	ST	3
325024051	60 Kapaa Street, Hilo, Hawaii 96720	$9,525.00	ST	3
325028016	2065 Waianuenue Ave., Apt M, Hilo, Hawaii 96720-1207	$9,399.47	ST	3
326016013	442-A Wainaku Street, Hilo, Hawaii 96720	$11,561.00	ST	3
326016013	442-A Wainaku Street, Hilo, Hawaii 96720	$11,561.00	ST	3
326026006	18 Makakai Place, Hilo, Hawaii	$16,666.56	ST	3
382005008	82-6301 Puuhonua Rd., Captain Cook, Hawaii	$11,790.00	ST	3
442018040	374 Molo Street, Kapaa, Hawaii 96746	$25,000.00	ATU	3
455001029	5063-A Weke Road, Hanalei, Hawaii	$17,842.00	ST	3
314010013	14-4707 Alapaki Lane, Pahoa, Hawaii, 96778	$18,706.00	ATU	2
214005022	4896 Uakea Rd, Hana, Hawaii 96813	$26,406.00	ST	2
314010044	14-4949 Laimana Avenue, Pahoa, Hawaii 96778	$10,500.00	ST	2
343013043	43-2013 Paauilo Mauka Road, Paauilo, Hawaii 96776	$12,400.00	ST	2
227004002	77 Nahele Road, Haiku, Hawaii	$10,813.00	ST	1
456004008	5-5851 Kuhio Highway, Hanalei, Hawaii, 96714	$28,792.00	ST	1

Appendix B

ALTERNATIVE AFFORDABILITY MEASURES

Hours of Labor at Minimum Wage

Table B.1 summarizes the statewide results for the equivalent hours of minimum wage (HM) to pay for cesspool upgrades for the low, average, and high cost scenarios. For the entire state of Hawaiʻi, the average conversion cost scenario would require approximately 21 hours per month of labor at minimum wage in order to pay for cesspool conversion and maintenance costs, with a low- and high-end estimate of 10 and 34 hours respectively.

The HM metric was created to measure affordability as opposed to define it, however, there are no widely accepted guidelines or benchmarks for contextualizing HM. Eight hours or roughly a full day of work at minimum wage has been suggested a starting point for measuring affordability for water and wastewater service using the HM metric.[1] Like the MHI analysis, the HM analysis shows that the cesspool conversion program would prove to be a significant financial burden for many property owners, with the average conversion cost requiring more than three times as many hours at minimum wage, before even accounting for sewer costs.

Table B.1 Statewide Estimate for Hours of Minimum Wage Labor Needed for Cesspool Costs

Cost Description	Cesspool Conversion Cost Scenario		
	Low Cost	Average Cost	High Cost
Monthly Installation Repayment Cost	$61	$139	$230
Monthly Operating Cost	$33	$71	$109
Total Monthly Cesspool Conversion Cost	$94	$210	$339
Hours per Month of Labor at Minimum Wage	10	21	34

Notes:
(1) Based on the minimum, maximum, and median for water providers surveyed.

ALICE

The Federal Poverty Level (FPL) provides a benchmark for determining what households can be considered "impoverished" and thus qualify for assistance and support programs, but there is often a large segment of households that are above this threshold but struggle to make ends meet with their income. In fact, the FPL is so low for most states, that many references to the FPL are in terms of multiples of FPL, e.g. 200% of FPL or 400% of FLP. "The FPL, with its minimal and uniform national estimate of the cost of living, far underestimates the number of households that cannot afford to live and work in the modern economy" (ALICE Report, 2020).

Asset Limited, Income Constrained, Employed (ALICE is one measure used to define households who may not qualify for aid under FPL measures but still have significant challenges making ends meet. ALICE Household Budgets are intended to provide a more realistic estimate of how much income is necessary to both live and work in a given geography. This economic indicator has been in existence for about a decade. The 2018 ALICE Household Survival Budget for a family of four in Hawai`i is estimated at $90,828 per year (United for ALICE, 2020). This compares to the FPL for a family of four estimated at $28,870 in 2018. There have been 3 reports published based on 2016, 2017 and 2018 data. It typically takes about 2 years to analyze the data. Therefore, the current 2020 ALICE report is based on 2018 data.

[1] Teodoro, 2018.

While ALICE indicators are prepared for each state through census data, approximately 20 states[2] actively support additional economic research in their respective states to further understand the drivers of economic challenges in their communities. This research is led by a 27-person national advisory committee that represents the various states, including Hawai`i and is tasked with making sure that the data and research are applied independently and consistently towards the development of ALICE models and tools.

The ALICE budget is comprised of 9 categories indicated in below, with sources of data:

	CATEGORY	SOURCE
1.	Housing	HUD (State Dept of Housing and Urban Development)
2.	Child Care	State registered childcare homes
3.	Food	USDA's Thrifty Food Plan
4.	Transportation	AAA and Federal Hwy Administration
5.	Health Care	MEPS (Medical Expenditure Panel Survey) – a national database of medical spending
6.	Technology	Consumer Reports
7.	Taxes	Federal, state, and local taxes estimates from IRS and Tax Foundation
8.	Savings	No source reported
9.	Miscellaneous	Estimated at 10% of budget

The main conclusions of the most recent ALICE report for Hawai`i indicate a troubling trend. Despite strong economic growth until COVID-19 impacts hit the state in March 2020, the number of ALICE households rose from 22% in 2007 to 33% in 2018. The total number of households in Hawai`i is estimated at 455,100. This trend is exacerbated by the recent COVID-19 impacts with the ALICE report estimating that an additional 35,000 households would become ALICE households by the end of 2020.

As mentioned earlier, these data are compiled by local researchers using a standard methodology for calculating Hawai`i based costs for the 9 categories mentioned previously. The ALICE Research Advisory Committee for Hawai`i was comprised of the following individuals:

- Kathy Fujihara-Chong, M.B.A., HMSA
- Beth Giesting, M.S., Hawai'i Budget & Policy Center
- Janice Ikeda, M.A., Vibrant Hawai'i
- Joyce Lee-Ibarra, M.S., JLI Consulting
- Ivette Rodriguez Stern, M.S.W., University of Hawai'i, Center on the Family
- Janice Takahashi, M.U.R.P., State of Hawai'i, Hawai'i Housing Finance and Development Corporation
- Gavin Thornton, J.D., Hawai'i Appleseed Center for Law and Economic Justice
- Hua Zan, Ph.D., University of Hawai'i, Center on the Family

[2] AK, CT, FL, HI, ID, IL, IN, IO, LA, MA, MI, NJ, NY, OH, OR, PA, TN, TX, VA, WA and WI

Affordability Results by ALICE Statewide

Across the state, it is estimated that only 6 percent of homeowners with a cesspool reside in a census block group with an MHI below the federal poverty level or $30,718. However, over three-quarters of CBG would fall below the ALICE threshold.

This difference between the FPL and ALICE metrics highlights the significant challenges many residents face when paying for basic utilities like wastewater. Their income puts them above the thresholds often used for state and federal income assistance, but it is not enough to comfortably afford basic services. The ALICE metric aims to highlight this group of residents.

Figure B.1 shows the ALICE metric by county and statewide. Statewide, 85 percent of cesspool owners fall within the ALICE household metric. The County of Hawai`i has the most cesspool owners that fall within the ALICE household metric with 96 percent, followed by the County of Kaua`i (83 percent), County of Maui (76 percent), and the City and County of Honolulu (53 percent).

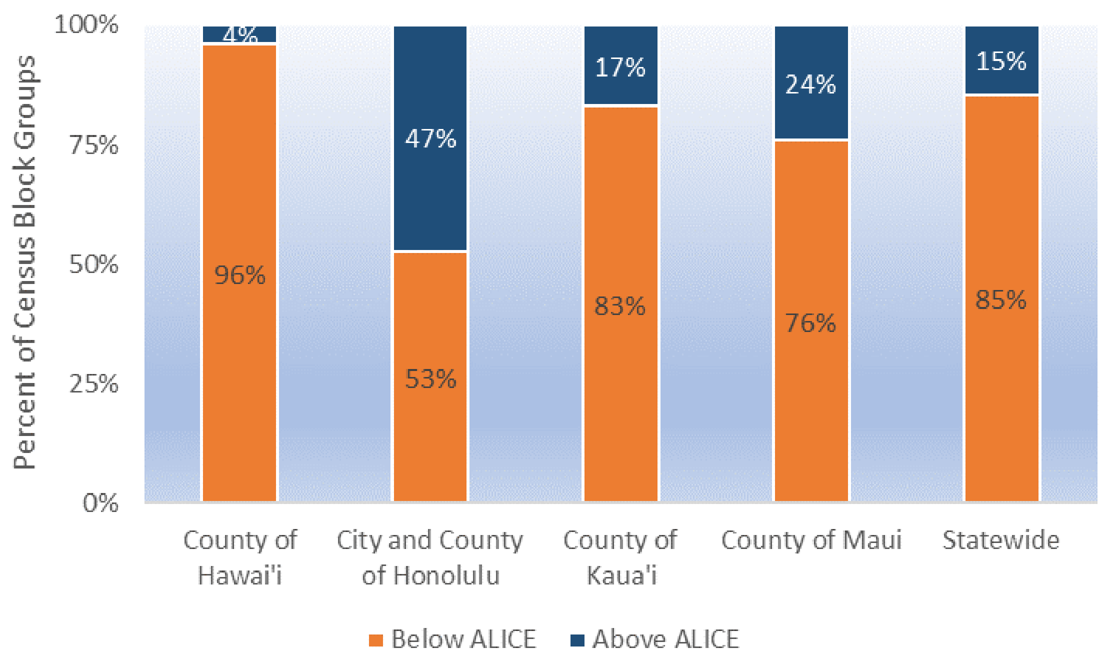


Figure B.1 Percent of Cesspool Homeowners by Census Block Groups and Asset Limited, Income Constrained, Employed (ALICE) Household Budgets

Figure B.2 depicts the income distribution for cesspools owners across the state, based on the median household income for the Census Block Group of the cesspool. Also shown is the annual income that would be needed for the cost of conversion to fall at or below 2 percent of income without the rebate ($126,125). For those cesspool owners who are eligible to apply for and receive the $10,000 rebate, the adjusted average cost of cesspool conversion is approximately $150 per month, which is 2 percent of an annual income of $89,766. The ALICE income threshold ($90,828) is also shown for comparison as the green, dashed line.

Table B.2 summarizes the affordability analysis in terms of the number of cesspool homeowners based on FLP, ALICE, and median household income. It is projected that 97 percent of cesspool homeowners (82,424 residents) will pay more than 2 percent of their income for the cesspool conversions. This statistic decreases to 85 percent (71,799 homeowners) when assuming each cesspool homeowner could take advantage of a hypothetical $10,000 rebate. Using the ALICE household survival budget, 85 percent (72,487 residents) statewide will be financially burdened by the costs of cesspool upgrades without financial assistance. As a result, the conversions are likely to be a significant financial burden at the household level. Furthermore, measures of poverty and income-constraints show that most homeowners have little room in their household budgets for such a significant expense.

The following sections summarize the affordability analyses using the ALICE metric by county.

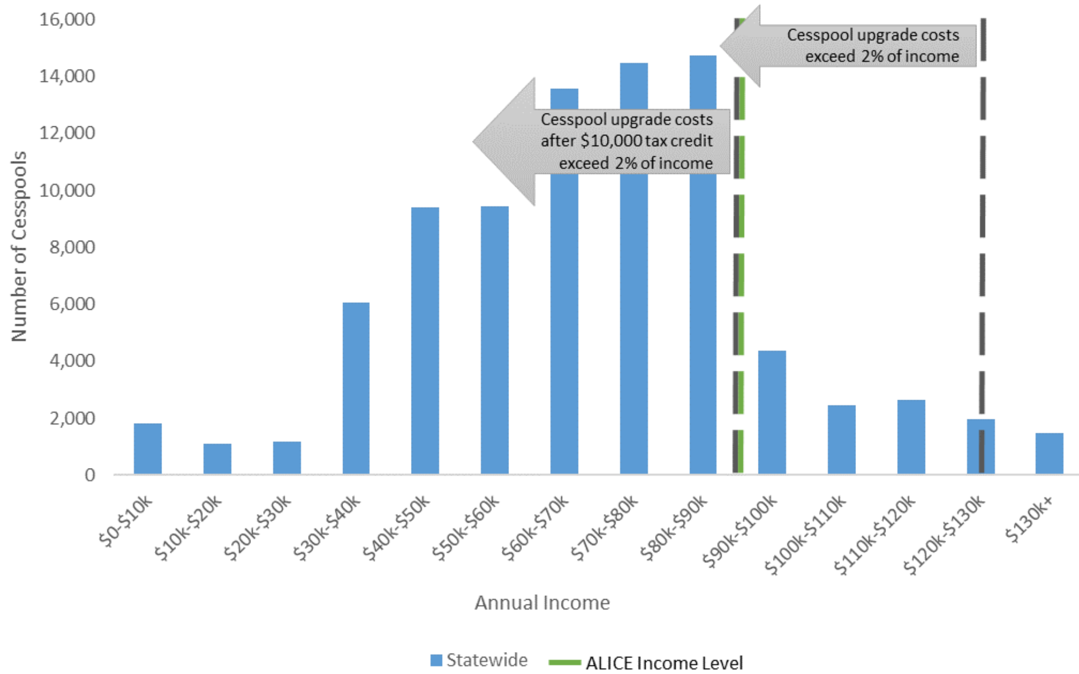


Figure B.2 Statewide Median Household Income Levels and Estimated Conversion Cost as Percent of Annual Income

Table B.2 Summary of the Cesspool Owners by County Based on Key Affordability Criteria

Affordability Measure	County of Hawai'i	County of Kaua'i	County of Maui		City and County of Honolulu	Statewide
			Maui	Moloka'i		
Below Federal Poverty Level(2)	3,254	204	416	297	512	4,683
Below ALICE Household Survival Budget(3)	46,359	10,094	9,104	1,241	5,689	72,487
Below 2 Percent Median Household Income(4)						
With Hypothetical $10,000 Rebate	46,359	9,533	9,000	1,241	5,666	71,799
Without Hypothetical $10,000 Rebate	48,303	11,507	11,888	1,439	9,287	82,424

Notes:

(1) Affordability analysis was for the average scenario with $23,000 cesspool upgrade costs, and monthly costs of $210 if the cesspool conversion is financed over 20 years at 4 percent interest.

(2) Federal poverty level is $30,718 annual income. Residents who have household incomes below the federal poverty level are likely to require financial assistance for cesspool conversions.

(3) Asset Limited, Income Constrained, Employed (ALICE) Household Survival Budget is $90,828 annual income for a family of four. Residents who have household incomes below ALICE level may be financially burdened by the costs of cesspool conversions.

(4) The 2 percent of median household income threshold is $126,125 annual income based on USEPA definition of "cost burdened". Residents who are financially burdened by cesspool conversion costs and may require financial assistance.

County of Hawai`i - ALICE Levels

Like the state as a whole, the majority of the County of Hawai`i's cesspool homeowners have incomes above the FPL. However, Hawai`i County has the most homeowners with cesspools that are considered below the ALICE threshold (94 percent), and thus under significant financial strain to afford the cesspool conversion costs. With such a large portion homeowners below the ALICE budget threshold, most Hawai`i County cesspools homeowners cannot afford cesspool upgrades without significant funding support.

City and County of Honolulu – ALICE Levels

The City and County of Honolulu has approximately 5 percent of cesspools located in Census Block Groups where the median household income is below the Federal Poverty Level. Notably though, the County has the lowest percentage of cesspools assumed to be below the ALICE threshold at 47 percent. This is nearly double the rate for Maui, the next highest county at 24 percent. This likely reflects the disparate income distribution across the City and County of Honolulu, with high levels of homeowners at both ends of the income spectrum.

County of Kaua`i – ALICE Levels

The County of Kaua`i has the smallest share of residents assumed to be living below the FPL across all counties in Hawai`i at 2 percent. Despite this low number, there is a significant percentage of residents that would fall below the ALICE survival budget threshold, with 83 percent of Kaua`i's cesspool owners assumed to be under this threshold. It is unlikely that these homeowners will be able to afford cesspool conversion costs without additional funding resources

Island of Maui – ALICE Levels

It is estimated that 3 percent of residents on Maui are below the FPL, while 75 percent of residents are estimated to fall below the ALICE threshold.

Island of Moloka`i – ALICE Levels

It is estimated that 3 percent of residents on Moloka`i are below the FPL, while 86 percent of residents are estimated to fall below the ALICE threshold. While the percent of households assumed to be below the FPL is relatively in line with the rest of the state, Moloka`i has the largest share of residents living between 100 and 200 percent of the FPL, the highest among any island and more than double the next highest (Hawai`i County). This significant share of residents living above the poverty level but by a very small amount is likely to result in significant affordability challenges for Moloka`i residents.

Appendix C

AFFORDABILITY ANALYSIS BY STATE LEGISLATIVE DISTRICT

Table C.1 Hawaiʻi County House District Affordability Measures

House District	Cesspools	Percent of Residents with Cesspools with Household Incomes Below FPL	Percent of Residents with Cesspools with Household Incomes Below ALICE	Percent of Residents with Cesspools Projected to Spend >2 percent of Household Income on Cesspool Conversion
1	7,568	5	100	100
2	5,159	11	92	100
3	8,742	0	100	100
4	9,334	15	100	100
5	7,100	13	94	94
6	4,845	0	93	93
7	5,549	0	85	85

Table C.2 Maui County House District Affordability Measures

House District	Island	Cesspools	Percent of Residents with Cesspools with Household Incomes Below FPL	Percent of Residents with Cesspools with Household Incomes Below ALICE	Percent of Residents with Cesspools Projected to Spend >2 percent of Household Income on Cesspool Conversion
8	Maui	1,062	1	50	50
9	Maui	205	21	47	53
10	Maui	849	0	71	71
11	Maui	1,016	1	96	96
12	Maui	6,212	0	75	99
13	Maui	2,740	14	80	91
13	Moloka'i	1,434	16	85	85

Table C.3 Kauaʻi County House District Affordability Measures

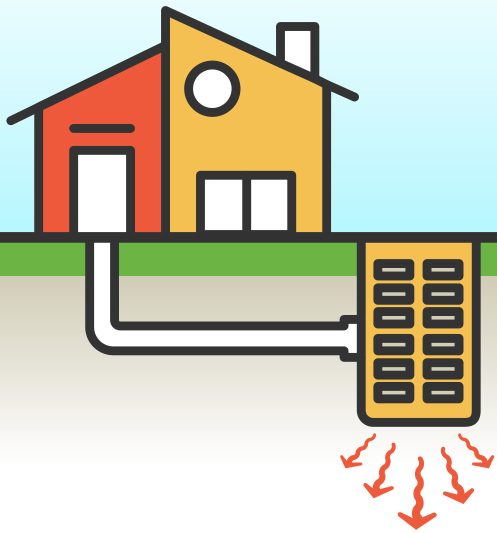
House District	Cesspools	Percent of Residents with Cesspools with Household Incomes Below FPL	Percent of Residents with Cesspools with Household Incomes Below ALICE	Percent of Residents with Cesspools Projected to Spend >2 percent of Household Income on Cesspool Conversion
14	4,679	2	87	94
15	2,838	2	83	83
16	4,568	0	80	85

Table C.4 City and County of Honolulu House District Affordability Measures

House District	Cesspools	Percent of Residents with Cesspools with Household Incomes Below FPL	Percent of Residents with Cesspools with Household Incomes Below ALICE	Percent of Residents with Cesspools Projected to Spend >2 percent of Household Income on Cesspool Conversion
17	164	1	1	1
18	139	0	4	12
19	346	3	25	40
20	144	0	49	70
21	23	9	100	100
22	84	1	95	96
23	133	5	25	34
24	431	0	9	9
25	165	5	55	56
26	114	24	71	81
27	89	6	60	70
28	31	0	23	55
29	136	1	88	100
30	310	62	95	95
31	23	17	83	83
32	8	0	63	63
33	133	7	10	11
34	16	0	63	94
35	52	25	58	100
36	54	0	37	37
37	25	0	52	72
38	17	0	53	53
39	87	0	61	61
40	963	0	41	54
41	126	2	32	50
42	117	0	59	67
43	540	30	99	99
44	828	5	58	100
45	836	0	100	100
46	44	0	70	100
47	2,785	0	56	64
48	849	0	42	42
49	181	8	10	12
50	159	0	1	1
51	577	0	25	70

Appendix C

Example Public Outreach Handout



RULES ARE CHANGING FOR YOUR

HOME CESSPOOL

CESSPOOLS NEED TO GO!

Cesspools are underground wells used to dispose of household wastewater into the groundwater table. In 2017, the Hawaii State Legislature passed Act 125 requiring the replacement of all cesspools by 2050 to prevent environmental contamination. Cesspools pose a high risk to drinking water sources and coastal ecosystems. Even if you don't plan on being in your house in 2050, having a cesspool will negatively effect the resale value of your home.

HOW DO I KNOW IF I HAVE A CESSPOOL?

You probably **don't** have a cesspool if:

- ✓ You pay a sewer bill or sewer charge on your water bill.
- ✓ Your home was built recently.
- ✓ An alternative wastewater system other than a cesspool is shown at your residence on the "OSDS" map found here: **geoportal.hawaii.gov**

Inquire with the Department of Health if you're unsure of whether or not you have a cesspool!

OK, SO HOW DO I FIX IT?

1 Hire a licensed civil engineer to help you make a plan

2 Submit your plan to the Department of Health for approval

3 Hire a licensed contractor to build new system

4 Engineer submits inspection report for approval

CAN I AFFORD THIS?

Check out our local financing options.

Typical replacement costs range from $9,000 to more than $60,000. For current financing opportunities, contact the Department of Health or visit their website listed below.

State or County Support (if available)

Home Refinancing

Federal Grants and Loans (if available)

For additional information contact the Department of Health at 808-586-4294 or visit their website at **health.hawaii.gov/wastewater**

CESSPOOL ALTERNATIVES

Different locations will require different levels of treatment! Follow this guide for an idea of what system you may need and then get in touch with a local engineer for a personalized estimate as prices may vary.

Is your property near an existing sewer system?

Recommendation: A

Is your property small[1], sloped[2], upcountry[3], in a floodzone, or near a body of water[4]?

Recommendation: B + C + D

None of the above?

Recommendation: B + D

1 *Less than 10,000 sf*

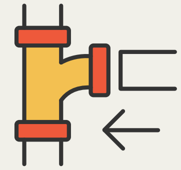
2 *Slope greater than 8%*

3 *Mauka of the UIC line (a boundary protecting drinking water aquifers)*

4 *Within 1,000 ft of a drinking water source, 50 ft of a waterbody, or 3 ft of water table*

SEWER CONNECTION OR BASIC TREATMENT

Every property will need to either connect to an existing sewer system or install a septic tank to treat wastewater onsite! Septic tanks need annual maintenance while a sewer connection means you'll get a monthly sewer bill!



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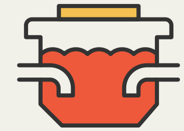


A Existing Sewer System

This is the lowest maintenance option but there is a connection fee and a monthly sewer bill!

B Septic Tank

This tank settles out and breaks down solids, which then need to be pumped out every few years by a licensed contractor.

C ADDITIONAL TREATMENT

Homes using onsite treatment near a vulnerable water resource need additional treatment with their septic tank to reduce the amount of nutrients discharged into the environment.

Alternative Toilets

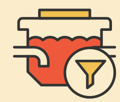
These waterless toilets don't produce wastewater! The septic tank handles the rest of the water from your house.

OR

Aerobic Treatment

In this case, the septic tank is smaller and an aerated zone is added for additional treatment.

OR



Biofilter

A media like sand or gravel is used to polish the water leaving your septic tank.

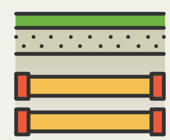
D DISPOSAL

Treated water needs to be fed back into the ground.

Seepage Pit

Converting your cesspool into a seepage pit is the cheapest option but it's not always allowed.

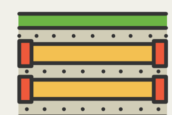
OR



Absorption Field

Tubes with tiny holes spread wastewater out underground so it can filter through the soil.

OR



Evapotranspiration

This option is the same as the absorption field except it's shallow so the water feeds your plants then evaporates.

For additional information contact the Department of Health at 808-586-4294 or visit their website at **health.hawaii.gov/wastewater**

Appendix B. Cesspool Conversion Technologies Research Summary Report Prepared by Carollo Engineers

PREPARED FOR
HAWAII STATE DEPARTMENT OF HEALTH

CESSPOOL CONVERSION TECHNOLOGIES RESEARCH SUMMARY REPORT

FINAL | JANUARY 2021

Prepared by

carollo
Engineers...Working Wonders With Water®

in association with

College of ENGINEERING
UNIVERSITY OF HAWAI'I AT MĀNOA

Hawaiʻi State Department of Health

CESSPOOL CONVERSION TECHNOLOGIES RESEARCH
Summary Report

FINAL | JANUARY 2021

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THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.
SIGNATURE 04/30/2022 EXPIRATION DATE OF THE LICENSE

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Table of Contents

Introduction

Act 125 requires the conversion of all cesspools in Hawai'i to approved systems by 2050. The purpose of this study is to assist the Department of Health (DOH) with the evaluation of onsite technologies for cesspool conversions.

LEGISLATIVE ACTIONS TO BAN CESSPOOLS IN HAWAI'I

Throughout the State of Hawai'i, there are approximately 88,000 cesspools, releasing an estimated 53 million gallons per day (mgd) of wastewater to the environment. Most of the existing cesspools provide wastewater disposal for single family residences, as opposed to large-capacity systems serving multiple residences or commercial areas. Given that over 90 percent of the State's drinking water supplies are from groundwater sources, cesspools pose a potential environmental and public health risk.

In 2017, the Hawai'i State Legislature passed Act 125, which states that by January 1, 2050 all cesspools in the State, unless granted exemption, shall upgrade or convert to a septic or aerobic treatment unit, or connect to a sewer system (Act 125, 2017). The Legislature then passed Act 132 in 2018, which established a Cesspool Conversion Working Group (Working Group) to develop a long range, comprehensive plan and commission a statewide study of sewage contamination in nearshore marine areas (Act 132, 2018).

As a result of Act 125, homeowners will be required to upgrade their existing cesspools to a technology that complies with current health regulations. Historical costs of cesspool upgrades to approved systems range widely from approximately $9,000 to $60,000 or more depending on the wastewater system capacity (based on bedroom count), technology, and location or site constraints.[1] Assuming the average conversion cost of $23,000, the potential magnitude of the financial burden to convert all 88,000 cesspools is approximately two billion dollars.[2]

Assuming an average conversion cost of $23,000, the potential magnitude of the financial burden to convert all 88,000 cesspools is approximately two billion dollars.

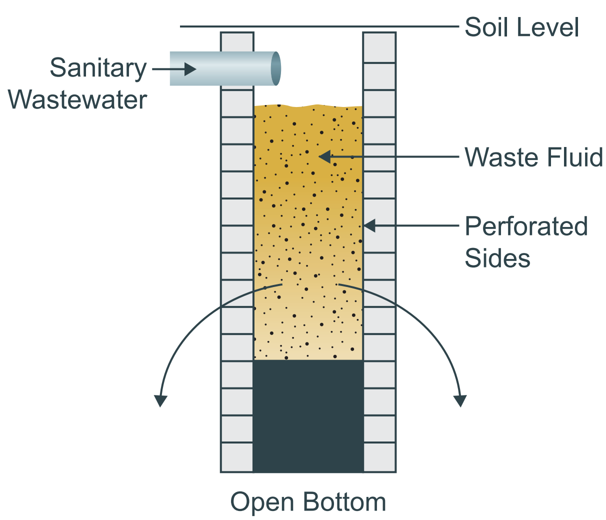

FIGURE 1. Cesspool Schematic.
Cesspools are underground excavations that receive sanitary wastewater from bathrooms, kitchens, and washers. The structure usually has an open bottom and perforated walls.

1. Based on cost data from DOH.
2. Costs shown in 2020 dollars.

Conversion Priorities

In the 2018 Legislature Report, DOH identified priority areas for cesspool conversions based on environmental and public health risks:

- **Priority 1:** Significant risk of human health impacts, drinking water impacts, or draining to sensitive waters.
- **Priority 2:** Potential to impact drinking water.
- **Priority 3:** Potential impacts on sensitive waters.
- **Priority 4:** Impacts not identified.

Table 1 summarizes the current priority areas by geographic region. DOH may revisit cesspool prioritization methods, and as a result, priority areas could be revised.

TABLE 1. Initial Priority Upgrade Areas Established by DOH Wastewater Branch (DOH, 2018)

GEOGRAPHIC AREA	PRIORITY LEVEL ASSIGNED	NUMBER OF CESSPOOLS	ESTIMATED EFFLUENT DISCHARGE (MGD)
Upcountry area of Maui	1	7,400	4.40
Kahalu'u area of O'ahu	1	740	0.44
Kea'au area of Hawai'i Island	2	9,300	4.90
Kapa'a/Wailua area of Kaua'i	2	2,900	2.20
Poipu/Koloa area of Kaua'i	2	3,600	2.60
Hilo Bay area of Hawai'i Island	3	8,700	5.60
Coastal Kailua/Kona area of Hawai'i Island	3	6,500	3.90
Puako area of Hawai'i Island	3	150	0.60
Kapoho area of Hawai'i Island	3	220	0.12
Hanalei Bay area of Kaua'i	3	270	0.13
Diamond Head area of O'ahu	3	240	0.17
'Ewa area of O'ahu	3	1,100	0.71
Waialua area of O'ahu	3	1,080	0.75
Waimanalo area of O'ahu	3	530	0.35
	TOTAL ASSIGNED	42,730	26.87
Hawai'i Island Un-Assigned	NA	24,430	12.18
Kaua'i Un-Assigned	NA	6,930	4.57
Maui Un-Assigned	NA	4,800	3.50
O'ahu Un-Assigned	NA	7,610	5.08
Moloka'i Un-Assigned	NA	1,400	0.80
	TOTAL UN-ASSIGNED	45,170	26.13
	OVERALL TOTALS	87,900	53.00

SCOPE OF TECHNOLOGIES EVALUATION OF CESSPOOLS CONVERSIONS

There are three options for cesspool conversions including:

1. **New onsite system.** New onsite wastewater treatment and disposal at an individual household level.
2. **Decentralized system.** New decentralized sewer systems that collect and treat sewage from multiple homes for treatment and disposal.
3. **Centralized sewers.** Connection to existing or new centralized sewer systems.

This report summarizes the technologies evaluation and challenges of cesspool conversions for Hawai'i, primarily focused on new onsite systems. A limited review of decentralized systems is also included. Evaluation of connection to an existing regional collection system and treatment plant was not included in the scope of this study.

Various approved and innovative onsite and decentralized wastewater treatment technologies were evaluated. The intent of this work is to provide guidance to the Working Group regarding the applicability, performance, and relative costs of different onsite and decentralized systems that may be considered for cesspool conversions required under Act 132.

The details of this effort were presented in a series of the following previously prepared technical memoranda (TMs):

- TM 1 – Assessment of Onsite Treatment Technology Testing and Approval Procedures Utilized by Other States
- TM 2 – Septic Tank Systems Review
- TM 3 – Onsite Treatment Technologies Evaluation
- TM 4 – Evaluation of Decentralized Cluster Wastewater Systems

Each of these TMs are presented in their entirety in Appendix A of this report.

LIMITATIONS

The content of this report was prepared specifically for the Working Group and was completed based on previous studies and publicly available information. Future public outreach and education are planned as a part of the overall cesspool conversion strategy development. Other considerations that may have impacts to this evaluation include exemptions to cesspool conversion, or changes to the priority areas. Granting exemptions to cesspool conversions are at the discretion of the DOH per Act 125. Ongoing efforts are underway to study available cesspool data validation and prioritization. If new information or guidance on cesspool priority areas is developed, the technologies evaluation should be revisited.

This report is not meant to provide specific design guidance for engineers or homeowners to convert their cesspools. Ultimately, homeowners should seek more specific guidance from a properly licensed and experienced civil engineer and/or general construction contractor. The engineer will need to prepare various studies and designs before a construction permit can be issued and constructed upgrades can begin. This will involve going through several steps to evaluate and select processes for the specific property that are both technically sound and cost effective.

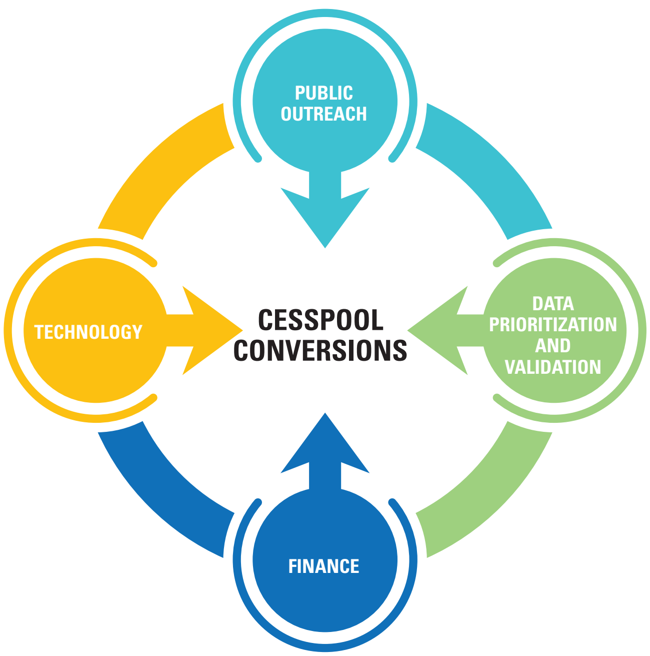

FIGURE 2. Four Aspects of Cesspool Conversion.
The Working Group is engaged in three aspects of cesspool conversions—conversion technologies, financing and funding needs, and data prioritization and validation. A separate but related effort is underway for public outreach and education.

Onsite Wastewater Treatment and Disposal Technologies

As cesspools are upgraded to new, approved onsite systems, homeowners will need technical guidance in selecting the appropriate and most cost-effect conversion technologies.

BACKGROUND

The following sections provide descriptions and characteristics of the onsite treatment and disposal technologies evaluated as part of this study. The technologies have four levels of approval noted relative to their potential application to cesspool conversions in Hawai'i:

- **Approved.** These technologies are already approved for use in current regulations[2] and the permitting and review process are more readily obtained than options that are not approved.
- **Approval Required.** These technologies are mentioned in current regulations; however, detailed design calculations must be submitted, and design review is required by DOH prior to site-specific approval. Thus, implementation of these technologies is possible, but will likely require a longer implementation timeline than approved options.
- **Innovative.** These technologies are commercially available outside of Hawai'i, but do not have established regulatory design criteria and would require design review by DOH. Implementation of these technologies would have a longer timeline than approved options.
- **Emerging.** These technologies are at a research stage, and/or are undergoing pilot-testing or full-scale probationary approval in other states. They are not commercially available and do not have established regulatory design criteria. DOH does not currently have a process for approving these technologies, thus implementation of these options would have a long timeline.

Table 2 summarizes the onsite technologies that were evaluated. Summary descriptions of each treatment, disposal, and alternative toilet technology are presented in Appendices B, C, and D, respectively.

KEY CONSIDERATIONS FOR ONSITE SYSTEM OPTIONS

There are several considerations when selecting the type of onsite system for cesspool conversions. These factors are site-specific and require planning and design on a case-by-case basis.

- **Site Restrictions.** Available land area and soil characteristics will dictate which technologies are feasible. The following constraints should be evaluated:
  - Separation from groundwater table.
  - Lot size.
  - Soil percolation rate.
  - Ground slope.
  - Location relative to flood zones.
  - Proximity to surface waters.
- **Treatment Performance.** Some systems provide better treatment than others. The following performance characteristics should be considered:
  - **Applicability to each priority area.** Is there sufficient treatment to protect the environment?
  - **Recognized certifications.** Technologies that have been rigorously tested and are certified make them easier for the DOH to approve. These technologies demonstrate treatment for typical wastewater pollutants (NSF40) and nutrients (NSF245).
  - **Removal of fecal coliform.** Fecal coliform are indicative of disease-causing pathogens in the wastewater. Consideration should be given to the need for disinfection.
- **Cost.** Consideration should be given to both initial and long-term costs.
  - Construction cost.
  - Operation and maintenance (O&M) costs.

2. *Hawai'i Administrative Rules (HAR) 11-62.*

TABLE 2. Onsite Treatment, Disposal, and Alternative Toilet Technologies[8]

TECHNOLOGY	APPROVAL STATUS
Treatment	
Septic Tank	Approved[1]
Aerobic Treatment Unit (with and without denitrification)	Approved[1]
Chlorine Disinfection	Approved[1]
Ultraviolet Disinfection	Approved[1]
Recirculating Filter	Approved[1]
Eliminite Wastewater Treatment Process	Innovative[3]
NITREX™ Nitrogen Removal Process	Innovative[3]
Recirculating Gravel Filter[5]	Emerging[4]
Disposal	
Absorption	Approved[1]
Seepage Pit	Approved[1]
Presby Enviro-Septic®	Approved[1]
Evapotranspiration	Approval Required[2]
Constructed Wetland	Approval Required[2]
Drip Dispersal	Approval Required[2]
Passive Treatment Unit[6]	Innovative[3]
Nitrification/denitrification biofilters, including various layered configurations[7]	Emerging[4]
Alternative Toilets	
Composting Toilet	Approval Required[2]
Incineration Toilet	Approval Required[2]

Notes:
(1) Technology approved by DOH in HAR 11-62.
(2) Technology mentioned in HAR 11-62, but design review is required.
(3) "Innovative" technologies are commercially available outside of Hawai'i, but do not have established regulatory design criteria and would require design review by DOH Wastewater Branch.
(4) "Emerging" technologies are at a research stage and/or are undergoing pilot-testing or full-scale probationary approval in other states. They are not commercially available and do not have established regulatory design criteria. DOH Wastewater Branch does not currently have a process for approving these technologies.
(5) Studied by the Washington State Department of Health.
(6) Developed in Florida.
(7) Studied in Massachusetts and New York.
(8) See Appendices B, C, and D for summary descriptions of each technology.

TREATMENT TECHNOLOGIES

There are many onsite treatment technologies used throughout the United States and the world. The treatment technologies reviewed for this study were limited to those that would most likely be applicable to cesspool conversions in Hawai'i. While other treatment options may apply, all non-approved technologies would first need to obtain approval from the DOH before installation requiring a longer timeline for implementation and potentially more costly conversion.

Approved

The technologies that are already approved for use in Hawai'i are listed in current regulations (Hawai'i Administrative Rules (HAR) Title 11 Chapter 62). These technologies are discussed in the following sections.

Septic Tank

The most common conversion treatment technology that is approved for use in the State of Hawai'i is a septic tank system. Septic tanks are generally easy to install and maintain as they are typically a passive system that does not require power. Routine maintenance includes inspection and pumping approximately every two years. The downside of septic tanks is that without subsequent treatment processes, they do not remove nitrogen, so they may not be an appropriate conversion technology depending on the location within the priority areas. Further study is needed to determine recommended design criteria for septic tanks that are sufficiently protective of human health and the environment. More information on septic tanks is included in Appendix A - TM 2, and Appendix B.

Aerobic Treatment Unit

Aerobic treatment units (ATUs) provide biological treatment with the addition of air and mixing of the collected sewage. The storage tank retains the solids and the treated sewage flows into an approved disposal system. The ATU can be operated and designed differently to provide removal of ammonia and nitrate, both common pollutants in household wastewater. ATUs require power and more frequent inspections and pumping than septic tanks.

Chlorine Disinfection

Chlorine is a powerful oxidizing chemical often used for disinfection of water or wastewater after treatment. Solid hypochlorite in the form of powder or tablets (similar to tablets for swimming pools) can be used in onsite systems. All forms of chlorine are toxic, corrosive, and require careful handling and storage. Chlorine tablets are commonly used for systems. Chlorine tablets do not require electricity, are easy to operate and maintain, and are relatively inexpensive.

Ultraviolet Disinfection

Ultraviolet (UV) disinfection uses lamps emitting UV light that acts as a physical disinfection agent to prevent bacterial growth. A power source is required for the UV bulbs. UV disinfection is a polishing step that follows other treatment, such as septic tanks or ATUs; disinfected effluent then flows to the disposal system. Disinfection may be required for cesspool upgrades near sensitive waters or drinking water sources.

Recirculating Filter

Certain recirculating filters are approved for use in Hawai'i and are NSF40 and NSF245 certified. Wastewater must first flow through a septic tank prior to the recirculating filter, then to the disposal system. The advantage of this system is that secondary treated effluent can be produced without aeration.

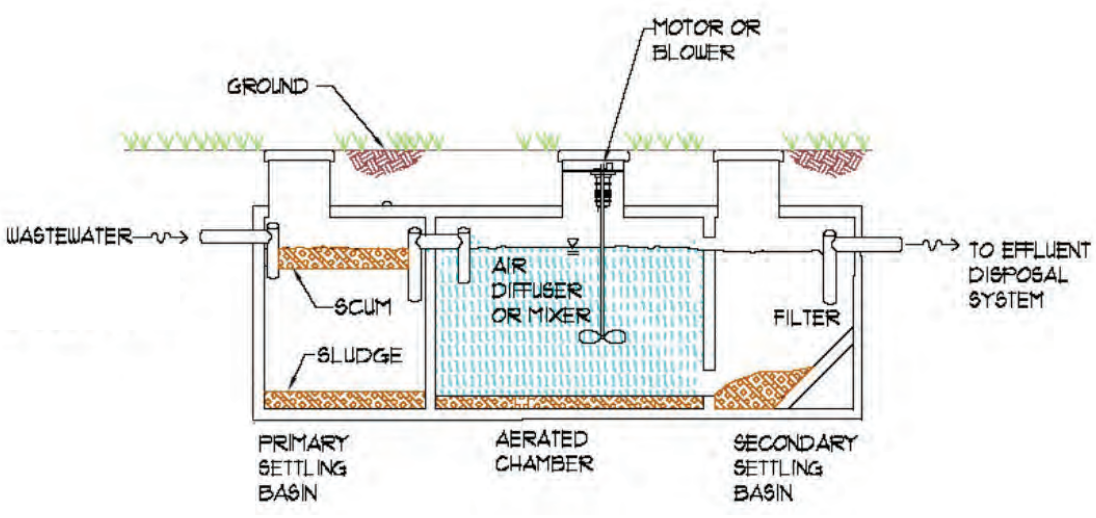

FIGURE 3. Schematic of Suspended-Growth Flow-Through ATU.
Aerobic treatment units can remove ammonia (nitrification) and nitrate (denitrification) providing better nitrogen treatment than a septic tank.

Innovative

The Eliminite and NITREX™ wastewater treatment systems are two innovative technologies that were reviewed as part of this study. Both offer potential for application in Hawai'i, but would require special approval by DOH. More information on each of these systems can be found in Appendix B.

Emerging

The recirculating gravel filter is an emerging technology which has been applied in the State of Washington for the treatment of septic tank effluent to remove nitrogen. DOH does not currently have a process for approving emerging technologies, thus a technology review and approval process would need to be developed prior to considering the use of this onsite treatment system in Hawai'i.

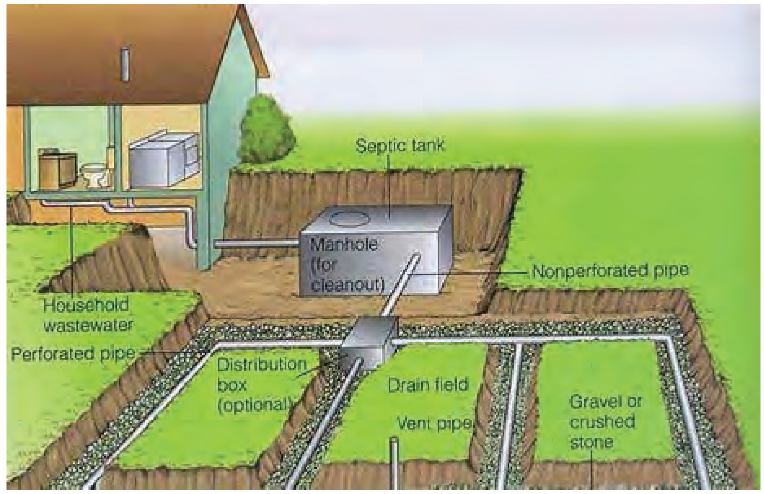

FIGURE 4. Trench Absorption System.
Absorptions systems are a common, cost-effective disposal option for onsite systems but do have a minimum space requirement.

DISPOSAL TECHNOLOGIES

Similar to onsite treatment, there are many different disposal technologies that could apply to cesspool conversions. However, the focus of this study was on disposal options that were the most likely options for Hawai'i and can be implemented relatively easily.

Approved

The disposal technologies that are already approved for use in Hawai'i are listed in current regulations (HAR 11-62) and are summarized below.

Absorption

Absorption systems are buried approximately 1.5 to 3 feet below grade and dispose of treated effluent by allowing the water to drain into the soil. The wastewater is typically first treated by a septic tank or ATU before it is distributed through perforated pipes laid in a trench or bed. Depending on soil conditions, new fill or bedding may be required. Absorption systems are relative easy to install and maintain, but do have minimum space requirements. Current regulations require a minimum area of of 350 square feet for a 4-bedroom home; larger areas may be required pending soil conditions. If sufficient space is not available, another disposal option should be considered.

Seepage Pit

Seepage pits are an approved disposal technology but are typically allowed only if there is not enough space for another disposal option and must be proceeded by the appropriate level of treatment. Pending DOH approval, an existing cesspool can be cleaned and repurposed for use as a seepage pit. These systems are typically constructed from reinforced concrete rings that are 8 to 10 feet in diameter and a height of 2 feet, that are stacked in order to achieve the depth required (usually 15 to 30 feet) to meet percolation requirements.

Presby Advanced Enviro-Septic® System

The Presby Advanced Enviro-Septic® System is an approved disposal technology that usually follows a septic tank and has NSF40 certification[3] because it provides additional treatment. It is a network of 10-foot long pipes for further treating and percolating septic tank effluent. It consists of special pipes embedded in a specific type of System Sand. Space requirements are similar to or slightlly less than what is required for an absorption sytem. This system does not require power or replacement media and can remove conventional pollutants (Presby Environmental, 2018).

FIGURE 5. Presby Advanced Enviro-Septic® Treatment System. (Presby Environmental, 2018) Presby systems can be used in higher priority areas where nitrogen removal is required.

Approval Required

Treatment technologies requiring DOH approval include:

- Evapotranspiration
- Constructed Wetland
- Drip Dispersal

Evapotranspiration and constructed wetlands do not require power, whereas drip dispersal requires power to pump treated effluent to the disposal system.

Innovative

Florida researched several types of passive disposal systems, such as biofilters that provide better nitrogen removal than standard absorption systems. These systems are not yet approved for use in Hawai'i, but may be a cost effective option for conversions requiring nitrogen removal.

Emerging

Emerging disposal technologies include:

- Nitrification/denitrification biofilters, including various layered configurations

These options require further study and demonstration prior to potential application to Hawai'i.

ALTERNATIVE TOILET TECHNOLOGIES

Alternative toilets provide treatment and disposal of toilet waste by converting it to compost or incinerating the waste to ash. Additional treatment and disposal of graywater (shower and laundry waste) and kitchen blackwater is still required. Design review and approval by DOH is required prior to installing alternative toilets. Alternative toilet technologies include:

- Composting toilets
- Incineration toilets

3. https://d2evkimvhatqav.cloudfront.net/documents/ww_nsf_40_and_245.pdf?mtime=20200417153207&focal=none

Technology Testing and Approval Procedures

The Hawai'i State DOH Wastewater Branch needs to develop review and approval processes for new technologies.

Onsite systems are regulated by the Hawai'i State DOH Wastewater Branch. Current Hawai'i regulations include procedures, design criteria, standards, and restrictions for design and installation of approved technologies. Detailed criteria are provided only for septic tanks, ATUs, and absorption trenches/beds. All other systems and technologies must be approved on a case by case basis, the procedures for which are not currently specified in detail.

To efficiently review and approve the designs for 88,000 cesspool upgrades, the DOH, in conjunction with the four counties, will need a process in place to review and approve innovative and emerging technologies. New technologies may have benefits, such as better treatment, reduced capital cost, or less maintenance than currently approved options. The current process for obtaining approval of new technologies in Hawai'i does not prescribe application procedures, fees, timelines, testing durations, sampling protocols, performance requirements, or renewal periods. In addition, DOH does not currently have procedures to certify new technologies or maintain a state-approved list of these technologies. DOH would need to establish procedures to review and approve of new, innovative, or emerging technologies for application to cesspool upgrades.

Several other states have established rules and processes for approving new technologies. The following section summarizes the lessons learned and suggested best practices from other states for reviewing and approving new technologies for cesspool conversions. The states investigated include: Delaware, Florida, Maryland, Massachusetts, New Jersey, New York, Rhode Island, and Texas. Figure 6 summarizes the major steps of the technology approval and system permitting process used by the State of Florida.

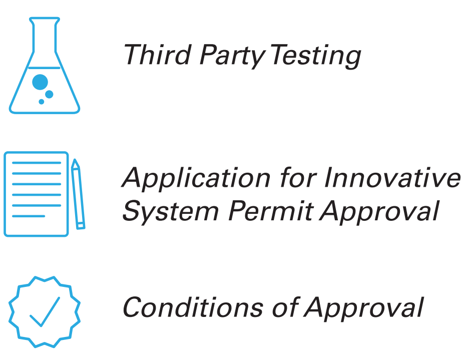

FIGURE 6. Florida Department of Health Innovative System Permit Approval Process.
Florida requires third party testing prior to vendors applying for approval. Approved technologies also must meet the Department of Health's conditions of approval.

APPROVAL PROCESSES UTILIZED BY OTHER STATES

Each of the states reviewed utilize different procedures and apply a range of requirements for the approval of new onsite technologies. Some states are very prescriptive on processes, requirements, durations, etc. with several types of progressive permitting phases to manage; and other agencies have less complicated procedures. The characteristics and components of these procedures were compared and evaluated for best practices.

The goal for DOH is to create a procedure that first and foremost protects public health and the environment. This goal must be balanced with data needs, review time, program complexity, program staffing and cost, testing, designer and installer needs, and homeowner costs. These are numerous and often competing factors to consider, and there is no perfect system. An effective system should strive to achieve the following:

- Provide a simple application process.
- Require only relevant information needed by DOH, and in a standard format/location to facilitate efficient review.
- Utilize a small number of types/phases of permits to manage.
- Limit the number of water quality tests required of the applicant.
- Provide and enforce a well-defined protocol for testing, including duration, sampling intervals, and types.

The suggested best practices and lessons learned from other states are summarized below (see Appendix A, TM 1 for notes from interviews with other states):

Additional agency staff. Most state agencies expressed concerns that they are understaffed to manage their programs. Staff members manage anywhere from 100 to 3,000 permit applications per staff member per year. Most agencies desire more staff so that they can do more inspections and follow up on converted systems.

Application fee and program funding. Most states expressed concern that they are underfunded. In general, they recommend adoption of an appropriate application fee that will cover the total cost of review and approval of new technologies.

- Some agencies also recommend that fees go to a dedicated (versus general) fund for cesspool conversion program management.
- Some states recommend requiring by law that homeowners convert their cesspool at point-of-sale of the home and implement meaningful fines for non-compliance.

Standardized application forms and templates. Utilizing standardized application forms and templates for required submittals helps to streamline the application review and approval process.

Water quality standards. Consider multiple sets of numerical water quality standards such as:

- Secondary treatment.
- Advanced wastewater treatment – where total nitrogen removal is required or desired.

Interviews with other state agencies showed that the common, recommended monitoring parameters are total Kjeldahl nitrogen, nitrite, and nitrate.

Certified laboratories. Requiring that testing is completed by a qualified third party according to standards established by the National Sanitation Foundation (NSF), American Society for Testing and Materials (ASTM), or Environmental Protection Agency (USEPA)-approved entities will help to bolster testing integrity.

Testing and data management. To sufficiently demonstrate satisfactory treatment performance, at a minimum, system testing should be conducted on a monthly basis, for one year, for at least 10 systems. Sampling and monitoring data can get unwieldy to manage and a good database program is required to facilitate data management and use.

Approvals. Other states recommend implementing a simplified approval process and suggest having two types of approvals –"Provisional" and "Approved", to allow a probationary period followed by conversion to be approved. The approval should be permanent, however, there should be a periodic reviews of process performance – conducted by a third party.

Consider not issuing official certifications for new technologies. Of the states reviewed, three have issued certifications of technologies when they approved the technology (Rhode Island, Massachusetts, and New Jersey). Rhode Island has since stopped issuing certifications because it gives the appearance of an endorsement.

Certifications and Training. Consider implementation of a certification program (and maintain lists on the DOH webpage) for:

- Designers
- Installers
- Inspectors/Maintainers

Decentralized Cluster Wastewater Systems

As an alternative to approved onsite systems, some neighborhoods may be able to collectively convert their cesspools using decentralized cluster wastewater systems.

BACKGROUND AND ASSUMPTIONS

In some cases where several cesspools are in close proximity, it may be feasible to construct small-scale, decentralized cluster wastewater systems for a number of homes on a neighborhood level. These systems will require wastewater collection, treatment, and disposal elements. A high-level evaluation of decentralized systems was performed for this study. The cluster systems evaluated were limited to those that can collect and treat domestic wastewater from 10 to 100 homes or capacities of approximately 5,000 to 50,000 gallons per day. However, many of these systems are modular and expandable to an extent. Decentralized systems could be owned and operated by public or private entities in Hawai'i.

CONSIDERATIONS FOR DECENTRALIZED WASTEWATER SYSTEMS

There may be instances and locations where decentralized systems are a better option for cesspool conversions in Hawai'i compared to individual, onsite solutions, or connections to centralized sewers. Factors to consider include:

- **The number of systems in the cluster and the separation distance between them.** There may be an ideal density of cesspools within a neighborhood that would allow for a cost-effective solution. This would need to be evaluated on a site-specific basis by a licensed engineer.
- **Terrain.** Depending upon the local soils, slopes, and other site-specific features, the terrain may limit the options and potential application of a decentralized system. Onsite systems need only consider the terrain of individual properties.
- **Availability of land.** Decentralized treatment systems will likely need to be constructed on newly acquired land and may require easements. These cluster systems would only be a viable option if the required land is available.
- **Public support for a decentralized system, including shared funding for a utility to provide O&M services.** For an onsite system, the homeowner is the only party involved and is responsible for the financing, O&M, any permits, and fines due to non-compliance or spills, etc. This is simple for the owner since they do not rely on other homeowners, a sewer district board, or potential future capital assessments for other people's problems. At the same time, the owner of an onsite system must be the responsible party and plan to have the O&M, and other related services, completed. While cost can be a powerful motivator, some homeowners may see value and convenience in having a separate service operate and maintain a decentralized system over an individual onsite approach. A decentralized utility has stable, regular monthly bills rather than less frequent larger bills for pumping/servicing/repair of an onsite system. Failures and surprise costs due to lack of care are much less likely for continuously operated cluster approach than onsite systems which are frequently neglected because they are "out-of-site, and out-of-mind".

SYSTEM TECHNOLOGIES

Decentralized cluster systems require wastewater collection, treatment, and disposal. The following sections summarize options available for each. More detailed information can be found in Appendix A, TM 4 – Evaluation of Decentralized Cluster Wastewater Systems.

Collection System

The collection system conveys wastewater from each home to a treatment and disposal facility and consists of a network of pipes and related equipment such as pumps, valves, manholes, etc. located on private and public property. The following options for wastewater collection may be appropriate for decentralized cluster systems. Summary descriptions of each of these collection system technologies can be found in Appendix E.

- Gravity Sewers
- Liquid-Only Pressure Sewers
- Low Pressure Sewers
- Vacuum Sewers

Wastewater Treatment

These systems treat the wastewater collected from the homes to a suitable degree to allow disposal and/or reuse. The process generally consists of tanks and other process equipment required for separation and storage of solids, oxidation of organic matter, and often disinfection of pathogenic microorganisms. Treatment facilities typically require land space and power, including back-up generators, and must have controlled access (fencing and alarms) and be maintained by certified operators who need 24/7 access. Pre-engineered, package plant type systems are generally more compact and economical for decentralized treatment facilities versus site-specific, ground-up complete designs. Such systems are also modular, facilitating easy expansion due to possible future growth. The different treatment technology options considered are listed below. Summary descriptions of each of these treatment options are presented in Appendix F.

- Activated Sludge
  - » Conventional
  - » Extended Aeration
  - » Membrane Bioreactor
- Attached Growth Bioreactors
  - » Textile Filter
- Moving Bed Bioreactor
- Constructed Wetlands

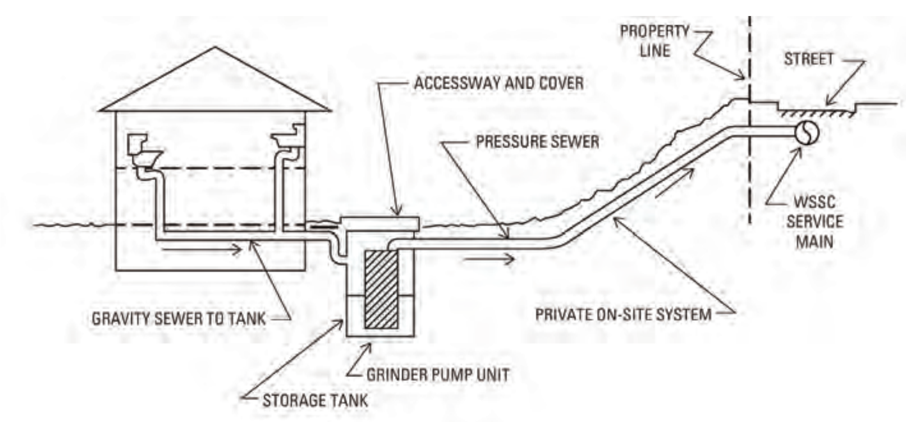

FIGURE 7. Low Pressure Sewer Systems
Low pressure sewers can be used to as a component of a decentralized system.

Effluent Disposal

The effluent disposal system must properly dispose or reuse the effluent from the treatment facility. Disposal can normally occur on the same site as the treatment facility (requiring additional land space), while reuse would usually require conveyance off-site to managed reuse areas. Residual solids must also be properly disposed of at an off-site facility. Effluent disposal options are listed below and summarized in Appendix G:

- Percolation
  - Absorption Trench/Bed
  - High Pressure Drip
  - Low Pressure Pipe
  - Seepage Pit
- Water Reuse
- Evapotranspiration
- Injection Well
- Surface Water Discharge

Seepage pits, injection well,s and surface water discharges are unlikely effluent disposal options and are included for completeness. Effluent disposal systems are regulated in HAR 11-62-25. Some of the basic provisions of these regulations are as follows:

- Disposal systems shall at least consist of a primary disposal component and a separate 100 percent back-up disposal component.
- Both primary and backup disposal units shall be designed to handle the peak flow, determined by the county or design engineer and approved by DOH.
- Stricter data monitoring and data submittals are required for subsurface disposal systems.
- Provisions to facilitate operation, maintenance, and inspection are required on a case-by-case basis.
- Disposal systems shall include provisions for purging and chemical shock treatment.

SUMMARY OF DECENTRALIZED CLUSTER WASTEWATER SYSTEMS

Benefits

Decentralized cluster wastewater systems may make sense to convert several cesspools that have a high density, are within high priority areas, and where there is community support for this kind of a solution. The benefits of implementing cluster systems, where feasible include:

- **Potential for rapid conversions.** The use of cluster systems may allow the conversion of a greater number of cesspools at a single point in time. This could help to mitigate the public health and environmental risks in high priority areas in the near term.
- **Reducing the administrative oversight and enforcement burden on state/county agencies.** For the county/state, having all systems converted on an individual basis is a much larger task than having decentralized cluster systems. Just in terms of sheer numbers of permitted units, it could reduce the number by orders of magnitude (e.g. instead of 88,000 individual units; 880 to 8,800 cluster systems).
- **Reduce the burden on individual homeowners to hire engineers and contractors independently to design and construct onsite systems.** A coordinated, organized effort to evaluate a cluster system for a neighborhood would relieve the burden on individual homeowners to understand and determine their cesspool upgrade needs.

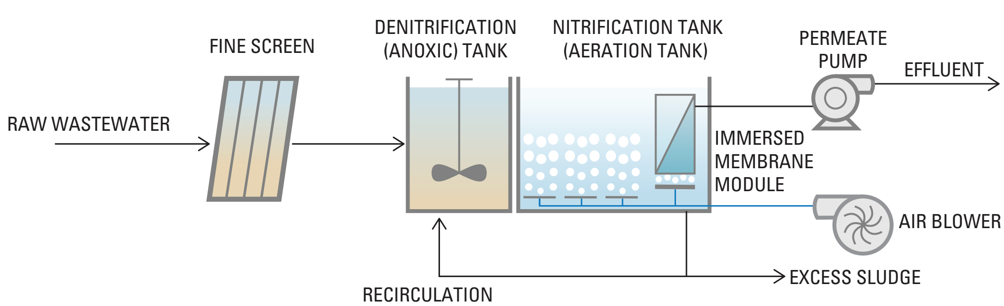

FIGURE 8. Membrane Bioreactor Treatment Process
Membrane bioreactors can be installed in a compact footprint and produce water suitable for reuse.

- **Ensure proper operations and ongoing maintenance of the systems by requiring a licensed wastewater operator.** Cluster systems are regulated and inspected by the State of Hawai'i DOH Wastewater Branch the same manner as existing WWTPs. The rules and procedures are already in place, including the requirement that state-licensed WWTP operators oversee the cluster systems. This is more likely to ensure that systems are inspected, operated, maintained, repaired, and function as required to meet regulations. A similar regulatory and enforcement program for individual onsite system management does not currently exist at the county/state level in Hawai'i and it will need to be developed, implemented, funded, and appropriately staffed .
- **Potentially broaden the range of funding opportunities.** One of the hurdles in funding cesspool conversions is that many existing funding options require a conduit agency or intermediate party to manage and administer available grant or low interest loan funds to individual homeowners for cesspool conversions. Given that decentralized systems will need to be managed and operated by a third party, this also opens the door for more funding options. In addition, if water reuse is a disposal option for the decentralized system, there are additional funding opportunities that may apply. Water reuse is not allowed for onsite systems; thus, those funding opportunities would not be available.

FIGURE 9. System Testing
Decentralized wastewater systems would be subject to the same operator licensing, rules, and requirements current in place for existing wastewater treatment plants.

Challenges

The challenges to implementing cluster systems for cesspool conversions in Hawai'i include:

- **Need for neighborhood-level coordination.** Implementation of decentralized solutions for cesspool conversions requires that a group of homeowners to take the initiative to form an association or district to collect fees and procure various professional and construction-related services. Legislative measures may be necessary to facilitate neighborhood-level coordination especially if participation will be required of homeowners. To truly evaluate the feasibility of decentralized systems for certain neighborhoods, a licensed engineer needs to perform a site-specific analysis and develop costs for a recommended system. This process could take time and involve attorneys to facilitate formation of a homeowner's association if needed.
- **Cost.** Decentralized cluster systems require higher up-front planning and design fees and have higher construction costs than onsite wastewater treatment systems. In addition, collection system construction costs can be significant. A site-specific analysis is necessary to evaluate the feasibility and best overall system options for a neighborhood. The engineering evaluation could be quite expensive – easily 5 to 10 times the cost of an onsite design for a single homeowner. In addition, the construction would be more extensive than onsite systems, and construction costs would accordingly be higher on a per lot basis.
- **Need for skilled operators.** Licensed wastewater operations professionals are required to operate and maintain the cluster system components in perpetuity.
- **Land/space requirement.** Decentralized systems would likely need to be constructed on newly acquired land and may require easements. These cluster systems would only be a viable option if the required land is available.

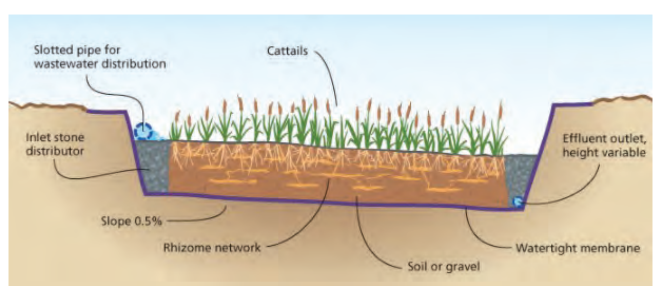

FIGURE 10. Treatment Wetlands Schematic.
Treatment wetlands require significant land area for implementation.

Findings and Recommendations

As the State continues to develop the cesspool conversion strategy, there are several issues that warrant further investigation. This section summarizes findings, recommendations, and the need for future studies and other early actions.

FURTHER EVALUATION OF SEPTIC TANK SYSTEMS

Hawai'i's existing wastewater regulations include a sufficient amount of guidance for septic tank system application and installation (HAR 11-62-31). Typical septic tank systems include a septic tank followed by a soil absorption system. However, the State may consider reviewing or evaluating the following design considerations in the future:

- **Allowable "density" of septic tank systems or numeric limits for total nitrogen.** Septic tank systems are known to provide water quality benefits over cesspools. However, septic tank systems do not provide significant treatment for total nitrogen. Upgrading cesspools to septic tanks in areas with a high density may not provide significant protection to groundwater or near surface water quality. Limiting the number of septic tank systems allowed within a certain area may help to provide groundwater and near surface water quality protection. Another way to protect water quality is to implement a numeric limit for total nitrogen discharged from onsite systems in certain areas.

DEVELOP A COORDINATED STRATEGY FOR METHODS OF CONVERSIONS

Because there are so many site-specific considerations for cesspool conversions, a clearer understanding of the best options to convert cesspools would be helpful to the State and cesspool owners. Some areas within the State do not have options to connect to local sewers, leaving decentralized treatment or continued onsite treatment as their only options. Decentralized treatment may not be feasible for other areas of the State due to low cesspool densities, nonfavorable site conditions, lack of community support, etc.

A countywide or statewide study focusing on developing recommended conversion options for different areas would be helpful in guiding homeowners with their conversion and may also help to develop strategic funding programs. Key objectives of such as study could include:

- Identification of cesspools that can be easily connected to existing sewers.
- Identification of cesspools that can be connected to extended or new sewer systems.
- Feasibility study of decentralized treatment for high-density, high-priority cesspool areas.
- Evaluation of the appropriate level of treatment required to protect public health and the environment for different areas of the State.

This study would require transparent feedback and input from various agencies, such as the counties and privately owned WWTPs on their future planning efforts and system capacities. Such a study would help to guide the conversion strategies for localized areas and a coordinated effort with public outreach, education, financing, and technical solutions.

BEST PRACTICES FOR APPLICATION AND APPROVAL OF ALTERNATIVE AND INNOVATIVE TECHNOLOGIES

The following recommendations are based on interviews and review of new, onsite technology testing and approval processes of other states:

- **Staffing Plan.** Develop a plan for the significant additional staff that will be required to administer and manage the cesspool conversion program. As part of this effort, define the necessary state-provided services and identify the associated staffing needs.
- **Fees and program funding.** Consider adopting appropriate fees to cover program costs. Consider dedicating those fees to a dedicated fund, and requiring by law, that homeowners convert their cesspools at the point-of-sale of the home.
- **Standardized application forms and templates.** Develop and use standardized application forms and templates for required submittals to streamline the application review and approval process. Suggested submittal materials include: technology description, design criteria, installation criteria, O&M requirements, warranty, and results of previous studies.
- **Water quality standards.** Consider multiple sets of numerical water quality standards such as:
  - » Secondary treatment.
  - » Advanced wastewater treatment – for where total nitrogen removal is required or desired.

Parameters may include: total suspended solids, 5-day biochemical oxygen demand pH, alkalinity, total nitrogen, total phosphorus, ammonia, nitrate, nitrite, and fecal coliform.

- **Certified laboratories.** Require that testing is completed according to NSF, ASTM, or USEPA-approved entities or by a qualified third party to bolster testing integrity. The State intends to develop a standardized program to obtain and maintain laboratory certifications.
- **Testing period, sampling intervals, and number of systems tested.** Establish appropriate testing period, sampling intervals, and number of systems to be tested to demonstrate satisfactory performance (e.g. one year of monthly sampling with a minimum of 10 installations).
- **Data collection and management.** Maintain a good database program to facilitate data management and utilization, and to track long-term performance of systems, inspection/maintenance compliance, and data/report submissions. This kind of a database program could also help Hawai'i to track long-term performance of systems, inspection/maintenance compliance, and data/report submissions. Data management must be coordinated with existing systems in place by the seperate counties.
- **Approvals.** Consider implementing a simplified approval process that has two types of approvals – "Provisional" and "Approved", to allow a probationary period followed by conversion to be approved. The approval for new technologies should be permanent; however, there should be periodic reviews by a third party of process performance. Consider maintenance of a list of approved technologies on the DOH webpage.
- **Technology certification.** Avoid issuing official certifications for new technologies.
- **Certifications and training.** Consider implementation of a certification program (and maintain lists on the DOH webpage) for:
  - » Designers
  - » Installers
  - » Inspectors/Maintainers

  Consider requiring manufacturers of approved new technologies to provide training for the certified individuals.

STAFFING/TRAINING/ WORKFORCE DEVELOPMENT

Once there is a better understanding of the feasible methods of conversions for different areas in the State, there needs to be sufficient, trained professional staff, contractors, and potentially wastewater system operators to implement and support the converted systems. Availability of well-trained staff and other human resources will impact the rate of cesspool conversions. This will require development of training programs and professional certifications so that the conversions are implemented successfully, and the upgraded systems are operated to deliver their designed performance.

PUBLIC OUTREACH, EDUCATION, AND HOMEOWNER TOOLS

Public outreach and education will be critical to progressing the cesspool conversion program for Hawai'i. Most importantly, cesspool owners will need clear guidance on what steps to take to successfully convert their cesspools and connection to technical and financial resources. Homeowner guidance should include:

- Educational resources on why cesspool conversions are needed.
- Feasible cesspool conversion options (i.e. connect to sewer, new decentralized system, or new onsite system).
- Access to professional engineers who can design the appropriate system.
- Access to contractors that are qualified and experienced in constructing the new system.
- Potentially licensed operators that can operate and maintain the new system.
- Guidance on financial support or funding options.

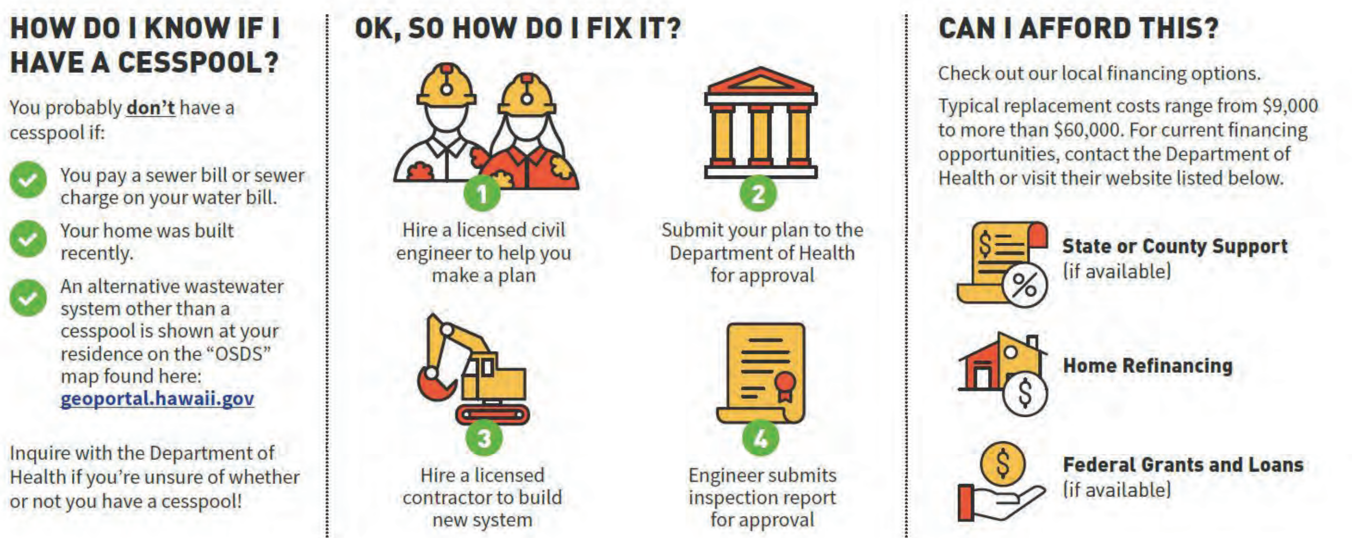

FIGURE 11. Example Public Outreach Handout
See Appendix H for the full page example handout.

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Appendix A

Technical Memoranda

Technical Memorandum 1:
ASSESSMENT OF ONSITE TREATMENT TECHNOLOGY TESTING AND APPROVAL PROCEDURES UTILIZED BY OTHER STATES
(July 2020)

Technical Memorandum 2:
SEPTIC TANK SYSTEMS REVIEW
(November 2020)

Technical Memorandum 3:
ONSITE TREATMENT TECHNOLOGIES EVALUATION
(October 2020)

Technical Memorandum 4:
EVALUATION OF DECENTRALIZED CLUSTER WASTEWATER SYSTEMS
(November 2020)

Hawaiʻi State Department of Health
Cesspool Conversion Technology Research

Technical Memorandum 1
ASSESSMENT OF ONSITE TREATMENT TECHNOLOGY TESTING AND APPROVAL PROCEDURES UTILIZED BY OTHER STATES

FINAL | July 2020

carollo in association with College of Engineering, University of Hawaiʻi at Mānoa

Hawaiʻi State Department of Health
Cesspool Conversion Technology Research

Technical Memorandum 1
ASSESSMENT OF ONSITE TREATMENT TECHNOLOGY TESTING AND APPROVAL PROCESSES UTILIZED BY OTHER STATES

FINAL | July 2020

CARI K. ISHIDA
LICENSED PROFESSIONAL ENGINEER
No. 14977
HAWAII U.S.A.
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.
SIGNATURE 04/30/2022 EXPIRATION DATE OF THE LICENSE

ROGER W. BABCOCK, JR.
LICENSED PROFESSIONAL ENGINEER
No. 12133-C
HAWAII, U.S.A.
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.
SIGNATURE 04/30/2022 EXPIRATION DATE OF THE LICENSE

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Abbreviations

Alk	Alkalinity
ASTM	American Society for Testing and Materials
ATT	alternative treatment technology
ATU	aerobic treatment unit
AIE	alternative, innovative, and emerging
ANSI	American National Standards Institute
BAT	best available technology
BCDHE	Barnstable County Department of Health and Environment
BOD_5	5-day biochemical oxygen demand
Carollo	Carollo Engineers, Inc.
$CBOD_5$	5-day carbonaceous biochemical oxygen demand
CCWG	Cesspool Conversion Working Group
COMAR	Code of Maryland Regulations
DE	Delaware
DNREC	Delaware Department of Natural Resources and Environmental Control
DOH	Hawaii State Department of Health
EPA	US Environmental Protection Agency
ETV	Environmental Technology Verification - USEPA
FAC	Florida Administrative Code
FDOH	Florida Department of Health
FL	Florida
FOG	fats, oil, and grease
gpd	gallons per day
gpd/ac	gallons per day per acre
HAR	Hawaii Administrative Rules
I/A	innovative and alternative
INBR	in-ground nitrogen-reducing biofilter
ISP	innovative system permit
LAA	local approving authority
LAMP	local agency management program
MassDEP	Massachusetts Department of Environmental Protection
MD	Maryland
MDE	Maryland Department of the Environment
mg/L	milligrams per liter
N/A	not applicable
NJ	New Jersey

NJAC	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NJPDES	New Jersey Pollution Discharge Elimination System
NH_4	ammonium
NO_2	nitrogen dioxide
NO_3	nitrate
NSF	National Sanitation Foundation
NY	New York
O&M	operation and maintenance
OSDS	onsite treatment and disposal system
OSSF	onsite sewage facilities
OSS	onsite sewage system
OSTS	onsite sewage treatment system
OSWT	onsite wastewater treatment and disposal system
PDP	product development permit
PBTS	performance-based treatment system
RI	Rhode Island
RICR	Rhode Island Code of Regulations
RIDEM	Rhode Island Department of Environmental Management
SCDH	Suffolk County Department of Health Services
ST	septic tank
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TKN	total Kjeldahl nitrogen
TM	technical memorandum
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
TWA	treatment works approval
TX	Texas

Technical Memorandum 1

ASSESSMENT OF ONSITE TREATMENT TECHNOLOGY TESTING AND APPROVAL PROCEDURES UTILIZED BY OTHER STATES

Executive Summary

Hawaiʻi's Act 125 requires the upgrade of all 88,000 existing residential cesspools by the year 2050. As a result, it is expected that these existing onsite sewage disposal systems will be replaced by a more appropriate technology, some of which may be emerging and innovative in nature.

Onsite wastewater treatment and disposal is regulated by the Hawaiʻi State Department of Health Wastewater Branch (DOH). Current Hawaiʻi regulations for onsite wastewater treatment (OSWT) and disposal systems include procedures, design criteria, standards, and restrictions for design and installation of approved standard OSWT technologies (Hawaiʻi Administrative Rules [HAR] 11-62). Detailed criteria are provided only for septic tanks (ST), aerobic treatment units (ATU), and absorption trenches/beds. All other systems and technologies must be approved on a case by case basis, the procedures for which are not currently specified in detail.

To efficiently review and approve the designs for 88,000 cesspool upgrades, the DOH will likely need a more prescriptive application and approval process for alternative, innovative, and emerging (AIE) technologies. AIE technologies are OSWT and disposal technologies not included in existing regulations but may have benefits over conventional options. The current process for obtaining approval of AIE technologies in Hawaiʻi does not prescribe application procedures, fees, timelines, testing durations, sampling protocols, performance requirements, or renewal periods. In addition, DOH does not currently certify AIE technologies or maintain a state-approved list of these technologies. Several other states have established rules and processes for approving AIE technologies. The procedures of other states were evaluated for best practices to assist DOH in developing a new, efficient application/approval methodology. States investigated include Delaware, Florida, Maryland, Massachusetts, New Jersey, New York, Rhode Island, and Texas.

Each of the states reviewed utilize different procedures and apply a range of requirements for the approval of AIE systems. The variation is wide, with some public entities being very prescriptive on processes, requirements, durations, etc. and having several types of progressive permitting phases to manage; while other agencies have less complicated procedures. The characteristics and components of these procedures were compared and evaluated for best practices.

The goal for DOH should be to create a procedure and set of requirements that first and foremost protects public health and the environment. This goal must be balanced with information and data needs, DOH review time, program complexity, program staff needs/costs, testing duration, testing costs, testing oversight, designer needs, installer needs, and homeowner needs/costs. These are numerous and often

competing factors to consider, and there is no perfect system. An effective system should strive to achieve the following:

- Applicants will not have extensive questions during application preparation.
- Most relevant information needed by DOH is included and in a standard format/location to facilitate efficient review.
- There is a small number of types/phases of permits to manage.
- Testing of a limited number of water quality parameters by the applicant.
- There is a defined protocol for testing, including duration, sampling intervals, and types.

These characteristics were integrated with the assessment of the approval processes of the 8 states and interviews with some state agencies to develop the following considerations for revision of Hawai'i's approval process components (see Appendix A for notes of interviews with other states) :

1. **Additional agency staff.** Most state agencies expressed concerns that they are under staffed to manage their conversion programs. Staff members manage anywhere from 100 to 3,000 permit applications per staff member per year. Most agencies desire more staff so that they can do more inspections and follow up on converted systems.
2. **Application fee and program funding.** Most states also expressed concerns that they are underfunded. They recommend adoption of an appropriate application fee that will cover the total cost of review and approval of new technologies is recommended. Other agencies also recommend that fees go to a dedicated (versus general) fund for cesspool conversion program management. In addition, other states recommend point-of-sale conversion and notification of DOH to be required by law with meaningful fines for non-compliance.
3. **Standardized application forms and templates.** Utilizing a standardized application form (form-fillable) could help to streamline the application review and approval process (Rhode Island form is a good example). Likewise, standardized templates for required submittals could help the review process (form-fillable, specific clear format). An example of a local guidance document is the the Honolulu's Storm Water Quality Report template. Suggested submittal materials include: technology description/info, design criteria, installation criteria, operations and maintenance (O&M) requirements, warranty info, and results of previous studies. Some states also require registered 3rd party reports, and/or draft manuals for owners, designers, installers, inspectors and maintainers.
4. **Water quality standards.** Consider multiple sets of water quality numerical standards such as:
    a. Secondary treatment.
    b. Advanced wastewater treatment – for where TN removal is required or desired.

    Parameters may include: total suspended solids (TSS), 5-day biochemical oxygen demand (BOD_5), pH, alkalinity (Alk), total nitrogen (TN), total phosphorus (TP), ammonia (NH_3), nitrate (NO_2), nitrite (NO_3), and fecal coliform. However, interviews with other state agencies showed that the common, recommended monitoring parameters are total Kjeldahl nitrogen (TKN), NO_2, and NO_3.

5. **Certified laboratories.** Requiring that testing is completed according to National Sanitation Foundation (NSF), American Society for Testing and Materials (ASTM), or Environmental Protection Agency (EPA)-approved entities or other by a qualified third party will help to bolster testing integrity.
6. **Testing period, sampling intervals, and number of systems tested.** The testing period for AIE technologies should be performed for an appropriate time frame to demonstrate satisfactory performance (e.g. 12 months minimum). The sampling interval should be at least monthly. Multiple systems should be tested (e.g. minimum of 10). Interviews with other state agencies showed

sampling and monitoring data can get unwieldy to manage. One common recommendation was for a good database program to facilitate data management and utilization. A good database program could help Hawaiʻi to track long-term performance of systems, inspection/maintenance compliance, and data/report submissions, which other states have been unable to implement.

7. **Approvals.** Consider limiting approvals to just one type of system – called AIE systems. Interviews with other state agencies showed the common recommendation for a simplified approval process. Consider having two types Provisional and Approved, to allow a probationary period followed by conversion to approved. The approval should be permanent, however, there should be a periodic review of process performance – conducted by a hired third party. Consider maintenance of list of approved AIE technologies on the DOH webpage.
8. **Consider <u>not</u> issuing official certifications for AIE technologies.** Of the states reviewed, three issued certifications of technologies (Rhode Island, Massachusetts, and New Jersey). When a technology is approved a certification document is issued. Rhode Island has stopped issuing certifications because it gives the appearance of an endorsement. This may not be a good approach for Hawaiʻi.
9. **Certifications and Training.** Consider implementation of a certification program (and maintain lists on the DOH webpage) for:
    a. Designers
    b. Installers
    c. Inspector/Maintainers

   Consider requiring manufacturers of approved AIE technologies to provide public trainings for the certified individuals. Other states often require O&M contracts of homeowners or homeowner training. In addition, other states recommend monitoring inspection services to avoid falsification of reports.

1.1 Introduction and Background

According to the US Environmental Protection Agency (EPA), cesspools are underground excavations that receive sanitary wastewater from bathrooms, kitchens, and washers. The structure usually has an open bottom and perforated sides (unlined). Domestic wastewater flows into the structure and the solid waste collects at the bottom of the cesspool and the liquid waste flows out of the perforations. Cesspools are not designed to treat wastewater but rather to retain solids and allow liquid wastes to percolate into the subsurface which may be hydraulically connected to groundwater and surface water.

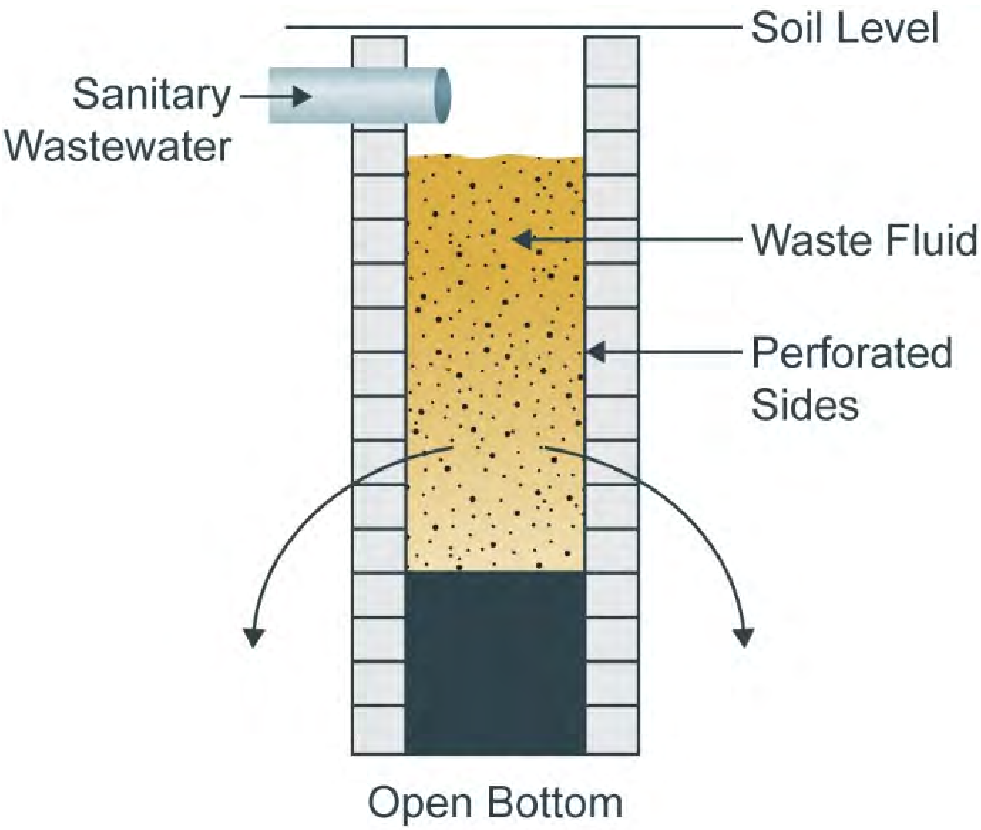

Figure 1.1 Cesspool

Throughout Hawai'i, there are approximately 88,000 cesspools; a majority of which are for single-family, residential wastewater disposal. In 2018, the Hawai'i State Legislature passed Act 125, which states that by January 1, 2050 all cesspools in the state of Hawai'i, unless granted exemption, shall upgrade or convert to a preferred waste treatment system or connect to a sewer system.

Act 132 allowed for the creation of the Cesspool Conversion Working Group (CCWG), with the DOH Director or designee as the chairperson. Other CCWG members include: the DOH wastewater branch chief or their designee; four members of the county wastewater agencies of the Counties of Hawai'i, Honolulu, Kaua'i, and Maui; a member representing the wastewater industry appointed by the president of the senate; a member of the financial and banking sectors appointed by the speaker of the house of representatives; members of the University of Hawai'i Institute of Marine Biology and Water Resources Research Center; a member of the

Hawai'i Associate of Realtors appointed by the Speaker of the house of representatives; a member of the Surfrider Foundation appointed by the President of the senate; one representative appointed by the Speaker of the house of representatives; and one Senator appointed by the President of the senate.

The CCWG subsequently retained the Carollo Engineers, Inc. (Carollo) team to support the cesspool conversion technologies and finance research as a part of the Cesspool Conversion strategy for the state of Hawai'i.

Existing Hawai'i regulations include an approval process for conventional OSWT technologies such as septic tanks, aerobic treatment units (ATUs), and disposal technologies, such as soil absorption systems, gravelless absorption systems, and seepage pits. However, approval of emerging and innovative technologies are on a case-by-case basis[1]. AIE technologies are OSWT and disposal technologies not included in existing regulations, but may have benefits over conventional OSWT and disposal technologies. Other states have established protocols for reviewing and approving AIE technologies. The Carollo team was tasked with reviewing and summarizing these protocols for evaluating and approving AIE technologies.

The purpose of this technical memorandum (TM) is to provide an assessment of what other states have done to date to evaluate and approve emerging and innovative OSWT and disposal technologies. It includes a summary of Hawai'i's current approval processes for OSWT, disposal, and AIE technologies, and a review of the approval processes for AIE technologies for Delaware, Florida, Maryland, Massachusetts, New Jersey, New York, Rhode Island, and Texas. The TM concludes with a summary of the approval processes for AIE technologies for the aforementioned states and a summary of best practices for approval processes for AIE technologies in Hawai'i for consideration.

1.2 Existing Hawai'i Approval Processes for Onsite Disposal Systems and Alternative Technologies

HAR include regulations for individual wastewater systems (HAR 11-62.31). The following sections summarize the current approval processes for OSDSs and emerging and innovative wastewater treatment technologies.

1.2.1 Hawai'i Approval Processes for Onsite Disposal Systems

The DOH is the agency that oversees on-site systems in the State. The Hawai'i regulations for OSWTs are contained in HAR 11-62 Wastewater Systems[2], subchapter 3 Individual Wastewater Systems. The general requirements specify:

- A minimum lot size of 10,000 square feet.
- A maximum of 5 bedrooms per system.
- A maximum flow of 1,000 gallons per day per system.
- No cesspools are allowed for new buildings and cesspool upgrades are required when buildings are modified.
- OSDSs must have an O&M manual.
- Written approval of an OSDS by the DOH Director is required prior to operation – this requires the engineer's certification and the "as-built" plans.

Regulations specify design criteria and procedures for the following approved processes:

- Septic tanks.

[1] HAR 11-62-34 refers to "new and proposed disposal systems."
[2] https://health.hawaii.gov/opppd/files/2015/06/11-62-Wastewater-Systems.pdf

- ATUs.
- Soil absorption systems.
- Gravelless absorption systems.
- Seepage pits.

Hawaiʻi regulations mention several other systems that must be evaluated on a case-by-case basis including:

- Evapotranspiration systems.
- Elevated mounds.
- Subsurface and recirculating sand filters.
- Drip irrigation.
- Disinfection

There are no design criteria for these other systems, but they are "approved" for use pending submission of engineering calculations/documentation.

For all OSWT systems, HAR 11-62 requires a site evaluation by a licensed engineer, including site slope, soil profile, thickness of soil layers, depth to groundwater, depth to bedrock, distance to water bodies and soil percolation tests (protocol is specified). The rule also specifies minimum separation distances to structures, property lines, surface waters, trees, other treatment units, and potable water wells.

1.2.2 Hawaiʻi Approval Process for Emerging and Innovative Technologies

The approval of innovative, alternative or experimental systems in Hawaiʻi is done on a case-by-case basis (HAR 11-62-35). The rules mention composting toilets, incinerator toilets, natural systems, and "other" systems, and that appropriate NSF or equivalent test procedures must be used and submitted to the DOH Director[3].

The rules specify that innovative systems can be approved if:

- Such systems could benefit the people of Hawaiʻi.
- The owner agrees to collect operational data for up to 12 months and submit it to DOH.
- The owner agrees to repair or replace the system if the Director finds the system performance to be unsatisfactory.

The processes for applying, approving, or testing of innovative systems in Hawaiʻi are not specified in detail. There is currently no list of approved AIE technologies.

1.3 Review of Approval Processes in Other States

A review was conducted of the practices utilized to approve AIE technologies and equipment in several states that have large numbers of onsite systems and active conversion programs. Information was gathered exclusively from publicly-available, on-line resources for each state. While each state evaluated maintains live websites containing the pertinent information, it is possible that some information is out-of-date, which is a limitation of this review. It could be that those states/agencies have approved changes that are scheduled to take effect in the near future or that "unofficial" practices are utilized or exceptions are allowed that are not reflected in the rules.

In addition to web research, agencies were contacted via phone and email to gather additional information on "lessons learned" on their respective AIE approval processes, and cesspool conversion programs in

[3] Refers to the Director of the Department of Health or the Director's duly authorized agenda, including a contractor of the director.

general. The following agencies responded to requests for additional information on their cesspool conversion programs:

- Barnstable County Department of Health and Environment (BCDHE), Massachusetts.
- Rhode Island Department of Environmental Management (RIDEM), Rhode Island.
- Delaware Department of Natural Resources and Environmental Control (DNREC), Delaware.
- Suffolk County Department of Health Services (SCDHS), New York.
- Florida Department of Health and Environment (FDOH), Florida.

A summary of the key lessons learned is incorporated to section 1.5. Notes gathered from phone calls and emails to the agency contacts are included in Appendix A.

1.3.1 Delaware

Delaware is a coastal state (381 miles coastline) which has an estimated 70,000 onsite systems, 18 percent of which are estimated to be failing. Beginning in 2015, cesspools were banned and required to be replaced within one year of discovery. The state has a goal to replace 6,074 septic and leachfield systems by 2025. Low interest loans of up to $35,000 are available to homeowners for replacements with AIE systems. Delaware has established statewide performance standards for AIE technologies and has developed licensing for designers, installers, inspectors and maintainers of OSWT systems. Delaware is included in the study because of the detailed AIE technology approval process they have developed. The drivers for cesspool conversions were groundwater contamination as well as impaired rivers and streams.

1.3.1.1 Approval of Alternative/Innovative/Experimental Technologies

The State of Delaware DNREC is the agency that oversees onsite wastewater treatment systems in the State. Delaware[4]. The Delaware regulations applicable to all OSWT systems are contained in 7 Del.C Ch. 60 Regulations Governing the Design, Installation and Operation of On-site Wastewater Treatment and Disposal Systems[5]. General requirements for the construction of small systems (<2,500 gallons per day [gpd]) include but are not limited to the following:

- Permitting from the DNREC.
- Wastewater characteristics.
- Designer/contractor/operator/evaluator licensing.
- Site drawings.
- Soil profile notes.
- Zoning verification.
- Separation distances.
- Disposal system sizing.
- Soil percolation rates.
- Wastewater design flow rates.
- Depth to limiting zones.

The rule also states that all work regarding OSWT systems must be authorized by professionals who have acquired specific licensure. The classification of licensure consists of:

- Class A – Percolation Tester.

[4] https://dnrec.alpha.delaware.gov
[5] http://www.dnrec.delaware.gov/wr/Information/GWDInfo/Documents/DelawareFinalOnSiteRegulations_01112014.pdf

- Class B – Designer (conventional systems).
- Class C – Designer (conventional & innovate/alternative).
- Class D – Soil Scientist/Site Evaluator.
- Class E – System Contractor.
- Class F – Liquid Waste Hauler.
- Class H – System Inspector.
- Class I – Construction Inspector.

Section 5.3.31 is titled "Innovative/Alternative Wastewater Treatment and Disposal Systems". The rules state the following reasons in which innovative/alternative systems may be permitted on sites:

- The seasonal high groundwater table or limiting condition is found to be deeper than 10 inches.
- Installation is necessary to provide sufficient sample data.
- The system will be used continuously throughout its life.
- Zoning, planning, and building requirements are met.
- In case of failure, an acceptable backup system is readily available.

Section 5.3.31.3 is titled "Product Approvals" and states that the approval of an innovative/alternative system depends on "applications that provide thorough documentation of proven technology". The approval of AIE systems that do not meet the requirements set for conventional treatment systems is granted by DNREC on a case-by-case basis and, as a result, a classification system of approved technologies does not exist. DNREC, however, maintains a list of approved technologies. The approval process for a potential AIE system is shown in Figure 1.2 and described as follows:

- **Application.** Applicants submit their request to the DNREC including:
  - Long-term use data from similar facilities that proves the proposed capabilities, or short-term documentation from reliable sources (Universities or National Sanitary Foundation International).
  - Executive summary describing the system (construction drawings, materials, etc.).
  - O&M manuals.
  - Design drawings must be completed by a Class C professional.

  If the application is accepted, a permit will be issued specifying installation guidelines, O&M requirements, and duration and frequency of system monitoring. The system must be constructed and used within two years of issuance.

- **Conditions of Approval**. The following conditions apply to newly approved, AIE systems:
  - Installed systems are inspected by a Class C, Class E.2 or Class E.3 wastewater professional, or both the DNREC and the manufacturer.
  - If the installation passes all inspections, the DNREC issues the applicant with a Certificate of Satisfactory Completion.
  - If the DNREC deems any system unsatisfactory, it is the owner's responsibility to repair, replace, or abandon the system.
  - Regular monitoring of the system will be carried out by the DNREC or its designee, as specified on the permit.
- **Testing and Monitoring.** Testing and monitoring periods vary from case to case and are documented in the construction permit found on the DNREC's website. Systems that treat flows less than 2,500 gpd must either reduce the total nitrogen concentrations by 50 percent or to a concentration of 20 mg/L.

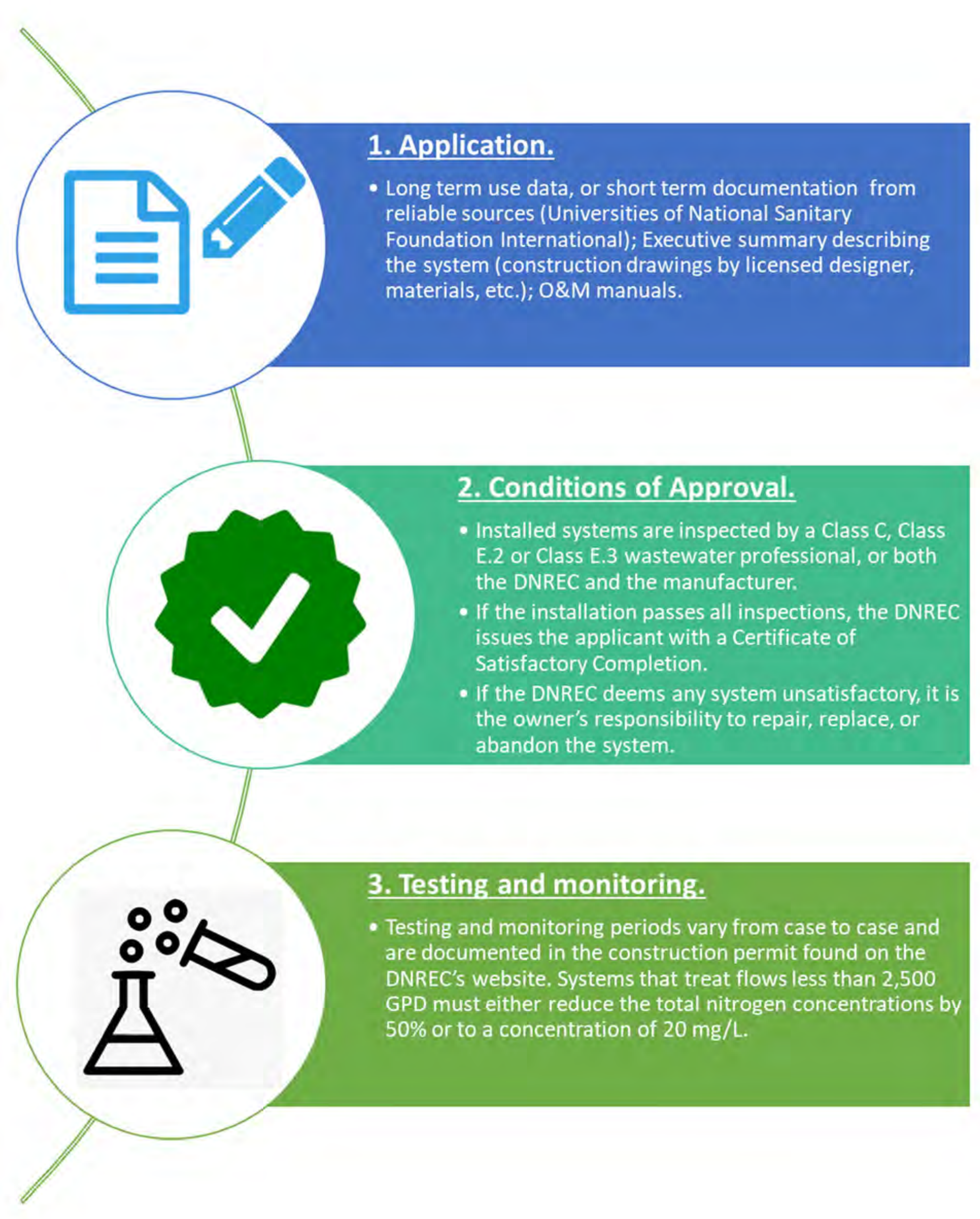

Figure 1.2 Delaware Department of Natural Resources & Environmental Control Alternative/Innovative/Experimental Technology Approval Process.

1.3.1.2 Summary of Approved Technologies in Delaware

Delaware has listings online for approved systems and components of the following categories. The complete list is shown in Appendix B and additional information is on the DNREC website[6]:

- Advanced Treatment Systems and Units (26 listings).
- Advanced Treatment Components (7 listings including biofilters and biological augmentation).
- Drip Dispersal Systems (4 listings).
- Aerobic Treatment Units (3 units).

1.3.2 Florida

Florida is a coastal state (8,436 miles coastline) which has an estimated 2,600,000 onsite systems serving one third of the population. The state has shallow groundwater and has had significant water quality issues. In 2008, legislation was passed that mandated the development of a comprehensive nitrogen reduction strategy for onsite systems. The resulting studies cost over $5 million. Florida has studied, piloted, and finally developed design criteria for passive denitrifying leachfields and also has detailed approval processes for AIE technologies. The emphasis in Florida is on replacement of cesspools and septic tanks with AIE technologies that remove nitrogen. Florida is included in the study because of the large number of onsite systems, the detailed AIE technologies approval process developed, and the work they have completed on passive nitrogen removal technology approval.

1.3.2.1 Approval of Alternative/Innovative/Experimental Technologies

The FDOH is the agency that oversees on-site systems in the state[7]. The Florida regulations for OSWT systems are contained in FAC 64E-6 (Standards for Onsite Sewage Treatment and Disposal Systems (FL-Rules)[8]. General requirements include but are not limited to the following:

- Wastewater flow capacity.
- Minimum setback distances.
- Separation distance to groundwater/impervious layers.
- Soil testing requirements.
- Effluent pipe sizing.
- Leachfield loading rates.
- Designer and installer licensing.
- Application requirements.

The rules also include standards for the following technologies that can be used "where standard subsurface systems are not suitable or where alternative systems are more feasible (FL-Rules, Section 6.009):

- Waterless, incinerating, or organic waste composting toilets.
- Sanitary pit privy.
- Mound systems.
- Filled systems.
- Drip irrigation systems.
- Tire chip aggregate systems.
- In-ground nitrogen-reducing biofilters (INBR).

[6] https://dnrec.alpha.delaware.gov/water/groundwater/alternative-systems/
[7] http://www.floridahealth.gov/environmental-health/onsite-sewage/
[8] http://www.floridahealth.gov/environmental-health/onsite-sewage/forms-publications/_documents/64e-6.pdf

The rules provide detailed requirements for most of these technologies, including design criteria. Part 9 of this section (FAC 64E-6-009 (9)) is "Other Alternative Systems" which identifies other technologies such as "low pressure distribution networks, small diameter gravity sewers, low pressure sewer systems, alternating absorption fields, and sand filters". These technologies can be approved where "evidence exists that use of such systems will not create sanitary nuisance conditions, health hazards, or pollute receiving waters". There are no formal design standards or submittals for these systems. The process for obtaining approval for any other system or component is as follows (FAC 64E-6-009 (8)):

- **OSWT System Testing.** Complete innovative system testing prior to making a request.
- **Application for approval.** Application for approval should include the following:
  - Detailed system design, construction plans, and certification of performance capabilities by a Florida licensed engineer.
  - Research supporting the proposed system/materials.
  - Empirical data showing results of innovative system testing in Florida.
  - A design, installation and maintenance manual showing how to design and install the system in accordance with Florida requirements for standard, filled, mounded, gravity-fed, dosed, bed and trench configurations.

After submission, the material is reviewed by the Onsite Sewage Program to determine whether or not there is a reasonable certainty of the effectiveness and reliability of the system. If not satisfied the FDOH will deny. If approved, the manufacturer shall list the FDOH approval date in the installation and design manual.

There are certain specific restrictions to this process (technologies that cannot be approved) and rules for conventional OSWT systems that also apply to AIE technologies:

- No alternative system can be approved that would reduce the required drainfield size using mineral aggregate as described in the rules.
- Items which are used to achieve a more advanced level of treatment than the baseline level.
- Aerobic treatment units.
- Septic tank designs, filters, seals, and sealants.
- Additives.
- Header and drainfield pipe, including layout.
- Water table separation and setback requirements.

Florida has a separate process for Innovative System Permits (ISP). Innovative systems are defined as: "an onsite sewage treatment and disposal system that, in whole or in part, employs materials, devices, or techniques that are novel or unique and that have not been successfully field-tested under sound scientific and engineering principals under climatic and soil conditions found in this state." The ISP permit application process is shown in Figure 1.3 and described below:

- **Third Party Testing.** Testing must be done by a third-party testing organization approved through the NSF environmental technology verification (ETV) program, or at an NSF test facility. If the data is found to be insufficient, a temporary permit can be issued for further testing and monitoring – with a fee of $2,500.
- **Application for ISP Approval.** Applicants must fill out an ISP application form DH 3143 and include the $2,500 application fee[9]; the form must be signed by a Florida licensed engineer. They must supply the following information:
  - Research and development studies.

[9] www.floridahealth.gov/environmental-health/onsite-sewage/forms-publications/index.html#innovative

  - Results of previous testing.
  - Design and installation criteria.
  - Performance and reliability data.
  - A disinterested third-party certifier report or a Florida Registered Engineer report.
  - Copy of system or product warranty.
  - Indicate the number of innovative systems and the testing time period requested.
  - Provide a sampling and analysis protocol with a mechanism for assessing performance.
  - Provide operation and maintenance manual.
- **Conditions of approval.** If approved, a one-time ISP is obtained from the Onsite Sewage Program. This permit is for a limited number of innovative systems to be installed and monitored during a given period of time. Construction permits must separately be obtained. In addition, the homeowner acknowledgement forms must be signed, and submitted. These AIE technologies are classified as engineer-designed performance-based treatment system (PBTS). After testing is complete and ISP expires, the product can apply for reclassification as an alternative system – PBTS.

The Florida process does not prescribe the exact testing period, or data requirements, but does have performance criteria for carbonaceous biochemical oxygen demand (CBOD), TSS, TN, TP, and fecal coliform. They also require testing by either NSF or an NSF-approved facility (ETV) which is highly prescriptive.

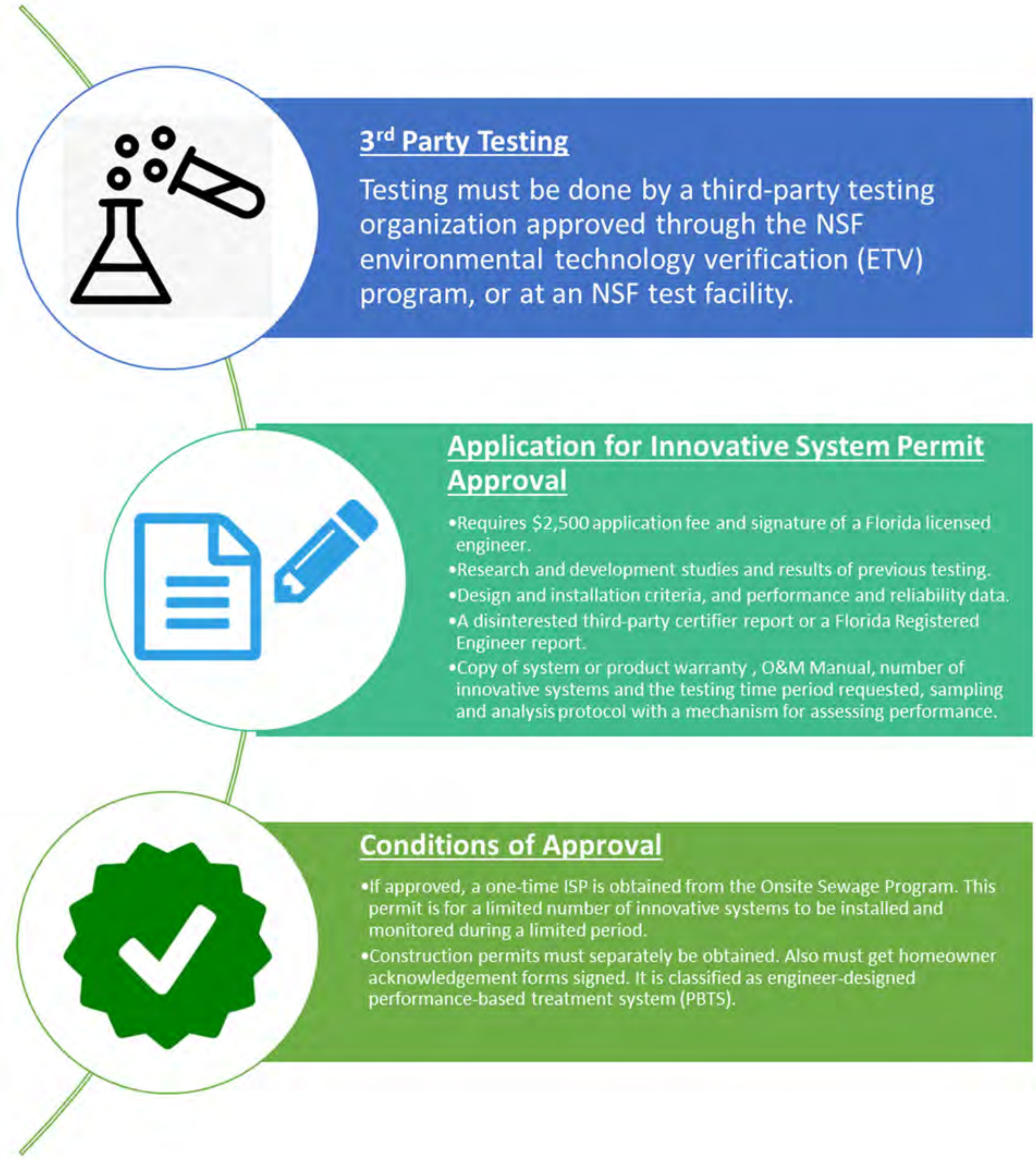

Figure 1.3 Florida Department of Health Innovative System Permit Approval Process

1.3.2.2 Summary of Approved Technologies in Florida

Florida has approved drainfield design standards for "nitrogen-reducing media layers" which includes a diagram of a layer-cake design that includes an upper drainfield area, a middle unsaturated nitrification sand layer at least 18 inches thick, and a bottom soil mix denitrification layer at least 12 inches thick (64E-6.009 (7)). The middle and bottom layers must be 12 inches wider and longer than the layers above them. The bottom layer must be at least 6 inches above the seasonal high-water table. The nitrification layer is sand and the denitrification layer is 40-60 percent wood chips/shavings/sawdust with the remainder fine aggregate.

Florida also has listings on-line for approved systems and components of the following categories[10]:

1. Approved Products and Components
   a. Alternative Drainfield Products (14 listings including chambers, tire chips and drip irrigation)
   b. Composting Toilets (5 listings)
   c. Incinerating Toilets – NSF Protocol P157 (one listing for a product in Norway)
   d. Fibers for Concrete Receptacles (12 listings)
   e. Pump Chamber Inserts/Filtered Pump Vaults (5 listings)
   f. Septic Tank Designs (dozens of listings)
   g. Septic Tanks Meeting HS20 Traffic Standards (18 listings)
   h. Septic Tanks Outlet Filters (18 listings)
   i. Septic Tank Seals and Sealants (8 listings)
2. Advanced Systems (ATUs, Performance-Based and Innovative Systems)
   a. Tanks Approved for use with Aerobic Treatment Units (ATUs) (dozens of listings)
   b. Advanced Systems and Permitted Maintenance Entities (21 listings of systems, dozens of service providers)
   c. Performance-Based Treatment Systems Including Innovative (not a listing, gives performance data)
   d. NSF 40 Certified ATUs (35 listings)
   e. NSF 245 Certified ATUs (9 listings)
3. Nitrogen-Reducing Systems for Springs Protection
   a. NSF 245 Certified ATUs (same 9 listings as above)
   b. Nitrogen-Reducing Performance-Based Treatment Systems (PBTS) (13 listings)
   c. Inground Nitrogen-Reducing Biofilters (INRBs) – not a listing, just refers to the rules

1.3.3 Maryland

Maryland is a coastal state (3,190 miles coastline) which had an estimated 420,000 onsite systems in 2004 when a bill was passed to upgrade OSWT systems to remove nitrogen. They found that OSWT systems contributed about 6 percent of nitrogen to Chesapeake Bay. The emphasis is on replacement of cesspools and septic tanks with AIE technologies that remove nitrogen. An average of 1,200 OSWT systems are converted to AIE systems annually. A total of 12,000 have either been connected to sewer or converted to AIE. Grants of up to $20,000 are available to homeowners for replacements with AIE systems. The money comes from a sewer fee ($5/yr) and an OSWT system fee ($60/yr). From 2016-2018, Maryland spent about $10.1 million per year to help install 1,000 AIE systems. Maryland is included in the study because of the large number of AIE technologies approved and installed.

1.3.3.1 Approval of Alternative/Innovative/Experimental Technologies

The Secretary or the Secretary's designee of the Maryland Department of the Environment (MDE) is the Approving Authority that oversees OSDS within the state[11]. Regulations on all onsite sewage disposal systems are contained in the Codes of Maryland (COMAR) 26.04 (Regulation of Water Supply, Sewage Disposal, and Solid Waste[12]. The general requirements specify:

- Minimum lot area.

[10] http://www.floridahealth.gov/environmental-health/onsite-sewage/products/
[11] https://mde.maryland.gov/Pages/index.aspx
[12] http://www.dsd.state.md.us/COMAR/SubtitleSearch.aspx?search=26.04.02.*

- Maximum density of 160 residents per square mile.
- One building per system.
- Approval of OSWT systems by the Approving Authority or a third party approved by the Approving Authority.
- OSWT systems may require an operating permit by the Approving Authority.
- Local jurisdictions may establish a management entity for OSWT systems.

Site evaluations are required by the approving authority, which include topography, geology, soil classification, hydrology, surface and subsurface drainage conditions, soil test results and boring logs, requirements for seasonal testing, performance of OSWT systems and wells in the area, and potential impacts of new OSWT systems on water wells in adjacent areas. Percolation test requirements, minimum drainage soil depths, minimum slopes, and horizontal separation distances from various features are also established in COMAR 26.04; however, it does not specify any qualifications for parties who may conduct a site evaluation.

MDE may approve new technology or experimental systems for situations in which a public sewer is not available and conventional OSWT systems are incapable of solving the issue. Approved systems are called best available technologies (BAT) and are summarized in Table 1.1. BATs are placed in one of four categories: Class I, Class II, Class III and Class IV.

Table 1.1 Classification of AEI On-Site Wastewater Treatment Systems in Maryland

Technology Type and Degree of Certification	Description	Probation Period	Renewal Period	Cost of Application/ Permit Process	Requirements
Class I	Fully approved treatment units; Field verified; Grant eligible	2 years	N/A	TBD	Total-N reduction to 30 mg/L or less, Successfully completed Maryland field verification
Class II	Currently undergoing field verification	2 years	N/A	TBD	Currently undergoing Maryland field verification
Class III	Field verified; Grant eligible	2 years	N/A	TBD	Total-N reduction to 48 mg/L or less, NSF 245, NSF 40 Class I, CAN/BNQ 3680-600, CEN Std. 12566-3 or equivalent certification, Must be paired with Class IV soil disposal system
Class IV	Approved Soil Distribution System (SDS); Sand Mound, At-Grade, or Low Pressure Dosing Dispersal	N/A	N/A	TBD	Nitrogen reduction of 20-30 percent without pretreatment; 75 percent with pretreatment
Class V	Waterless Toilets	N/A	N/A	TBD	N/A

Notes:
(1) N/A = not applicable
(2) TBD = to be determined

The steps in the overall approval process for BATs are shown in Figure 1.4 and summarized below:

- **Application.** Submit an application to the local Approving Authority for review. The Approving Authority may perform a site evaluation with the Water Management Administration's Regional Consultant, or request the applicant present a hydrology report, performed by a professional consultant.
- **Conditions for Approval.** A permit to design the system is granted to the applicant if both the Approving Authority and MDE determine that the site meets the general requirements:
  - The proposed system must be designed by a professional engineer, environmental health specialist, or other qualified consultant as determined by the Approving Authority.
  - One set of drawings will be submitted to the Approving Authority and MDE for concurrent review and approval to construct.
  - The applicant must submit a satisfactory agreement between the applicant, the Approving Authority and MDE if special operation or extensive maintenance is required.
  - A permit to construct the OSDS is issued by the Approving Authority once the applicant submits a copy of the land records notice that the area is served by a non-conventional OSDS.
- **Monitoring.** MDE monitors the newly installed OSDS for a minimum of 2 years.

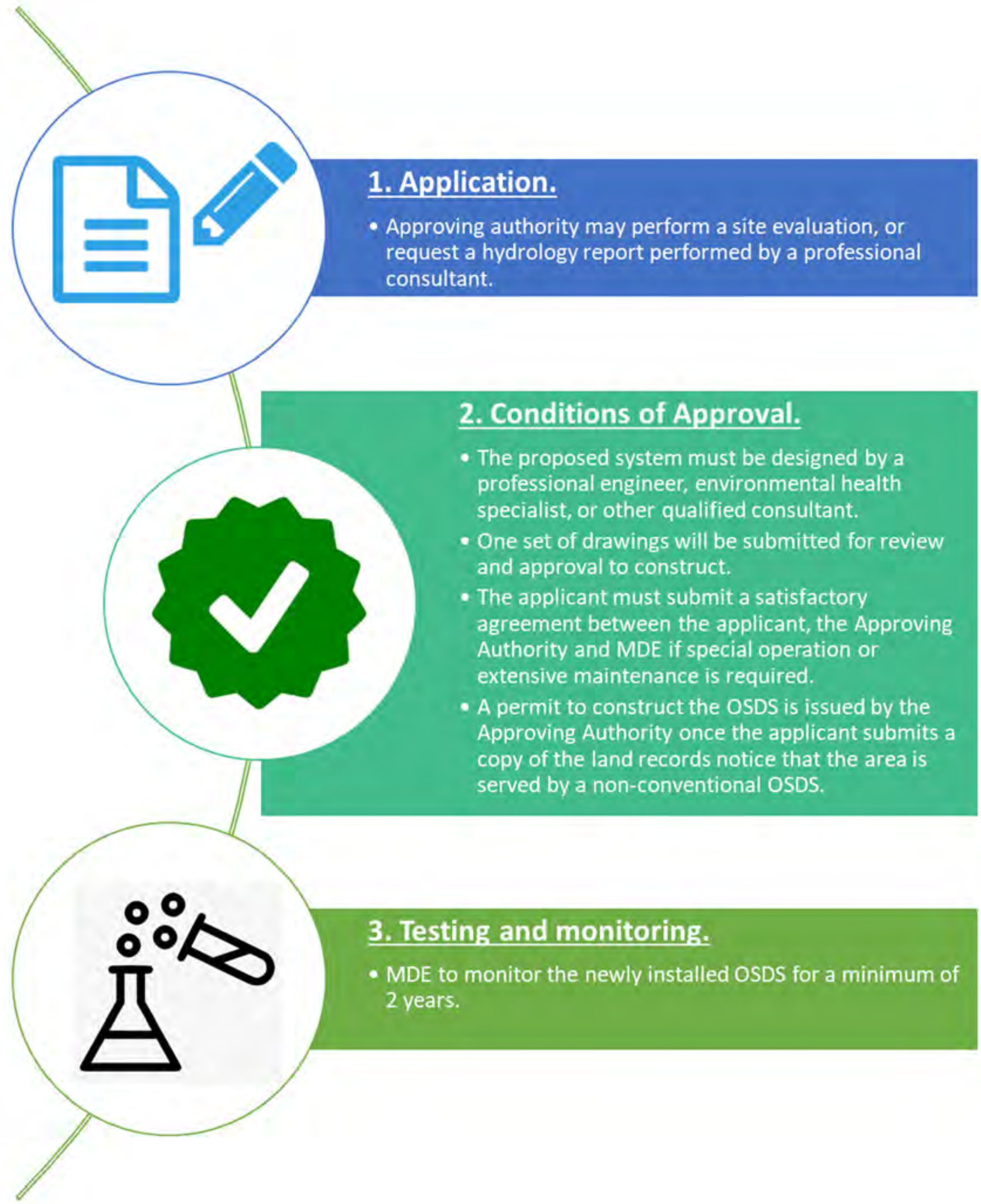

Figure 1.4 Maryland Department of Environment Best Available Technologies Approval Process

1.3.3.2 Summary of Approved Technologies in Maryland

Maryland has listings on-line for approved systems and components of the following categories[13]:

1. BAT Class I - Alternative Treatment Units (9 listings)
2. BAT Class II - Alternative Treatment Units (5 listings)
3. BAT Class III - Alternative Treatment Units (2 listings)
4. BAT Class IV (no product listings; design criteria is given)
   a. Sand Mound SDS
   b. At-Grade SDS
   c. Shallow Placed Low Pressure Dosed Dispersal SDS
5. BAT Class V - Compost Toilet (1 listing – Clivus Multrum)

1.3.4 Massachusetts

Massachusetts is a coastal state (1,519 miles coastline). The number of OSWT systems in Massachusetts is not readily available, but Massachusetts has a well-developed approval process for AIE technologies, including pilot stage, provisional use, and general use categories. Grants of up to $25,000 plus tax credits up to $1500 per year for 4 years for a maximum total of $6,000 are available to homeowners for replacements. Massachusetts is included in the study because of their detailed AIE approval process.

1.3.4.1 Approval of Alternative/Innovative/Experimental Technologies

The Massachusetts Department of Environmental Protection (MassDEP) provides oversight of all OSWT systems in the state[14]. The Massachusetts regulations on OSWT systems are contained in 310 CMR 15.000: Title 5 of the Environmental Code[15]. The general requirements specify:

- Maximum design flow of 10,000 gpd.
- Septic systems shall treat no more than one facility.
- Connection to sewer is mandatory if feasible.
- All septic tanks, distribution boxes, pump chambers, dosing chambers and grease traps are watertight and constructed of non-corrosive materials.
- More stringent requirements may be established by Local Approving Authorities (LAA).

Massachusetts developed an approval program for innovative, alternative, or experimental OSWT systems. These alternative systems may be considered for use in areas where connection to a municipal sewer system is not feasible, or to serve a facility in a nitrogen sensitive area which exceeds the minimum design flow of 440 gpd. To have an OSWT systems approved in Massachusetts, the system must go through a series of approval stages which is summarized in Figure 1.5 and as follows:

- **Application.** Submit a formal application to MassDEP or an agent authorized by MassDEP. Seek approval from LAA first if applying for site specific piloting approval. MassDEP may request additional information on the proposed system, such as performance evaluations of systems in other jurisdictions.
- **Conditions of Approval.** Pilot testing approval is issued under the following conditions:
  - Technical data of field performance shows environmental protection equal to or better than conventional OSWT systems.

[13] https://mde.maryland.gov/programs/Water/BayRestorationFund/OnsiteDisposalSystems/Pages/index.aspx
[14] https://www.mass.gov/orgs/massachusetts-department-of-environmental-protection
[15] https://www.mass.gov/doc/310-cmr-15000-title-5-of-the-state-environmental-code/download

  - The applicant presents an environmental monitoring and reporting plan for at least 18 months of operation.
  - The applicant provides a contract to the LAA and MassDEP ensuring that operation and maintenance will be performed appropriately by the vendor or other acceptable means.
- Provisional use approval is issued under the following conditions:
  - At least 75 percent of the systems in the piloting phase meet the general requirements for at least 12 months.
  - The applicant publishes notice of the application in the Massachusetts Environmental Policy Act (MEPA Environmental Monitor).
  - The applicant presents an environmental monitoring and reporting plan for at least 3 years of operation of the first 50 systems.
- Upon receiving the performance report of the provisional stage, MassDEP takes action:
  - Certify the system for general use if 90 percent of systems meet the general requirements.
  - Request additional evaluation at the discretion of MassDEP.
  - Disapprove use of the system if failed, failing or non-compliant with 150 CMR 15.000.

When certified for general use, MassDEP publishes a notice of the application in the MEPA Environmental Monitor and may establish special conditions to ensure environmental protection, and LAAs can impose additional conditions. The use of a system that has been denied for general use may still be permitted for use under 314 CMR 5.00: Ground Water Discharge Permit Program. Remedial use may be granted to systems that are likely to improve existing conditions of a particular site, under the conditions that the system is used for upgrading a failed, failing, or noncompliant system; the design flow is less than 10,000 gpd and will not increase; and the applicant provides proof that the system is successfully used for at least one year in other jurisdictions with similar climate conditions to Massachusetts. Approval for remedial use, however, does not provide a basis for provisional and general use approvals.

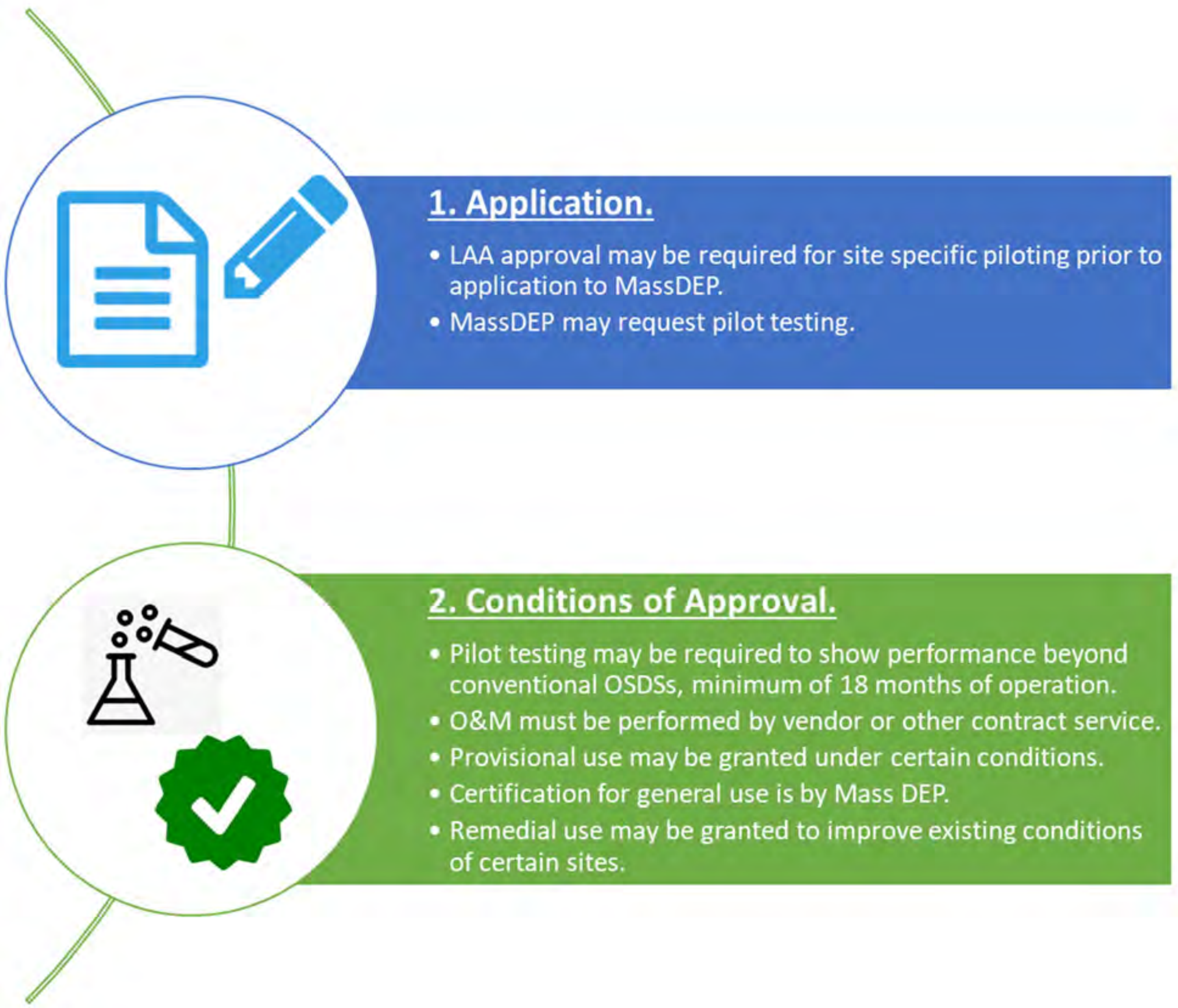

Figure 1.5 Massachusetts Department of Environmental Protection OSWT System Approval Process

1.3.4.2 Summary of Approved Technologies in Massachusetts

Massachusetts has listings on-line for approved systems and components of the following categories[16]:

- General Use
  - Alternative Treatment Systems and Components (15 listings, including pump vaults and recirculating sand filters)
  - Alternative Aggregate (1 listing – polystyrene aggregate)
  - Alternative Soil Absorption Systems, Patented Sand Filters and Chambers (13 listings)
  - Secondary Treatment Units (12 listings, including Aerobic Treatment Units)
- Piloting Use
  - Alternative Treatment Systems (6 listings)

[16] https://www.mass.gov/guides/approved-title-5-innovativealternative-technologies#-remedial-use-

  - Alternative Treatment Components (4 listings, including bubblers, filters, and phosphorous reducing devices)
- Provisional Use
  - Alternative Treatment Systems (9 listings)
  - Alternative Treatment Components (2 listings – biofilters)
- Remedial Use
  - Bottomless Sand Filters (Generic)
  - Recirculating Sand Filters (Generic)
  - Composting Toilets (Generic)
  - Alternative System Components (5 listings, including aeration devices, biofilters, and biological augmentation)
  - Drip Dispersal Systems (2 listings)
  - Alternative Soil Absorption Systems, Patented Sand Filters and Chambers (7 listings)
  - Secondary Treatment Units (15 listings)
- Effluent Tee Filters
  - 15 listings

1.3.5 New Jersey

New Jersey is a coastal state (1,792 miles coastline). The number of OSDSs in New Jersey is not readily available, but since 2012 cesspools must be upgraded upon property sale or transfer. New Jersey was included in this study because it has a very simple approval process for AIE technologies.

1.3.5.1 Approval of Alternative/Innovative/Experimental Technologies

The New Jersey Department of Environmental Protection (NJDEP) is the agency that oversees onsite systems in the state. The New Jersey regulations of OSWT systems are contained in N.J.A.C. 7:9A Standards for Individual Subsurface Sewage Disposal Systems[17]. The general requirements specify:

1. Maximum total daily volume of sewage per dwelling unit = 2,000 gpd.
2. OSWT systems are limited to treat no more than one property for sewage wastes only, and no more than the maximum total daily volume unless a treatment works approval (TWA) or New Jersey Pollution Discharge Elimination System (NJPDES) permit is issued by NJDEP.
3. OSWT systems shall not be installed, constructed, altered or repaired without first obtaining necessary permits.
4. Effluent discharge into any well, onto the ground surface or into any water course is prohibited.
5. Installation of an OSWT systems will be denied if a sanitary sewer line is within 100 feet of the property to be served and connection to the sewer line is feasible.
6. Cesspools, privies, outhouses, latrines, and pit toilets are prohibited.
7. Seepage pits may be allowed with compliance to N.J.A.C 7:9A-7.6.

For all OSWT systems, N.J.A.C. 7:9A requires a site evaluation to be performed, including slope, surface drainage and flood potential (protocol is specified). The rule also specifies minimum separation distances for

[17] https://www.state.nj.us/dep/dwq/pdf/njac79a.pdf

reservoirs, water service lines under pressure, water courses, occupied buildings, property lines, disposal fields, existing seepage pits and cesspools, and in-ground swimming pools.

In New Jersey, the approval of AIE systems is documented in a certificate of compliance. This is explained in N.J.A.C. 7:9A-3 Administration. The overall steps in the approval process for OSWT systems in New Jersey are summarized in Figure 1.6 and below:

- **Application.** Submit an application (standard form) for a construction permit to the administrative authority along with soil logs, soil test data, design data and calculations, and plans and specifications, all of which must be stamped and sealed by a septic system designer.

  If the administrative authority determines that the system does not meet one or more of the general requirements of N.J.A.C. 7:9A, the applicant will be directed to apply for a treatment works approval (TWA) and an NJPDES permit. The application should include endorsements by the administrative authority, and supporting documentation with proof of surface and groundwater quality protection.

- **Approval.** NJDEP and/or the administrative authority reviews the application and issues the TWA if the criteria are satisfied. Upon issuance of the TWA, the administrative authority may issue final design approvals, and any deviations from the general requirements will be stated in the TWA. A certificate of compliance is issued by NJDEP under one of the following conditions:
  - The administrative authority makes sufficient inspections of the construction and installation process, or
  - A licensed professional engineer submits a signed and sealed statement in writing that the system was located, constructed, installed or altered in compliance with the general requirements.

NJDEP does not specify probation periods, or effluent water quality limitations. They also do not provide a classification system of alternative and innovative technologies. However, NJDEP describes experimental systems as "new technologies which may improve the treatment of sanitary sewage prior to discharge or allow environmentally safe disposal of sanitary sewage in areas where standard sewage disposal systems might not function adequately". Advanced wastewater pretreatment components are used for altering an existing system to meet the increasing sanitary sewage volume of a site.

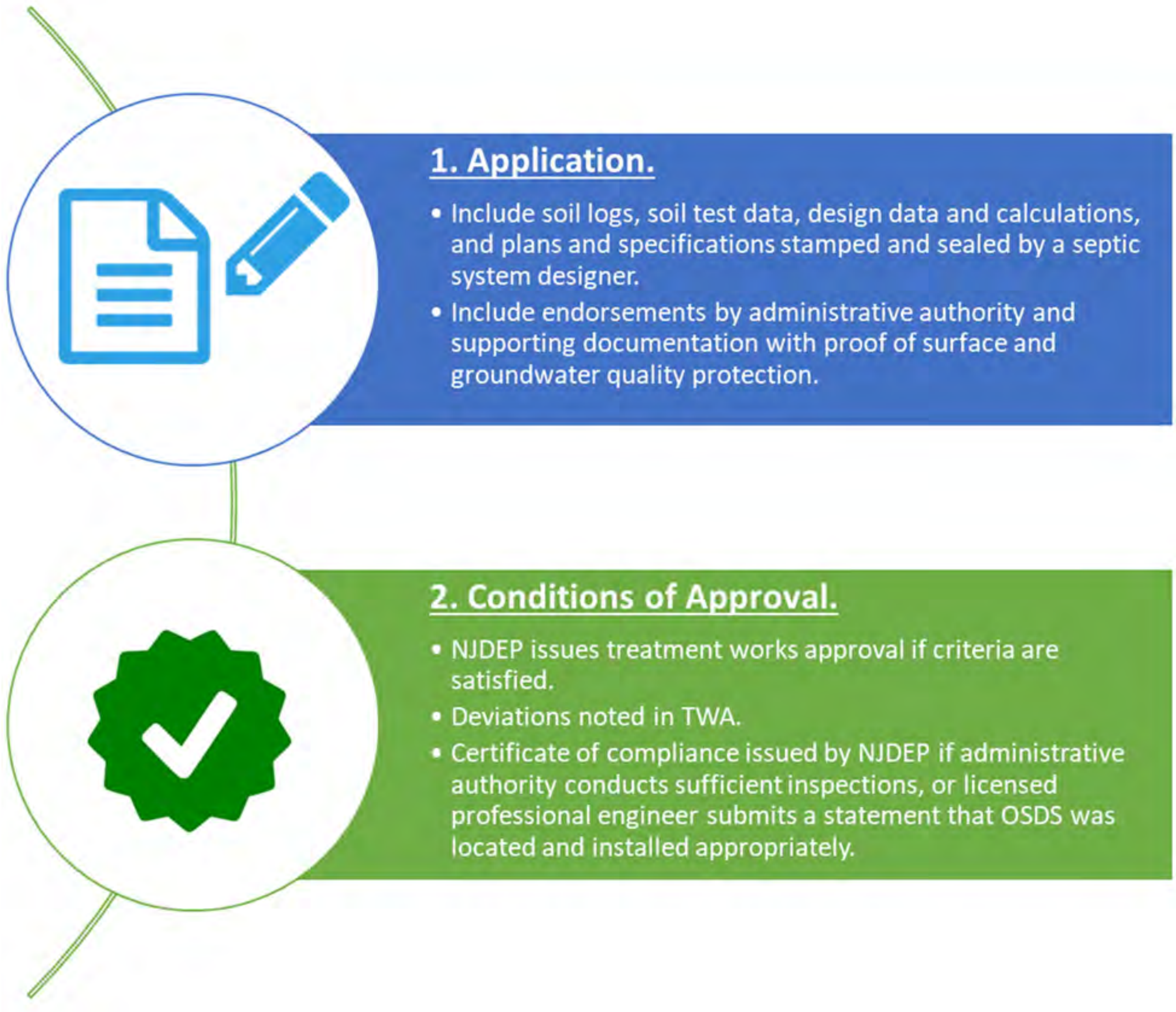

Figure 1.6 New Jersey Department of Environmental Protection OSDS Approval Process

1.3.5.2 Summary of Approved Technologies in New Jersey

New Jersey has listings on-line for approved systems and components of the following categories[18]:

1. Aerobic Treatment Units (dozens of listings)
2. Alternatives to Laterals and Filter Material (21 listings)
3. Dripper line/ Drip Tubing (2 listings)
4. Tire Chips (Generic)

1.3.6 New York

Suffolk County is the best example of an approval process for OSWT systems in New York State. It is a coastal county (980 miles coastline) which has an estimated 252,000 cesspools and 108,000 other OSDSs placing 75 percent of the population on OSWT systems. Their replacement efforts are driven by protection

[18] https://www.nj.gov/dep/dwq/owm_ia.htm

of drinking water aquifers from nitrogen contamination. They have identified 209,000 priority systems and estimate a need to replace almost 2,600 per year based on home sales. Suffolk County awards grants up to $30,000 per system for replacements that utilize AIE technologies and can award about 200 per year currently. Future funding will ramp up grants to 1,000 per year. At least 550 AIE system installations have been approved. Suffolk County is included in the study because of the large scale of the cesspool issue and the detailed and well-defined approval program they have developed.

1.3.6.1 Approval of Alternative/Innovative/Experimental Technologies

Suffolk County Department of Health Services (SCDH) is the agency that oversees on-site wastewater treatment systems[19,20]. The regulations for modified subsurface treatment in Suffolk County are found in The Suffolk County Code Chapter 760-610[21]. General requirements include the following standards: project location, sewer availability, subsoil and groundwater conditions, wastewater flow capacity and water quality. The approval process of innovative and alternative onsite wastewater treatment systems is detailed in the Suffolk County Code 760-19-104[22]. In order for a permit to be issued for the construction of an AIE system, it must be on the SCDH's list of approved technologies. The approval process is summarized in Figure 1.7 and below:

- **Application.** Submit documents to the SCDH including an engineering report describing the technology with process design calculations and drawings prepared by a licensed professional engineer. The application should also include performance data of previously installed and tested systems at a testing facility acceptable to the SCDH. The system must have been tested at full-scale with a minimum design capacity of 440 gpd. Influent and effluent sampling results collected over a minimum of one year at a maximum of 30 day intervals for total nitrogen (TN), total Kjeldahl nitrogen (TKN), ammonia (NH_3), nitrite (NO_2), nitrate (NO_3), pH, BOD_5, TSS, and alkalinity analyzed by a certified lab are required. The Department reviews the submitted items and issues a written determination to either approve or deny the technology within 60 days.
- **Conditions of approval.** The OSDS must be installed so that it can function by gravity flows. Effluent samples must be tested by state certified laboratory at least every 30 days after the system reaches equilibrium for TN, TKN, NH_3, NO_2, NO_3, pH, BOD_5, TSS, and alkalinity. When approved, the technology will be added to the SCDH's approved list and is subject to a series of approval phases before becoming fully available. A final guidance document must be submitted (design, installation, O&M). The applicant must provide training to the SCDH and Industry. The technology must be installed, operated and maintained according to guidance document.
- **Testing and Monitoring.** Duration and frequency of sampling of the effluent varies by approval phase (see Table 1.2) and must be analyzed by a state-certified laboratory. The four approval phases are experimental, piloting, provisional, and general use. To advance from one phase to the next, the technology must meet the requirements stated in the Suffolk County Code 760-19-104. A summary of the approval phases for Suffolk County New York is displayed in Table 1.2.

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[19] https://www.suffolkcountyny.gov/health
[20] https://www.suffolkcountyny.gov/health
[21] Sewage Facilities Requirements for Other Construction Projects (Other Than Single-Family Residences and Conventional Single-Family Residential Subdivisions or Developments): Suffolk County Sanitary Code - Article 6
[2222] Approval Process for I/A OSWT: Suffolk County Sanitary Code - Article 19

Table 1.2 Classification of AIE On-Site Wastewater Treatment Systems in Suffolk County, New York (NY)

Approval Phase	Sample Frequency	Number of Installations	Probation Period	Cost of Application /Permit Process	Additional Requirements
General Use	Every 36 Months (residential), or Every 12 months (commercial)	At least 20	N/A	NA	• Full technical report of sampling results, • Show that total-N effluent is less than 19 mg/L in 100 percent of Provisional 1 data set
Provisional 2	Every 12 Months (residential), or Every 12 months, unless seasonal then every month of operation (commercial)	At least 20	2 to 5 years	NA	• Show that total-N effluent is less than 19 mg/L in 75 percent of total piloting data set
Provisional 1	Bi-Monthly for 12 months (residential), and Monthly for 12 months; Bi-monthly for an additional 12 months (commercial)	20	2 to 5 years	NA	• Same requirements as Provisional 2
Piloting	Monthly; 12 months rolling average	At least 8; no more than 12	1 to 2 years	NA	• Have NSF 245 certification, or • EPA Environmental Technology Verification Program Certification, and • Show that total-N effluent is less than 19 mg/L in 75 percent of total experimental data set
Experimental	Monthly; 12 months rolling average	At least 3; no more than 5	1 to 2 years	NA	• Engineering report by a licensed P.E., • Lab test data

Notes
(1) N/A = not applicable
(2) NA = not available

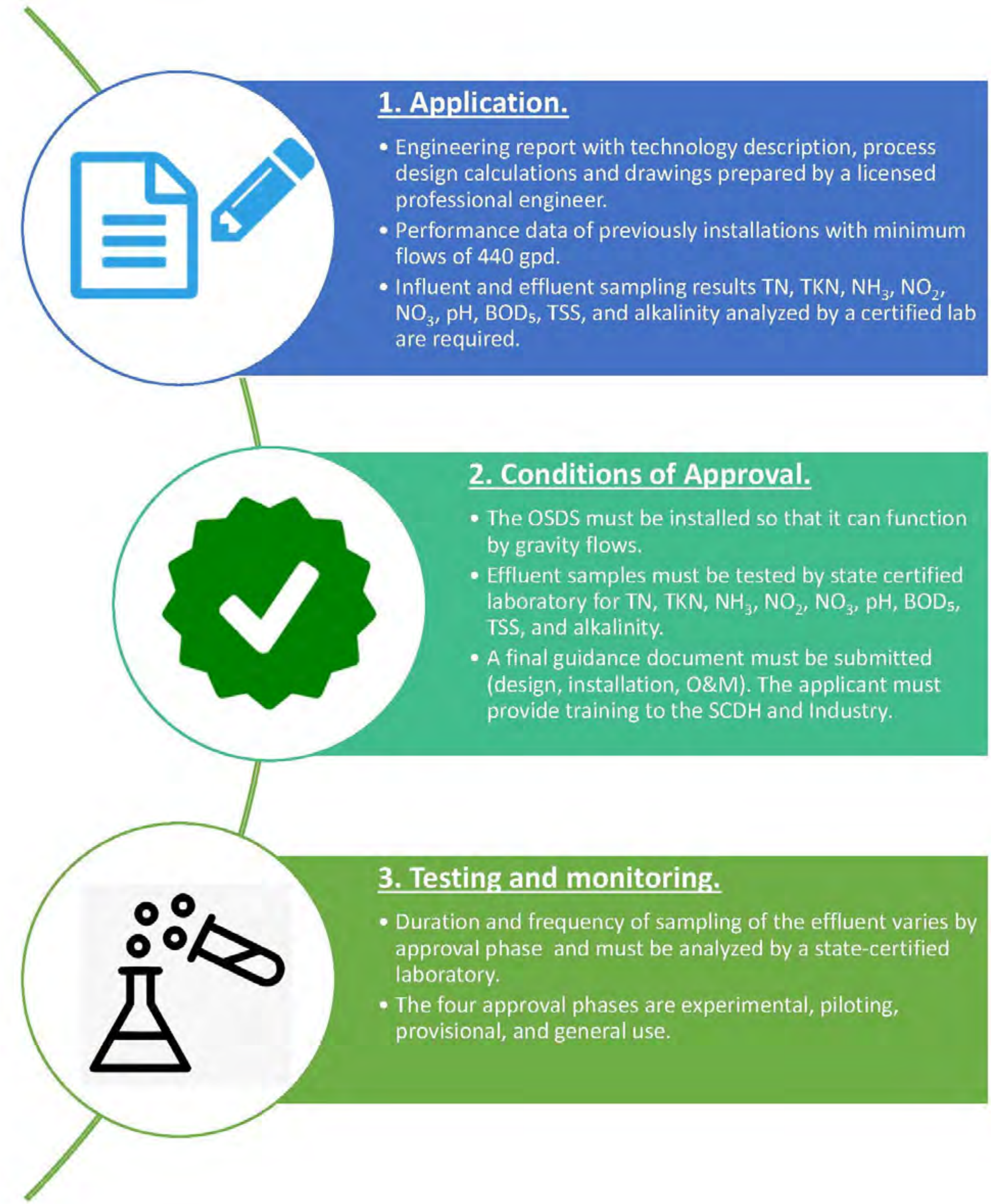

Figure 1.7 Suffolk County Department of Health Approval Process for Innovative and Alternative Onsite Wastewater Treatment Systems

1.3.6.2 Summary of Approved Technologies in Suffolk County NY

As of this date, the Suffolk County Department of Health Services List of Approved Innovative and Alternative Onsite Wastewater Treatment Systems (I/A OSWT) consists of:

- Six experimental technologies.
- Two piloting technologies.
- Eight provisional technologies.

Of the six experimental technologies, only two are currently installed—Lined Nitrogen Reducing Biofilters and Unlined Nitrogen Reducing Biofilters. There are currently no piloting technologies in use. SCDHS Division of Environmental Quality reports that there were 545 I/A OSWT system permit approvals and 169 installations as of 12/31/2018 (2018 Report on the Performance of Innovative and Alternative Onsite Wastewater Treatment Systems[23]).

1.3.7 Rhode Island

Rhode Island is a coastal state (400 miles coastline) which had an estimated 25,000 cesspools in 2007 when they passed a cesspool act to replace the 1,400 high priority cesspools (near coast, aquifers, and drinking water wells). It appears that the priority systems have been upgraded and since then a point-of-sale required upgrade approach has been adopted for cesspools in other areas. It is unclear how many cesspools remain in Rhode Island, however, as of 2015, almost 21,000 AIE technologies have been installed (these are not all for cesspool replacements, many are new homes). The cost of the program is unknown, however, the state received an EPA grant of $3 million dollars to create a plan/strategy and Rhode Island has created a low-interest loan program which has distributed at least $12.4 million dollars in 783 loans to homeowners to assist with upgrades. Rhode Island is included in the study because of the large number of AIE technologies approved and installed.

1.3.7.1 Approval of Alternative/Innovative/Experimental Technologies

The Rhode Island Department of Environmental Management (RIDEM) is the agency that oversees on-site systems[24]. The Rhode Island regulations for OSDSs is contained in 250-RICR-150-10-6 (Rules Establishing Minimum Standards Relating to Location, Design, Construction and Maintenance of Onsite Wastewater Treatment Systems (RI-Rules[25]). General requirements include but are not limited to the following: wastewater flow capacity, minimum setback distances, separation distance to groundwater/impervious layers, soil testing requirements, effluent pipe sizing, leachfield loading rates, designer and installer licensing, application requirements, etc.

Section 6.41 addresses "Alternative or Experimental Technology Approval". In order for a permit to be issued for construction of a non-standard technology in Rhode Island, it must have been approved and certified and appear on the RIDEM's approved list. The overall steps in the approval/certification process are summarized in Figure 1.8 and below:

- **Application.** The application to RIDEM must include several submittals for the proposed technology, such as technology information, approval/denial history, performance data, design criteria, installation criteria, operation and maintenance/cost/monitoring requirements, failure history, and draft guidance document for owners, designers, installers, and inspectors/maintainers.

[23] https://reclaimourwater.info/Portals/60/docs/2018_Performance_Evaluation_of_IAOWTS_Appendices_11-18-2019.pdf
[24] http://www.dem.ri.gov/programs/water/owts/
[25] https://rules.sos.ri.gov/regulations/part/250-150-10-6#meta-details

The application is reviewed by the OSDS Technical Review Committee which provides a recommendation within 90 days. The Director may approve or deny as submitted, and/or recommend resubmission with suggested modifications; with reclassification; or both.

- **Conditions of approval.** Once approved, a final guidance document must be submitted (design, installation, O&M). The applicant must provide training for licensed designers, installers and inspectors/maintainers. The technology is certified for use in Rhode Island and is added to the approved list. The certification contains: general design requirements, general certification requirements, operation and maintenance requirements, and reporting requirements.
- **Monitoring and Testing.** The Director may require monitoring/sampling, performance reports, annual summary reports.

Several degrees of approval certifications exist. An AIE technology's classification depends mainly on the timeframe of available data that shows the DEM's general requirements have been met. Table 1.3 summarizes the various AIE approval classifications in Rhode Island.

Table 1.3 Classification of AIE On-Site Wastewater Treatment Systems in Rhode Island

Technology Type and Degree of Certification	Renewal Period	Number of Installations	Probation Period	Cost of Application/ Permit Process	Additional Requirements
Alternative System Class One	Permanent	At least 10 in RI, or At least 10 in each of 3 other states	4 years	NA	
Alternative System Class Two	Every 5 years	At least 10 in RI, or At least 10 in each of 1 other state	2 years	NA	• Demonstrate theory or applied research
Alternative System Class Two with nitrogen-reduction	Every 5 years	At least 10 in RI, or At least 10 in each of 1 other state	2 years	NA	• Have NSF 245 certification Show that total-N effluent is less than 19 mg/L
Alternative Component Class One	Permanent	At least 10 in RI, or At least 10 in each of 3 other states	2 years	NA	• Manufacturer's and material standards are met
Alternative Component Class Two	Every 5 years	At least 10 in RI, or At least 10 in each of 1 other state	1 year	NA	• Manufacturer's and material standards are met
Experimental	N/A	At least 3 and no more than 10 in RI	2 years	NA	• Demonstrate that it works in practice and theory • Subject to third-party monitoring • Abandon and replace with approved technology upon failure

Notes
(1) N/A = not applicable
(2) NA = not available

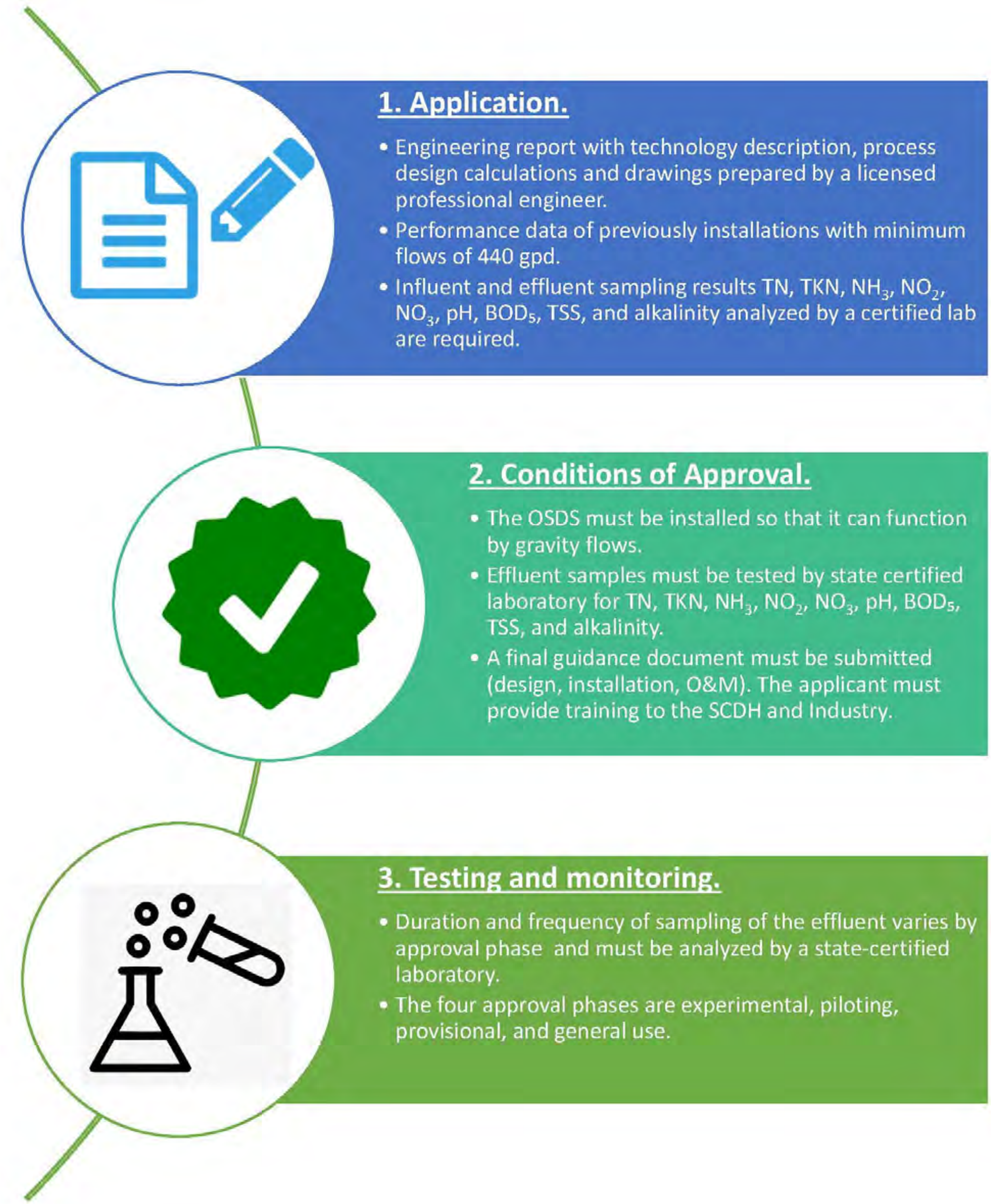

Figure 1.8 Rhode Island Department of Environmental Management Alternative and Experimental Technologies Approval Process

1.3.7.2 Summary of Approved Technologies in Rhode Island

The RIDEM website contains a list of the approved and certified Alternative/Experimental Technologies according to RIDEM's standards[26]. There are:

- Three Class I-Alternative Systems
- Nine Class II-Alternative Systems
- 14 Class I-Alternative Components
- Seven Class II-Alternative Components
- Zero Experimental Technologies

Most technologies approved as Alternative Systems were described by the system's capability to significantly reduce the effluent concentrations of BOD; TSS; fats, oil, and grease (FOG); and TN. The most common approved components are chambered leachfields and effluent filters. The list does not currently contain any "Experimental" technologies.

1.3.8 Texas

Texas is a coastal state (3,359 miles coastline) where about 45,000 new onsite systems are installed every year and 25-35 percent of the population is served by such systems (possibly 2 to 3 million systems total). The state has developed a rigorous approval process for proprietary and non-standard treatment systems. Texas is included in the study because of the large number of onsite systems they have, the rigorous AIE technologies approval process developed, and the large number of AIE technologies they have approved.

1.3.8.1 Approval of Alternative/Innovative/Experimental Technologies

The Texas Commission on Environmental Quality (TCEQ) is the agency that oversees the installation of OSWT systems. The Texas regulation of onsite sewage facilities (OSSFs) is contained in 30 Texas Administrative Code (TAC) Chapter 285 On Site Sewage Facilities[27]. Subchapter D (Planning, Construction and Installation Standards) contains the rules on approval of systems[28]. The Standards include the following elements:

1. Site Evaluation
    a. Soil analysis
    b. Groundwater evaluation
    c. Surface drainage analysis
    d. Separation requirements
2. Selection criteria for treatment and disposal systems
3. Criteria for sewage treatment systems
    a. Pipe from building to treatment system
    b. Standard treatment systems: 1) Septic tanks, 2) Intermittent sand filters
    c. Proprietary Treatment Systems
    d. Non-Standard Treatment Systems
    e. Effluent quality
4. Criteria for effluent disposal systems
5. Other Requirements
6. Emergency repairs

[26] http://www.dem.ri.gov/programs/benviron/water/permits/isds/pdfs/ialist.pdf
[27] https://www.tceq.texas.gov/rules/indxpdf.html#285
[28] https://www.tceq.texas.gov/assets/public/legal/rules/rules/pdflib/285d.pdf

7. Abandoned tanks, boreholes, cesspools and seepage pits
8. Water treatment equipment and appliances
9. Prevention of unauthorized access to OSSFs
10. OSSF maintenance and management practices

The regulations that are most relevant to AIE systems are 3c Proprietary Treatment Systems and 3d Non-Standard Treatment Systems. The difference is that 3c applies to vendor-supplied units and 3d applies to emerging or experimental designs not yet commercially available. The approval process for 3c is summarized in Figure 1.9 and below:

- **Testing.** Two testing options for proprietary treatment systems are provided.
  - **Method A.** Systems tested by NSF and listed as NSF 40 – Class I systems, or by an American National Standards Institute (ANSI) accredited testing institution, or by other standards approved by the executive director.
  - **Method B.** Systems not approved by Method A may only be approved through independent, third party testing for 2 years; and all supporting data submitted for approval by the executive director. The third party must obtain a temporary authorization from the executive director before testing; containing the number of systems to be tested (between 20 and 50), location of test sites (must be similar to where the technology will be used if approved), how the system will be installed and maintained, testing protocol for collecting/analyzing samples, equipment monitoring procedures, and provisions for data recording and data retention to evaluate performance and the effect on public health, groundwater and surface waters. The third party must obtain construction authorization from permitting authorities, and must notify homeowner that it is approved only for testing, if it fails, it will be replaced with an approved system at manufacturer's expense. It remains the manufacturer's responsibility until final authorization is received.
- **Application.** After completion of 2-years of testing, submit a detailed report on the performance. The director can issue conditional approval or deny use.
- **Monitoring and Ongoing Review.** Conditional approval only applies to use in similar areas, and is for a specified monitoring period not to exceed five years. The AIE system must be monitored according to a plan approved by the director. Approval or disapproval will be based on performance during the monitoring period. Upon successful completion of the monitoring period, the monitoring requirements can be lifted, the notice of approval made permanent for the test systems, and system is deemed suitable for use in similar areas. Approved systems must be reviewed every seven years – to be completed prior to the end of the seven-year period. System reviews must be performed by a third party such as NSF, ANSI- accredited, or other independent third party approved by the director. The review shall include evaluation of short-term and long-term effectiveness, structural integrity, maintenance of the system, owner access to maintenance support, any impacts the system had on the environment, and effectiveness of the manufacturer's installer training program. Any system not approved due to the review shall be removed from the approved list.

The approval process for Non-Standard Treatment Systems (3d) is the same as for Proprietary Treatment Systems. The Non-Standard systems section is applicable to any system not covered in 3b (standard treatment systems) or 3c. (proprietary treatment systems)

The Texas process does not prescribe data requirements (number of samples), but does prescribe the testing period, and does have performance criteria for CBOD, TSS, TN, TP, and fecal coliform. They do not require testing by NSF or a NSF-approved facility, but if not by NSF, there must be at least 20 systems tested by an approved, independent third party.

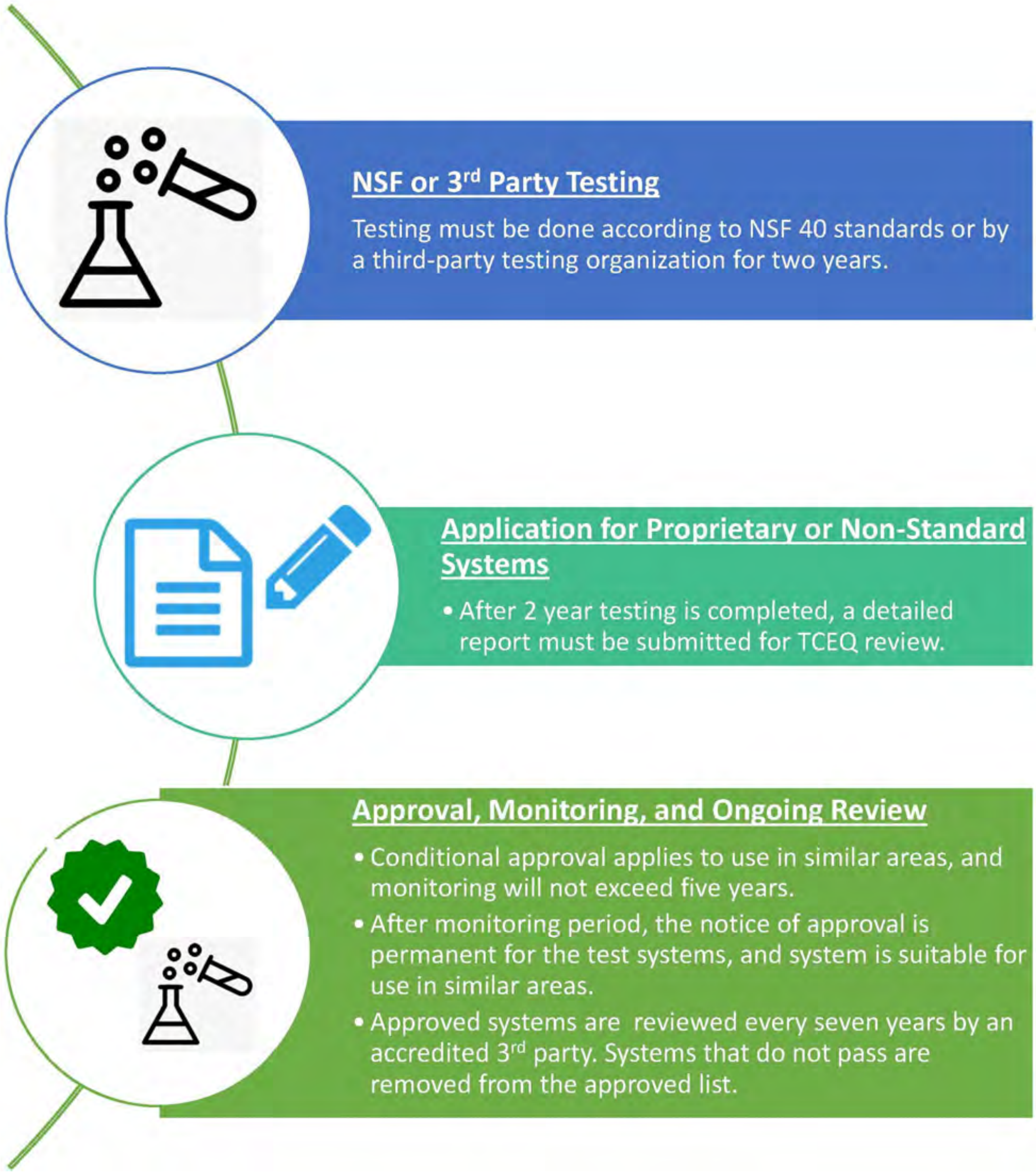

Figure 1.9 Texas Commission on Environmental Quality Proprietary and Non-Standard Treatment Systems Approval Process

1.3.8.1 Summary of Approved Technologies in Texas

Texas maintains online lists of approved systems[29] as follows:

- Composting toilets: 13 models of one brand and 16 models of another brand
- Disinfection devices: none listed
- Disposal systems: 6 brands with 6, 9, 1, 11, 1, and 3 models
- Effluent filters: 6 brands with 6, 2, 1, 50, 1, and 4 models
- Treatment systems: numerous systems by size:
    - 400-550 gpd: 26 brands
    - 600 gpd: 19 brands
    - 700-890 gpd: 24 brands
    - 900-1100 gpd: 22 brands
    - 1200-1500 gpd: 20 brands

1.4 Comparison of Approved Technologies, System Requirements, and Advanced/Innovated/Emerging Technologies Approval Processes

Table 1.4 compares the AIE onsite system approval processes for eight states studied. The table lists a variety of approval components such as types of systems, renewal/probationary periods, application submittal requirements, testing requirements, and training/certification requirements.

Each of the eight states reviewed utilize different procedures and have varying, specific requirements for approval. The variation is wide, with some states being very prescriptive on processes, requirements, durations, etc. and having several types of progressive permitting phases to manage; while others have less complicated procedures. Some observations and comparisons of the approval processes are as follows:

1. **Types:** There are as few as one type/phases of systems, Delaware and as many as five or six (Rhode Island and New York). Most states have just 2 or 3 categories. Fewer types of alternative systems and phases of approval are likely easier to manage.
2. **Probationary Periods:** The range for probation is from one to five years followed by permanent approval. Only three of the eight states studied have required probationary periods. Probationary periods seem like a good idea to ensure that AIE technologies perform as expected for extended periods and some studies (Suffolk County, NY) have shown that 20 percent of systems do not perform as well over time. However, it results in additional burdens on regulators with the responsibilities of tracking and monitoring.
3. **Renewal Periods:** The range is from non-renewal for experimental systems, to one to five years for probationary systems, to seven year system reviews of approved systems, to permanent approval (no renewals required). It seems prudent to have a renewal or review period even for "permanently" approved technologies. This renewal/review period could be as long as 10 years.
4. **Review Periods and Fees:** Review periods range from 15 to 90 days. Some states do not specify a review period. Application fees ranged from $115 to $3,675.
5. **Required Application Submittals:** There is quite a bit of common ground in this component with most states requiring extensive submittals. These include technology description/info, design criteria, installation criteria, O&M requirements, warranty info, and results of previous studies. Some states also require registered third party reports, and/or draft manuals for owners, designers, installers, inspectors and maintainers.

[29] https://www.tceq.texas.gov/permitting/ossf/ossf-products

6. **System Testing:** Most states provide alternatives including NSF, NSF-approved sites, EPA-approved sites, or university labs. Some states only allow NSF or other certified testing sites/organizations. Current practice in Hawai'i allows testing by NSF or other approved such as universities.
7. **Number of systems that must be tested:** Several states do not specify any number and leave it to the proposer to suggest – thus, the minimum could be one. For those states that specify a number, the range is from three to five for experimental systems, to 10 for probationary systems, to a minimum of 20 (and max of 50). It would seem that at least 10 to 20 systems should be tested in state at locally typical sitesprior to "permanent" approval.
8. **Water Quality Parameters to be Monitored:** All require TSS, BOD_5 (or $CBOD_5$), pH, and alkalinity. Many also require TN, TP. Some also require NO_2, NO_3, NH_3, TKN, FOG, and/or fecal coliform. At least one state requires all data to be produced by a state certified laboratory. In general, more data is better, however, data is expensive and especially from certified laboratories.
9. **Testing Period:** Some states do not specify a period. Most specify at least one year, and some states specify two or four years. Some specify the NSF testing period which is approximately nine months.
10. **Sampling Interval Requirements:** Some states require monthly or quarterly sampling, but most do not specify the sampling interval – leaving it up to the applicant to propose. It seems important to specify the sampling interval. Monthly sampling intervals or a minimum number of samples collected would be prudent to provide meaningful data.
11. **Special Denitrification Requirements:** The NSF 245 protocol specifies at least 50 percent removal of TN. Several of the New England states eschew the percent removal for a maximum concentration of 19 mg/L TN. Delaware specifies 50 percent and less than 20 mg/L. Florida specifies 65 percent removal. The NSF 245 standard specifies at least 50 percent TN removal which seems insufficient. It seems important to specify a maximum effluent TN concentration. However, it is not clear that 20 mg/L is low enough. Data posted from New York indicates that many of the ATUs are not able to consistently achieve the less than 19 mg/L standard, so careful consideration is required. Prior testing of N/DN systems in Hawai'i found that less than 19 mg/L TN and 50-80 percent removal can be achieved.
12. **Certifications Issued and Required:** Rhode Island is the only state that issues a certification for AIE technologies. Rhode Island also certifies designers, installers, inspectors, and maintainers. A few other states also certify these people, which seems like an important feature of these programs. All of the states maintain online lists of approved AIE technologies.
13. **Required Trainings:** Rhode Island requires approved system manufacturers to provide public training sessions for designers, installers, and inspectors/maintainers. This seems like an important program feature.

Table 1.4 Comparison of AEI On-Site Technology Approval Processes for Other States

Approval Process Component	Delaware	Florida	Maryland	Massachusetts	New Jersey	New York - Suffolk County	Rhode Island	Texas
	DNREC	FDOH	MDE	MassDEP	NJDEP	SCDH	RIDEM	TCEQ
Types or Phases	Innovative/Alternative	1. Alternative Systems 2. Innovative Systems Numerical WQ Standards: 1. Adv Secondary 2. Adv Wastewater 3. Florida Keys	1. BAT CLASS I 2. BAT Class II 3.BAT Class III 4. BAT Class IV 5. BAT Class V	1. Piloting 2. Provisional 3. General Use 4. Remedial	Experimental	1. Experimental 2. Piloting 3. Provisional 1 4. Provisional 2 5. General Use	1. Alt Systems Class 1 2. Alt Systems Class 2 3. Alt Sys Class 2 w/DN 4. Alt Components Class 1 5. Alt Components Class 2 6. Experimental Systems	1. Standard Systems 2. Proprietary Systems 3. Non-Standard Systems
Renewal Period	Not available	Not available	Permanent, but if samples show poor performance, can be revoked or suspended	1 & 2. 5 years 3 & 4. Permanent, but if annual samples show poor performance, may be revoked or suspended	Not available	General Use is permanent, but if annual samples show poor performance, can be revoked or suspended	1 & 4. Permanent 2, 3 & 5. Five Years 6. Not Renewable	System Review every 7 years
No. of Installations Required	Not available	Not available	Not available	1. No more than 15 2. At least 50 3 & 4. NA	Not available	1. 3 to 5 2. 8 to 12 3. 20 4 & 5. At least 20	1 & 4. 10 in RI or 10 ea in 3 other states 2, 3, & 5. 10 in RI or 10 in another state 6. 3 to 10 in RI	20 to 50
Probation Period	Not available	Not available	First 12 months	1. 18 months 2. 12 months as piloting 3. 3 years as provisional 4. 1 year in other jurisdictions	Not available	1 & 2. 1 - 2 years 3 & 4. 2 - 5 years 5. Permanent	1. Four years 2, 3, 4, & 6 Two years 5. One year	After 2 years testing, get conditional approval for a Monitoring Period ≤ 5 yearrs, after this period it is approved

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	Approval Process Component	Delaware	Florida	Maryland	Massachusetts	New Jersey	New York - Suffolk County	Rhode Island	Texas
		DNREC	FDOH	MDE	MassDEP	NJDEP	SCDH	RIDEM	TCEQ
Required submittals	Applicant Info	X	X	X	X	X	X	X	X
	Technology Info	X	X	X	X	X	X	X	X
	Design Criteria	X	X	X	X	X	X	X	x
	Installation Criteria		X	X			X	X	x
	O&M Requirements	X	X	X	X		X	X	X
	O&M Costs			X	X	X	X	X	
	Failure History							X	
	Draft Guidance: Owners				X			X	
	Draft Guidance: Designers						X	X	
	Draft Guidance: Installers							X	
	Draft Guidance: Inspectors and Maintainers			X	X			X	
	Fee	AEI Application fee - $0 Site Evaluation Application Fee - $65 Engineering Permit Application Fee - $115 Gravity System Application Fee - $50	Innovative System Permit Application Fee - $2,500	Not available	Innovative/Alternative (I/A) System Application Fee - $3,675 IA System Permit Fee - $50/yr/home $200 per site visit by operator $100 per sampling visit	Not available	Not available	A/E technology renewal fees: Class One or Two - $1,000 Experimental - $2,000 Class One or Two renewal - $500 Experimental renewal - $1,000	Not available
	Warranty		X				X		
	Research and Development studies	X	X		X	X			
	Results of previous testing	X	X		X	X			
	Registered 3rd party report	X	X	X					
	# of systems to test		X						X (20 to 50)
	Requested test period		X						2 yrs
	Sampling and analysis protocol proposed	X	X		X				X
Approval Process Component		Delaware	Florida	Maryland	Massachusetts	New Jersey	New York - Suffolk County	Rhode Island	Texas
		DNREC	FDOH	MDE	MassDEP	NJDEP	SCDH	RIDEM	TCEQ
Who Can Test		NSF or a University	NSF or NSF-approved	Third party testing facility chosen and trained by the manufactureer	System proponent	NJDEP/NJPDES	NSF or EPA-ETV or a NY-licensed PE	Not specified	NSF or other independent approved by Director

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Approval Process Component	Delaware	Florida	Maryland	Massachusetts	New Jersey	New York - Suffolk County	Rhode Island	Texas
	DNREC	FDOH	MDE	MassDEP	NJDEP	SCDH	RIDEM	TCEQ
WQ Parameters to be Tested	BOD_5, TSS, Fecal coliform, TN	$CBOD_5$, TSS, TN, TP, Fecal coliform	TN, TKN, Nitrate, Nitrite, DO, Temp, BOD, TSS, pH	TN, pH, BOD_5, TSS	Turbidity,Odor, pH	TN, TKN, NH_3, NO_2, NO_3, pH, BOD_5, TSS, Alk, by a Certified Lab	Flow, DO, Temp, BOD_5, TSS, pH, TN, NO_2, NO_3, NH_4, Alk, TKN, O&G	$CBOD_5$, TSS, pH
Test Period Specified	No, proposed by designer	No, proposed by designer	First 12 months	No, proposed by designer	No, proposed by designer	Minimum 1 year	Alt Sys Class I - 4 yrs, Alt Sys Class II - 2 yrs, Alt Comp Class I - 2 yrs, Alt Comp Class II - 1 yr	2 years
Number of Samples Specified	No	No	4 Samples Quarterly	Quarterly	No, proposed by designer	Monthly	Quarterly	No
Special DN requirement	TN: 50 percent removal and less than 20 mg/L	TN: at least 65% removal	TN effluent values less than (1) 19 mg/L and (2) 48 mg/L	TN effluent values less than 19 mg/L	N/A	TN effluent values less than 19 mg/L	preponderance of TN effluent values less than 19 mg/L	N/A
Review by:	Onsite System Advisory Board	FDOH Bureau of Onsite Sewage Programs	by BAT Technical Review Comt	MassDEP and Local Approving Authority	NJDEP/Local Administrative Authority		by OSDS Technical Review Comt	TCEQ
Review Period:	N/A	15 days	Not Specified	Not Specified	N/A	60 days	90 days	N/A
Approved List online?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Certification Issued?	Not available	Not available	Not available	Contains: general design requirements, general certification requirements, operation and maintenance requirements, and reporting requirements	Contains: general design requirements, general certification requirements, construction requirements, operation and maintenance requirements, and site requirements	Not available	Contains: general design requirements, general certification requirements, operation and maintenance requirements, and reporting requirements	Not available
Training Required?	Homeowners required to have O&M contract and homeowners may get trained.	Not available	Not available	Some counties require O&M contracts	Not available	Not available	Yes: for licensed designers, installers and inspectors / maintainers	Not available
Certification of Designers	Yes	PE	Not available	PE	PE	Not available	Yes	Not available
Certification of Installers	Yes	Yes	Not available	Yes	Yes	Not available	Yes	Not available
Certification of Inspectors	Yes	Yes	Not available	Yes	Yes	Not available	Yes	Not available
Certification of Maintainers	Homeowners required to have O&M contract.	Yes	Not available	Yes	Yes	Not available	Yes	Not available
Onsite System Registration or Permit?	Not specified	Not specified	Not available	Not specified	Not available	Yes, required, renewed every 3 years	None	Not available

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1.5 Summary of Best Practices for Application and Approval of AIE Technologies in Hawaiʻi

The goal for DOH should be to create a procedure and set of requirements that first and foremost protects public health and the environment, and then balances information/data needs, department review time, program complexity, program staff needs/costs, testing duration, testing costs, testing oversight, designer needs, installer needs, and homeowner needs/costs. These are a lot of issues to consider and there is no perfect system. A good AEI approval system will ensure the following:

- Applicants will not have questions during application preparation.
- All information needed by DOH to decide on approval is included in the application and in a standard format/order to facilitate efficient review.
- There are a small number of different types/phases of permits to manage.
- There is not an overwhelming amount of water quality data to analyze, but there is enough to assess system performance and reliability.
- The approval process will allow accurate assessment of O&M requirements and costs.

These characteristics were integrated with the assessment of the approval processes of the 8 states and interviews with some state agencies to develop the following considerations for revision of Hawaiʻi's approval process components (see Appendix A for notes of interviews with other states) :

1. **Additional agency staff.** Most state agencies expressed concerns that they are understaffed to manage their conversion programs. Staff members manage anywhere from 100 to 3,000 permit applications per staff member per year. Most agencies desire more staff so that they can do more inspections and follow up on converted systems.
2. **Application fee and program funding.** Most states also expressed concerns that they are underfunded. Adoption of an appropriate application fee that will cover the total cost of review and approval of new technologies is recommended. Other agencies also recommend that fees go to a dedicated (versus general) fund for cesspool conversion program management. In addition, other states recommend point-of-sale conversion and notification of DOH to be required by law with meaningful fines for non-compliance.
3. **Standardized application forms and templates.** Utilizing a standardized application form (form-fillable) could help to streamline the application review and approval process (Rhode Island form is a good example).Likewise, standardized templates for required submittals could help the review process (form-fillable, specific clear format). An example of a local guidance document is the the Honolulu's Storm Water Quality Report template. Suggested submittal materials include; technology description/info, design criteria, installation criteria, O&M requirements, warranty info, and results of previous studies. Some states also require registered third party reports, and/or draft manuals for owners, designers, installers, inspectors and maintainers.
4. **Water quality standards.** Consider multiple sets of water quality numerical standards such as:
    a. Secondary treatment.
    b. Advanced wastewater treatment – for where TN removal is required or desired.

    Parameters may include: TSS, BOD_5, pH, Alk, TN, TP, NH_3, NO_2, NO_3, and fecal coliform. However, interviews with other state agencies showed that the common, recommended monitoring parameters are TKN, NO_2, and NO_3.

5. **Certified laboratories.** Requiring that testing is completed according to NSF, ASTM, or EPA-approved entities or other by a qualified third party will help to bolster testing integrity.

6. **Testing period, sampling intervals, and number of systems tested.** The testing period for AIE technologies should be performed for an appropriate time frame to demonstrate satisfactory performance (e.g. 12 months minimum). The sampling interval should be at least monthly. Multiple systems should be tested (e.g. minimum of 10). Interviews with other state agencies showed sampling and monitoring data can get unwieldy to manage. One common recommendation was for a good database program to facilitate data management and utilization. A good database program could help Hawaiʻi to track long-term performance of systems, which other states have been unable to implement.
7. **Approvals.** Consider limiting approvals to just one type of system – called AIE systems. Interviews with other state agencies showed the common recommendation for a simplified approval process. Consider having two types Provisional and Approved, to allow a probationary period followed by conversion to approved. The approval should be permanent, however, there should be a periodic review of process performance – conducted by a hired third party. Consider maintenance of list of approved AIE technologies on the DOH webpage.
8. **Consider not issuing official certifications for AIE technologies.** Of the states reviewed, only Rhode Island issues certifications. When the RIDEM approves an AIE technology, they issue a certification document. These certifications have the appearance of RIDEM endorsing particular technologies, which may not be a good approach for Hawaiʻi.
9. **Certifications and Training.** Consider implementation of a certification program (and maintain lists on the DOH webpage) for:
   a. Designers
   b. Installers
   c. Inspector/Maintainers

   Consider requiring manufacturers of approved AIE technologies to provide public trainings for the certified individuals. Other states often require O&M contracts of homeowners or homeowner training. In addition, other states recommend monitoring inspection services to avoid falsification of reports.

1.6 References

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Appendix A

NOTES FROM INTERVIEWS WITH OTHER STATES

1. Contact: Emily-Michele Olmsted
Barnstable County Dept of Health & Environment (BCDHE), Massachusetts

Phone: (508) 375-6901 (talked on 9 June 2020)

Email: Emilymichele.Olmsted@barnstablecounty.org

Question	Response/Notes
How many people are needed?	One full-time person can handle 3,000 permits. Emily has been there 4.5 yrs and the number has increased from 500 to 3000 permits. This involves 27,000 samples and 43,000 inspections. There are about 25 private operators/firms.
Are more people needed?	Yes, then would be able to do more follow-up
Costs of program?	N/A
How does the management program work?	Either a town or county board of health or the State runs the program – depends on location. If the homesite is near the shore or nitrogen is otherwise a concern, then an I/A system is required and TN must be 19 mg/L or less. Otherwise a concrete septic tank and absorption system is OK. Barnstable Co has a database system that tracks required O&M contracts, reported inspection data and sample collection/data. The operators enter data on-line into the database. Database informs Emily when contracts expire. 1st letter sent by regular mail, 2nd by certified mail. 90% comply with these two steps. After that goes to collection/fines.
New approvals	Approvals of new I/A are done at State level: Pilot 12 systems w/monthly sampling; Provisional w/quarterly sampling; General Use. Measure lots of things (not sure how determined initially): CBOD/BOD, TSS, TN, NH_3, NO_2, NO_3, TP, pH, temp, DO, conductivity
Fees?	I/A application fee: $3675. I/A systems Permit fee: $50 per year per home – collected by operators (they transfer to BCDHE). Site visit by operator $200 plus $100 for sampling. This adds up to $1200/yr if require quarterly maintenance/sampling.
Online information?	Lists of certified operators, but not engineers or vendors. Rules, procedures, etc.
Public outreach efforts?	Website mainly. Only do a hodge-podge of occasional community events.
Recommendations	Set-up for success – put system type on the house deed. When transfer of deed – a septic survey is required. Partner with environmental groups. Provide education of homeowners – if no info, they don't want to pay – if don't understand, they think it is not working Have random Q/A checks on operators and their data (split samples).
Issues/problems?	More staff needed. Eliminate incentive to lie by operators. Homeowners know that there are 15 towns on the Cape and that you cannot watch 100% of them.

Question	Response/Notes
What to measure?	Recommend: only measure $CBOD_5$/TSS/TN quarterly for 1-2 years, then can request reduction to annual measurements. Labs need to be available locally (on same island).
Interesting data	There are 11 types of I/A systems with lots of data. They track what percentage meet the 19 mg/L TN median requirement. Most systems = FAST (709) which has 59% meeting; Singulair (170) 65% meeting; Advantex (67) 67% meeting; Bioclere (66) 74% meeting; SeptiTech (57) 60% meeting, etc.
Enforcement?	From the data above, it seems that there are at least 1000+ systems not in compliance: Previously: If an annual sample reading exceeded 19 mg/L N – had to test again w/in 45 days. If less than 19, then can resume annual sampling. If second sample is greater than 19, then start quarterly sampling and keep going until 4 consecutive quarterly samples are all less than 19 – then go to annual. Current: If an annual sample reading exceeds 19 mg/L N – the owner gets a notice that they "shall repair, replace, modify, or take other action as required by the approving authority..."

2. Contact: Stephen Tyrrell
Rhode Island Dept of Environmental Management (RIDEM), Rhode Island

Phone: (401) 222-4700 (talked on 11 June 2020)

Email: Stephen.Tyrrell@dem.ri.gov

Question	Response/Notes
How many people are needed?	They have one full-time person plus a half-time inspector to run the cesspool phase-out program. There are a total of 9,000 A/E systems approved and about 7,000 in service. There is inspection at end of construction, however, after installed, there is no tracking except for overflows. No permits or data collection programs. Stephen has been there three years. They handle a few hundred per year – this is all point-of sale upgrades. The permitting Department (separate) approves 500-600 systems per year and they have 6 engineers and 2 supervisors.
Are more people needed?	Yes, 3-5 people needed, so then could find cesspools, issue NOVs, follow-up, etc.
Costs of program?	N/A
How does the management program work?	Started in 2007 – went after 1400 cesspools within 200 ft of coast (all homes older than 1968 when septic law went into effect). Sent 3 letters over one year. Had good response. Enforcement was 4th letter with $200 fine. Fine should have been $2500 (Stephen). 2010 Point-of-sale amendment – was watered down at end – disclosure to RIDEM not required by law – but probably most do fix it. Enforcement is during spring when snow melts and there are overflows. In winter catch-up, look for old homes in a town-by-town basis. After construction, owner must show service contract – vendor must provide. After that there is no follow-up, no reporting, no data.
Recommendations	Record notice of cesspool on Land Evidence Record (deed). Have a good website – Stephen feels like theirs is TERRIBLE.
Issues/problems?	More staff needed. No follow-up No source of revenue – fees needed No data on whether systems are performing
Interesting data	They have a loan program with 1% interest. Use Rhode Island Infrastucture Bank (RIIB). There is $300 origination fee and 1% annual servicing fee, and that is it. Can get up to $25,000 and term up to 10 years. Can use for engineering and construction fees.

3. Contact: Brian Lafaille
Rhode Island Dept of Environmental Management (RIDEM), Rhode Island

Phone: (401) 255-6987 (talked on 24 June 2020)

Email: Brian.Lafaille@dem.ri.gov

Question	Response/Notes
How many people are needed?	Brian is the principal Engineer in the program, 14 yrs there. He has 11 people at the state level for all on-site enforcement, including 4 inspectors. There are 4 people for plan review, permitting. Per year: 2300 site reviews, 5000 permit reviews, 11,000 inspections. Once built, there is little oversight.
Are more people needed?	Yes, then would be able to do more follow-up
Costs of program?	N/A
How does the approval process work?	A lot of N-removal systems were approved with a limit of 50 units in the ground for a given technology – then data required to put more in. But no one followed up, now some vendors have 250 in the ground and no data. Now require data for 10 systems, quarterly for one year, before can install more. RI issued certificates to technologies, required annual reporting, # of homes, etc. – no follow-up was done – cancelled this (still shows on website). New: all technologies have a 5-year renewal – require data to be submitted.
Fees?	Only fees are for new/renew A/E technologies, none for homeowners. \$1,000 for Class One or Class Two, \$2,000 for Experimental, \$500 for renewal of Class One or Two, \$1,000 for renewal of Experimental. No annual fees for homeowners.
Public outreach efforts?	N/A
Recommendations	State mandates need to be funded by the state. Put in place a utility management fee to ensure a funding stream. Septic loan program is good. If you want to only get experienced vendors – just have one classification. If want to help develop new technologies – have two classifications. If want to allow experimental systems – have three classifications. General: keep it simple, don't need elaborate/fancy/complicated program. Set application submittal standards. Set the time for approval – 90d. Consider sea level rise.
Issues/problems?	More staff needed. Technical Review Committee exists to approve A/E systems. Includes builders, engineers, presentations by vendors, discussion, votes, members did not study the materials, cumbersome process for staff which had to do the back-and-forth with the vendors, staff did all the work. Have such a panel just make recommendations.
What to measure?	Currently: Flow, DO, Temp, BOD_5, TSS, pH, TN, NO_2, NO_3, NH_4, Alk, TKN, O&G – these are all good.

4. Contact: Jason Baumgartner
Delaware Dept of Natural Resources and Environmental Control (DNREC), Delaware)

Phone: (302) 233-5434 (talked on 26 June 2020)

Email: Jason.Baumgartner@delaware.gov

Question	Response/Notes
How many people are needed?	Delaware has 70,000 on-site systems. Cesspools were banned in 2015, with all systems to be replaced within one year of discovery.
Are more people needed?	Yes, then would be able to do more follow-up
Costs of program?	N/A
How does the management program work?	Homeowners are required to have an O&M contract. Homeowners can take training and get certified to maintain and inspect their own systems. About 1500 systems in DE require O&M contract. Inspections every 6 months are required and an annual report. Before 2007, the state provided inspectors to visit every system once per 3 years (no fee for this service). There is too much data to look at. No time. Used to track inspections – this has been in limbo for 2 years. Inspections are very basic – based on vendor input – really just whether it is operating – no sampling data is required.
New approvals	Application is on the web. There were a lot in 2005 at start, then very few after that. Third party testing is ok. NSF testing is not required. This works fine. Require 50% removal AND less than 20 mg/L TN. Vendors did group trainings initially, but then never again. Vendors certified the people to do O&M initially. They should have annual updates/recertification.
Fees?	I/A application fee: $0. $65 site evaluation application. $115 Engineering permit application. $50 gravity system application. No annual fees for homeowners.
Recommendations	Make fee for new I/A systems; should be $2500. Allow homeowners to get trained to inspect and maintain their system – it works. Tracking is critically important – they have little/none. Need to know which are being inspected or not and how well/if performing.

5. Contact: Justin Jobin
Suffolk County Dept of Health Services (SCDHS), New York)

Phone: (631) 599-3321 (talked on 10 July 2020)

Email: Justin.Jobin@suffolkcountyny.gov

Question	Response/Notes
How many people are needed?	Suffolk County is 1.5 million population, they have 250,000 cesspools. I/A program has 16 people, including 12 that work on grant/loan program (can get up to $30,000 in grants for a system). There is a 500-person waiting list for funding. Permitting needs 1 engineer per thousand apps. They have 20 sanitarians who can do 200 inspections per year each. There are 300 I/A systems installed per year.
Are more people needed?	Yes, then would be able to do more follow-up
Costs of program?	N/A
How does the management program work?	Three-legged stool (sewering, clustering, individual I/A's)
New approvals	How much data is really needed? A study was conducted and determined that for 90% confidence, need 12 data points from 20 operating systems. This is to know whether a system meets the less than 19 mg/L TN standard for I/A's.
Fees?	N/A
Public outreach efforts?	WQ issues are very visible in NY, fish kills, red/brown tides, reduced clam harvests. They go to 100's of events – that lots of people attend – very visible. There was a very visible technology demonstration program at the start – they gave lots of tours of systems that were half buried. They have partnered with various environmental groups – they helped a lot, lobbying for funding, keeping grants non-taxable, also boots-on-the-ground to get word out about the program.
Recommendations	They are currently updating their rules. New systems need monthly data for one year from 20 systems. For all others, annual sampling – are changing to once every 3 years. Experimental systems classification is still needed. General use Class need the 20 x 12 samples – vendor should pay for all of this. Suggest if lot is < 10,000 sf, require N-removal. Need a revenue fund. Suffolk Co is trying to get a monthly fee of $5. Need a grant to get started – NY State gave $3M grant to start this program and it only got started because of this grant.
Issues/problems?	Trying to get a revenue fund - $5 monthly fee (or $1/1000 gal water use). Need $70-100 Million/yr to run the program long-term.
What to measure?	Recommend for long-term monitoring: Sample parameters - Just need TKN and NO_3/NO_2. Also need pH, temperature in the field. Do not need BOD, TSS, ammonia. With just TKN and NO_3/NO_2 should be only $25/sample.
Interesting data	Pressure drain fields that are very shallow (18 inches deep) are OK since 2018/2019. These have shallow/narrow drainfields. These are

Question	Response/Notes
	very popular and good, they facilitate uptake of NO_3 by the plants/grass. There are 13 proprietary technologies approved and 8 with provisional approval. The smallest size ones are most popular. Only 8 passed the <19 mg/L TN requirement even though they had passed the NSF 245 approval (50% TN removal). They currently get 40% FujiClean, 30% HydroAction, then three that are smaller and similar (SeptiTech, Norweco, Orenco). Grants funding is very large in NY; since 2017, get $2M/yr. Upgrades can get $10,000 from NY state, plus $10,000 from Suffolk County, plus $5000 for pressure drain field, plus $5000 for low income (<80% MFI) – thus the total is $30,000. The average replacement cost is $27,000. In one city (Southampton) there is an additional $20,000 rebate possible – thus total is $50,000 possible. They do this via a fund from a 2% property transfer tax. Mostly local assembly/manufacturing is occurring – lots of jobs. A good database system is critical. Got a $2M grant from NY State to build a new in-house one. Currently using a private vendor system (Ocello from CA – start at $1/system to set up). Other vendors include Carmody and Orenco. Need to be able to track compliance, reports, data, due dates, enforcement actions, letters, etc.

6. Contact: Marcelo Blanco
Florida Dept of Health & Environment (FDOH), Florida)

Phone: (850) 491-0850 (talked on 24 July 2020)

Email: Marcelo.Blanco@flhealth.gov

Question	Response/Notes
How many people are needed?	N/A
Are more people needed?	N/A
Costs of program?	N/A
Fees?	Innovative systems permit (ISP) application fee is $2500.
How does the management program work?	Blanco recommended that I talk to Dr. Eberard Roeder for more info. Blanco is the Environmental Administrator and handles rules/policy for statewide program. There are 67 county health department offices – permits are issued at that level. They have an in-house database for everything and are currently building a new one. There is an annual fee for inspection. There is a requirement to have a maintenance contract in place. New rules are currently being drafted/issued.
Recommendations	Allow homeowners to get trained to inspect and maintain their system – it works. Twice per year inspection on own, submit reports, then have annual county inspection. In first few years, vendors should supply parts for systems, after that let engineers specify replacement parts – less costly. Technical Review Committee to approve I/A systems is good – gets everyone at the table, there have been no rules challenges faced yet – perhaps due to this committee.
Issues/problems?	N/A
Interesting data	One location in Florida Keys has a sewer utility that replaced a few hundred cesspools with N-removing IWS's. They paid for the replacements, they own, operate, and maintain all the systems. They have an easement to own/operate the systems located on private property. The homeowner pays the regular sewer fee (as if connected).

Appendix B

APPROVED INNOVATIVE/ALTERNATIVE SYSTEMS FOR DELAWARE

Table 1B Approved Innovative / Alternative Systems for Delaware

Proprietary Name	Meets PSN3	Approval Issued To	Approval Document
AdvanTex Treatment System AX-20 *	Yes	Orenco Systems, Inc	AdvanTex Treatment AX-20
AdvanTex AX-RT Treatment System	Yes	Orenco Systems, Inc	AdvanTex AX-RT Treatment System
Advanced Enviro-Septic® Treatment System		Presby Environmental	Advanced Enviro-Septic
AeroCell® SCAT Treatment Unit	Yes	Quanics, Inc.	AeroCell SCAT Treatment
American Manufacturing Perc-Rite(r) Drip Dispersal System - ASD	Yes	American Manufacturing Company	American ASD
American Manufacturing Perc-Rite(r) Drip Dispersal System - WD	Yes	American Manufacturing Company	American WD
Amphidrome Wastewater Treatment Systems		F.R. Mahony & Associates	Amphidrome Approval
Aqua Aire Aerobic Treatment Unit	Yes	Ecological Tanks, Inc.	Aqua Aire Approval.pdf
Aqua Safe Aerobic Treatment Unit	Yes	Ecological Tanks, Inc.	Aqua Safe Approval.pdf
Aquaworx Remediator		Aquaworx Remediator (A division of Infiltrator Systems, Inc.)	Aquaworx Remediator
BioBarrier Membrane Bioreactor System 0.5, 1.0, and 1.5		Bio-Microbics Incorporated	BioBarrier Approval.doc
Bioclere Advanced Treatment Unit	Yes	AquaPoint	Bioclere Advanced Treatment Unit
Bio-Coir® SCAT Treatment Unit	Yes	Quanics, Inc.	Bio-Coir SCAT Treatment Unit
Bio-Microbics FAST Advanced Treatment Unit	Yes	Bio-Microbics Incorporated	Bio-Microbics FAST Advanced Treatment Unit
Bio-Microbics RetroFAST Advanced Treatment Unit	Yes	Bio-Microbics Incorporated	Bio-Microbics RetroFAST Advanced Treatment Unit
Clearstream Advanced Treatment Unit		Clearstream Wastewater Systems, Inc.	Clearstream Advanced Treatment Unit
Cromaglass Advanced Treatment Systems	Yes	Cromaglass Corporation	Cromaglass Advanced Treatment Systems
Delta Pre-Engineered Drip*		Delta Environmental Products	Delta Pre-Engineered Drip
Delta Ultra Clear Aerobic Treatment Unit		Delta Environmental Products	Delta Ultra Clear Aerobic Treatment Unit

Proprietary Name	Meets PSN3	Approval Issued To	Approval Document
Delta Whitewater Aerobic Treatment Unit		Delta Environmental Products	Delta Whitewater Aerobic Treatment Unit
Ecoflo Coco ECDn	Yes	Premier Tech Aqua	Ecoflo Coco ECDn
Ecoflo Peat Biofilter		Premier Tech Aqua	Ecoflo Peat Biofilter
Ecopod Advanced Treatment Unit	Yes	Delta Environmental Products	Ecopod Advanced Treatment Unit
ECO-PURE 300 Series Peat Moss Biofilter		ECO-PURE Waste Water Systems	ECO-PURE 300 Series Peat Moss Biofilter
Enviro-Flo Advanced Treatment Unit		Enviro-Flo Inc.	Enviro-Flo Advanced Treatment Unit
E-Z Treat Advanced Treatment		E-Z Set Tank Company	E-Z Treat Advanced Treatment
Fuji Clean CEN-Series Advanced Treatment Unit	Yes	Fuji Clean USA, LLC	Fuji Clean CEN-Series Advanced Treatment Unit
Geoflow "drip" Dispersal System		Geoflow	Geoflow Dispersal System
H-Series Hoot System	Yes	Hoot Aerobic Systems Inc.	H-Series Hoot System
Hydo-Kinetic Model 600 FEU Advanced Treatment Unit	Yes	Norweco Equipment Company	Hydro Kinetic
Jet 500-CF Advanced Treatment Unit		Jet Inc.	Jet Aerobic Treatment Unit
Jet Aerobic Treatment Unit		Jet Inc.	Jet Aerobic Treatment Unit
Nitrex Filter Advanced Treatment Unit	Yes	Lombardo Associates, Inc.	Nitrex FilterAdvanced Treatment Unit
SludgeHammer Group, Ltd		SludgeHammer	SludgeHammer Group
Platinum Submerged Aerated Filter	Yes	ANUA	Platinum Submerged Aerated Filter
Puraflo Peat Biofilter		ANUA	Puraflo Peat Biofilter
Puraflo Peat Biofilter Denitrification System	Yes	ANUA	Puraflo Peat Biofilter DenitrificationSystem
PuraSys SBR Advanced Treatment Unit	Yes	ANUA	PuraSys SBR Advanced Treatment Unit
Singulair Green Model TNT Advanced Treatment Unit	Yes	Norweco Equipment Company	Singulair Green TNT Advanced Treatment Unit
Singulair Model 960 Advanced Treatment Unit		Norweco Equipment Company	Singulair 960 Advanced Treatment Unit
Singulair Model TNT Advanced Treatment Unit	Yes	Norweco Equipment Company	Singulair TNT Advanced Treatment Unit
White Knight Enhanced Biological Augmentation System		Knight Treatment Systems	White Knight Enhanced Biological Augmentation System

Hawaiʻi State Department of Health
Cesspool Conversion Technology Research

Technical Memorandum 2
SEPTIC TANK SYSTEMS REVIEW

FINAL | November 2020

carollo in association with College of Engineering, University of Hawaiʻi at Mānoa

Hawaiʻi State Department of Health
Cesspool Conversion Technology Research

Technical Memorandum 2
SEPTIC TANK SYSTEMS REVIEW

FINAL | November 2020

CARI K. ISHIDA
LICENSED PROFESSIONAL ENGINEER
No. 14977
HAWAII U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE

04/30/2022
EXPIRATION DATE OF THE LICENSE

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Abbreviations

ANSI	American National Standards Institute
BOD	biochemical oxygen demand
BWS	Honolulu Board of Water Supply
Carollo	Carollo Engineers, Inc.
CCWG	Cesspool Conversion Working Group
DOH	Hawai'i State Department of Health Wastewater Branch
EPA	United States Environmental Protection Agency
FRP	fiberglass reinforced polyethylene
ft	foot or feet
gpcd	gallons per capita per day
HAR	Hawai'i Administrative Rules
IAPMO	International Association of Plumbing and Mechanical Officials
in.	inch(es)
mg/L	milligrams per liter
min/in.	minutes per inch
MPN/100 mL	Most probable number per 100 milliliters
mgd	million gallons per day
N	Nitrogen
OSWT	onsite wastewater treatment
sf	square foot or feet
TM	Technical Memorandum
TSS	Total suspended solids

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Technical Memorandum 2

SEPTIC TANK SYSTEMS REVIEW

2.1 Executive Summary

Throughout Hawaiʻi, there are approximately 88,000 cesspools that release an estimated 53 million gallons per day (mgd) of wastewater to the environment. Most of these existing cesspools provide wastewater disposal for single-family residences, versus large-capacity systems serving multiple residences or commercial areas. Given that over 90 percent of the state's drinking water supplies are from groundwater sources, it was recognized that cesspools pose an environmental and public health risk.

One of the most common and well-known onsite wastewater treatment (OSWT) technologies accepted as a means for upgrading cesspools are septic tanks followed by a soil absorption system, collectively referred to as septic tank systems. Given appropriate site conditions, these systems can provide water quality benefits and may be one of the most cost effective OSWT options for current cesspool owners. The purpose of this technical memorandum (TM) is to present a general description of septic tank systems, discuss appropriate site conditions for their use, identify advantages/disadvantages, and summarize overall performance relative to cesspools. This document is not intended to be a comprehensive guide for cesspool conversion to septic tanks, and those interested in such a conversion should seek the advice of a registered professional engineer and/or licensed general contractor.

Septic tank systems are a common means of wastewater treatment and disposal for small populations, such as individual residences, small institutions, schools, etc., where a centralized sewer system may not be available, or a connection may not be feasible. The septic tank itself is typically constructed from concrete, fiberglass, plastic or other similar material. The size of the tank required is dependent upon the volume of wastewater to be handled which is usually expressed in terms of the number of bathrooms, bedrooms, and/or occupants of a residence. Unlike cesspools, septic tanks have unique inlet and outlet designs, baffles, and compartmentation to facilitate and breakdown its organics, resulting in an increased level of wastewater treatment.

Wastewater flowing out of the septic tank, flows to a soil absorption system for further treatment and ultimate disposal. Figure ES.1 shows a soil absorption system (or drain field) that includes pipes with small holes laid inside a covered trench filled with gravel where septic tank effluent is slowly released to percolate through the soil profile. Both the septic tank and soil absorption system collectively make up the septic tank system for OSWT and disposal.

Current Hawaiʻi wastewater regulations issued by the Hawaiʻi State Department of Health Wastewater Branch (DOH) provide design and installation guidance for septic tank systems. Specific guidance is provided for septic tank volumes, compartmentalization, and materials (Hawaiʻi Administrative Rules [HAR] 11-62-33.1 and International Association of Plumbing and Mechanical Officials [IAPMO] American National Standards Institute [ANSI] Z1000), and for inlet/outlet/internal septic tank requirements. Current regulations also provide guidance for soil absorption systems, which are a key component of effluent treatment and disposal following the septic tank. Space requirements for soil absorption systems can be significant in comparison to the footprint of cesspools. Existing regulations provide guidance on setback requirements, soil percolation tests, slope, and minimum depth to the seasonal high groundwater table.

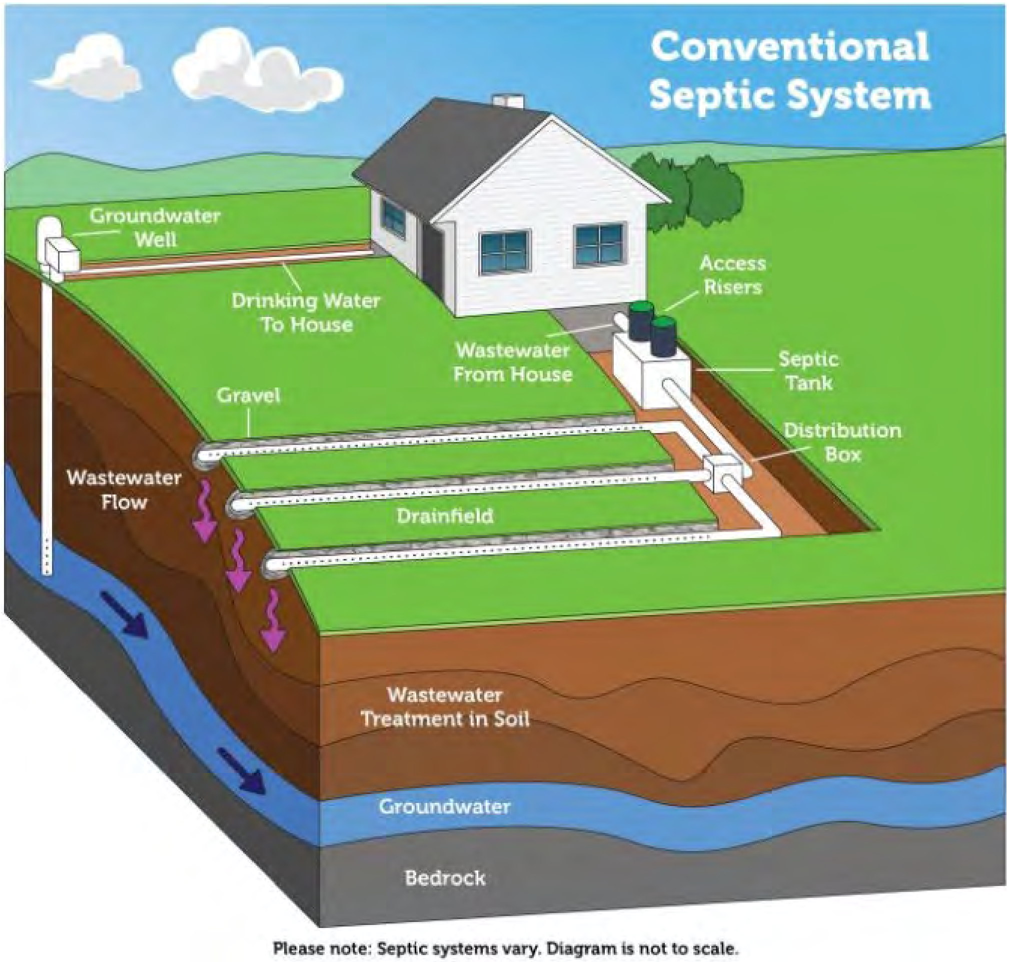


Figure ES.1 Septic Tank with Soil Absorption System or Drain Field (United States Environmental Protection Agency [EPA], 2017)

When designed and sited appropriately, and properly maintained, septic tank systems can provide water quality benefits beyond that which can be achieved by cesspools. Table ES.1 presents the relative water quality of raw residential, septic tank effluent, and following a typical soil absorption system. Cesspools are not designed to provide wastewater treatment; thus, cesspool effluent quality is expected to be similar to raw residential wastewater quality. Septic tank systems can provide improved treatment efficacy for total suspended solids (TSS) and biochemical oxygen demand (BOD), over cesspools.

Septic tank systems can be installed and maintained for relatively lower cost than many other OSWT systems. Maintenance includes periodic inspection, pumping of solids/scum, and cleaning the effluent screen. EPA guidance recommends that septic systems be inspected at least every three years by a professional. The inspector should look for leaks, check for signs of backup, inspect mechanical components (if any), inspect/clean the effluent filter/screen, and empty the tank by pumping out the septage, if necessary.

Table ES.1 Typical Water Quality Data for Raw Residential, Septic Tank Effluent, and Following Soil Absorption System

Contaminant	Typical Raw Residential Wastewater(1)	Typical Septic Tank Effluent Quality(2)	Typical Effluent Quality Following Soil Absorption System(2)
Total Nitrogen, mg N/L(4)	14-40	39-82	~1
TSS (mg/L)	100-400	49-161	~4
BOD (mg/L)	100-400	132-217	<30
Fecal Coliform, MPN/100 mL(3)	~10^6	1-10^6	~13

Notes:
(1) From Table 2-1 (Water Resources Research Center (WRRC) University of Hawaiʻi-Manoa, 2008).
(2) From Table 4-1 in the Onsite Wastewater Treatment Survey and Assessment Study (WRRC, 2008).
(3) MPN/100 mL = most probable number per 100 milliliters.

Homeowners should be cautious of what they put down their drains to avoid overwhelming their septic tank systems with trash, non-degradable materials, or chemicals that could create non-settling suspensions that could clog soil absorption systems.

Hawaiʻi's existing wastewater regulations include a sufficient amount of guidance for septic tank system application and installation (HAR 11-62-31). However, there are two design considerations that DOH may consider reviewing or evaluating in the future:

- **Depth to groundwater table.** One aspect of septic tank system guidance that is recommended for reevaluation is the requirement for the depth to the groundwater table for the soil adsorption system. The evaluation of the depth to the groundwater should be based on the amount of separation required to assure adequate treatment to protect drinking water supplies.
- **Allowable "density" of septic tank systems or numeric limits for total N.** Septic tank systems are known to provide water quality benefits over cesspools. However, septic tank systems do not provide significant treatment for total nitrogen. Upgrading cesspools to septic tank systems in areas with a high density within a small area may not provide significant protection to groundwater or near surface water quality. Limiting the number of septic tank systems allowed within a certain area may help to provide groundwater and near surface water quality protection. Another way to protect water quality is to implement a numeric limit for total N discharged from OSWT.

Figure ES.2 is an example decision tree to help homeowners determine if a septic tank system is a potential option for them to convert their cesspool. The first question asks about the cesspool location relative to coastal waters, surface waters, and potable water supplies based on current regulations. The second question asks if the property is listed in the Priority 1 or Priority 2 areas shown in the 2018 Department of Health (DOH) Act 125 Report[1]. If the first two sets of criteria are met, the minimum lot size question is posed, followed by slope of the property, and depth to the groundwater table. A minimum of 10 feet (ft) depth to the groundwater table was selected as an example. As described above, further evaluation of the requirement of depth to the groundwater table is warranted. This decision tree can be modified as needed but may be a helpful tool for homeowners to determine if upgrading their cesspool to a septic tank system is feasible.

[1] Cesspools located in the Priority 1 areas pose significant risk of human health impacts, drinking water impacts, or draining to sensitive waters. Priority 2 areas have potential impact on drinking water quality.

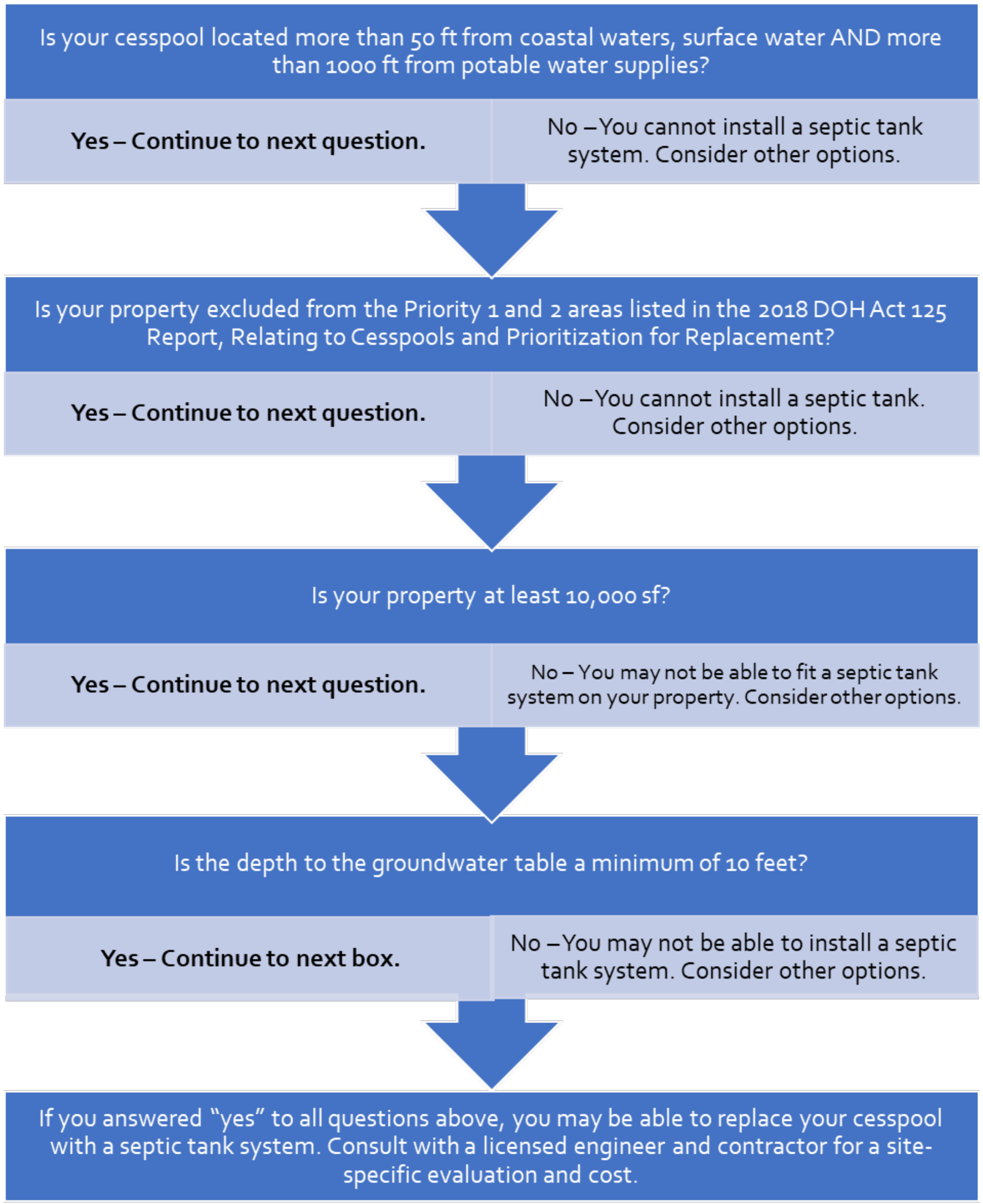


Figure ES.2 Decision Tree to Determine if a Septic Tank System is Feasible for Cesspool Conversion

2.2 Introduction

According to the EPA, cesspools are underground excavations that receive sanitary wastewater from bathrooms, kitchens, and washers. Figure 2.1 is a schematic diagram of a typical cesspool. The structure usually has an open bottom and perforated walls (unlined, except for geotextile on the outside). Domestic wastewater flows into the structure and the solid waste collects at the bottom of the cesspool and the liquid waste flows out of the perforations. Cesspools are not designed to treat wastewater but rather separate sanitary waste and allow liquid wastes to percolate into the soil strata and underlying groundwater table.

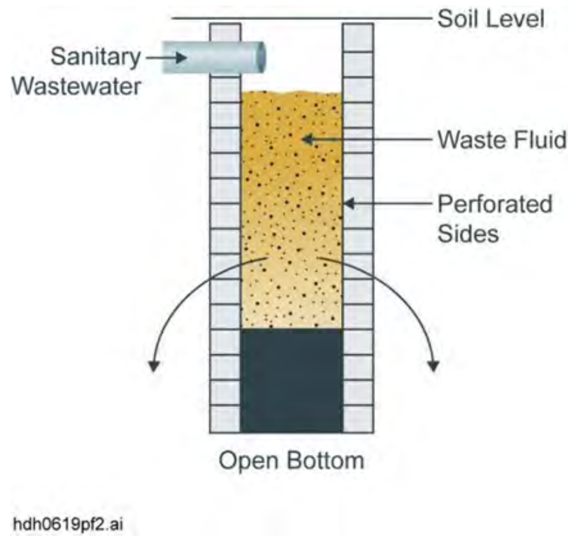


Figure 2.1 Schematic Diagram of a Typical Cesspool

Throughout Hawaiʻi there are approximately 88,000 cesspools that release an estimated 53 mgd of wastewater to the environment. Most of these existing cesspools provide wastewater disposal for single-family residences, versus large-capacity systems service multiple residences or commercial areas. Given that over 90 percent of the state's drinking water supplies are from groundwater sources, it was recognized that cesspools pose an environmental and public health risk.

In 2017, the Hawaiʻi State Legislature passed Act 125, which states that by January 1, 2050 all cesspools in the state of Hawaiʻi, unless granted exemption, shall upgrade or convert to a septic or aerobic treatment unit, or connect to a sewer system (ACT125, 2017). Act 132 was passed in 2018 to establish a Cesspool Conversion Working Group (CCWG) to develop a long range, comprehensive plan and commission a statewide study of sewage contamination in nearshore marine areas (ACT132, 2018). The CCWG retained Carollo Engineers, Inc., (Carollo) to provide expertise on OSWT technologies and cesspool conversion funding and finance options.

Given appropriate site conditions, an engineered system consisting of a septic tank followed by a soil absorption system, collectively referred to as a "septic tank system" may be an appropriate technology to replace existing cesspools. The purpose of this TM is to:

- Provide an overview and identify advantages and disadvantages of septic tank systems.
- Summarize design considerations and best practices for ideal septic tank system performance.
- Summarize maintenance needs for septic tank systems.
- Summarize overall performance of septic tank systems relative to cesspools.

This TM is not intended to be a comprehensive guide for cesspool conversion to septic tanks, and those interested in such a conversion should seek the advice of a registered professional engineer and/or licensed general contractor.

2.3 Overview of Septic Tank Systems

Septic tank systems are a common means of wastewater treatment and disposal for small populations, such as individual residences, small institutions, schools, etc., where a centralized sewer system may not be available, or a connection may not be feasible.

Figure 2.2 shows a cross section of a typical septic tank installation. Domestic wastewater flows from the household sewer pipes into the tank and undergoes settling and anaerobic processes to reduce solids and organics. Septic tanks are designed to hold water under anaerobic conditions for a minimum detention time of 6 to 24 hours during which the removal of settleable solids takes place (EPA, 2002). These solids collect and decompose at the bottom of the tank. Gas entrained with the solids rises through the wastewater to the surface and forms a layer of scum, until the gas escapes at which point the solids settle again. The flow through current from inlet to outlet can carry some of the solids towards the outlet causing them to be discharged with the effluent into the disposal system or soil absorption system[2] (Muralikrishna and Manickam, 2017). An effluent screen or filter can be added to the septic tank outlet to prevent excess solids from flowing out of the septic tank and potentially clogging the soil absorption system piping.

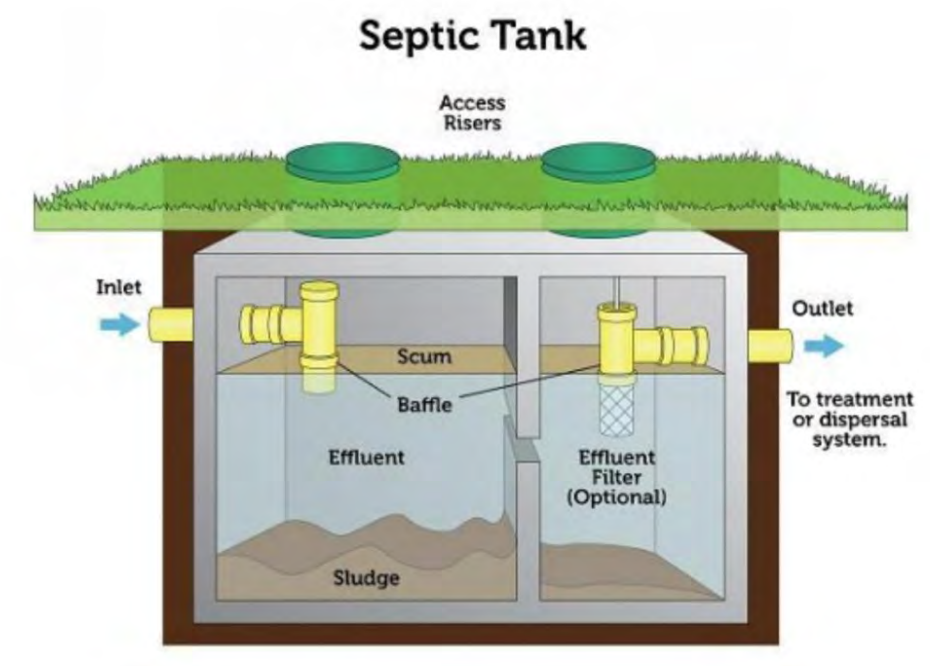


Figure 2.2 Septic Tank with Two Chambers (EPA, 2017)

After leaving the septic tank, wastewater flows to a soil absorption system for further treatment and ultimate disposal. Figure 2.3 shows a soil absorption system (or drain field) that includes pipes with small holes laid inside a covered trench filled with gravel where septic tank effluent is slowly released to percolate through the soil profile. The wastewater treatment efficacy of septic tank systems is dependent on the leaching ability (permeability) of the soil and it requires annual inspection and periodic removal of sludge and scum from the septic tank (Muralikrishna and Manickam, 2017).

Alternative soil absorption system media, such as sand, peat and sawdust, can help to improve removal of nutrients and other contaminants. These options for alternative soil absorption system media will be reviewed and discussed in TM 3 related to this project. This TM will focus on a conventional septic tank and soil absorption system as depicted in Figure 2.3.

[2] In this context, "disposal system" means a soil absorption system (also leach field, drain field, or dispersal system), seepage pit, or disposal trench (HAR 62-01).

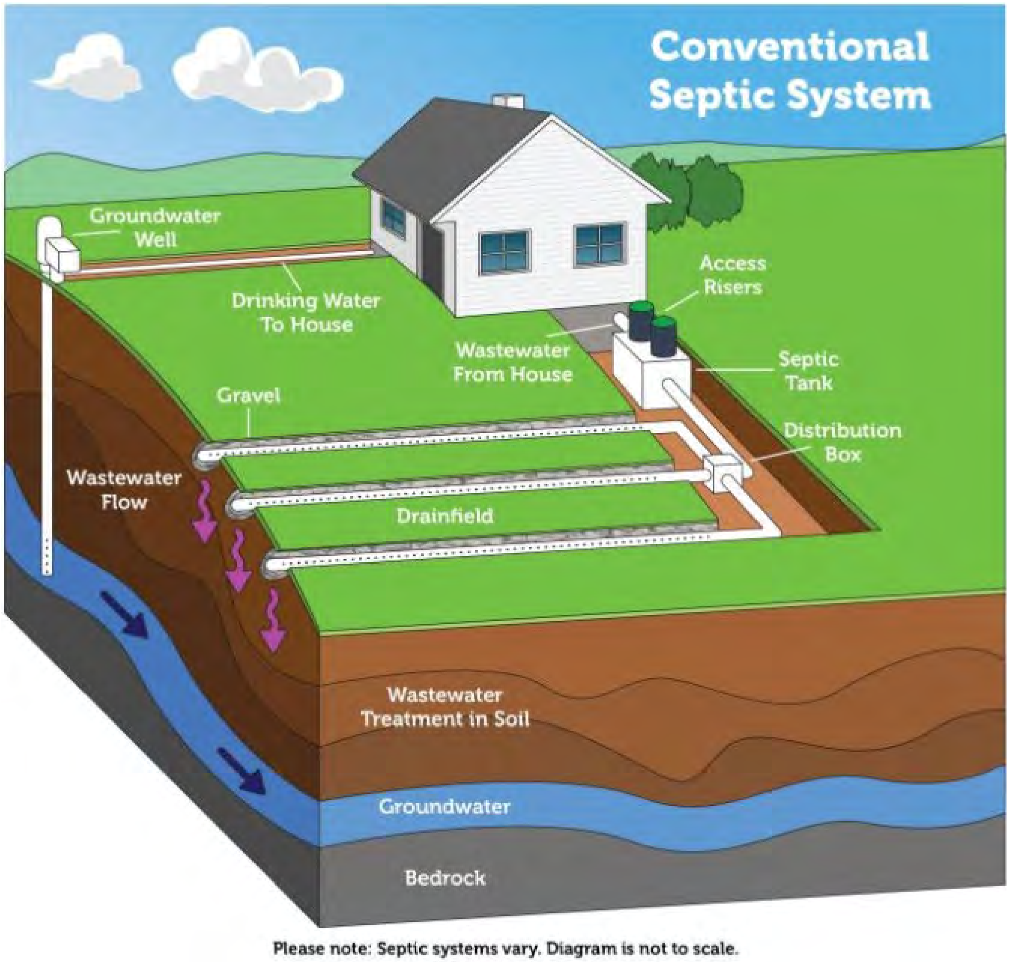


Figure 2.3 Septic Tank with Soil Absorption System or Drain Field (EPA, 2017)

2.3.1 History of Septic Tank Systems

Septic tanks were invented by Jean-Louis Mouras around 1860 in France. Mouras had been trying to design a method of waste disposal without going outside to use the restroom (such as an outhouse). He ran clay pipes from his house to a concrete tank in his backyard and used it successfully for ten years. When he decided to open the tank, both he and his neighbors were surprised to discover that it mostly contained liquid with a layer of scum on top. Subsequently, the system was introduced into the United States in 1883 (Amador and Loomis, 2020).

Following Mouras's design, early American septic tanks were made of concrete or steel and emptied into a soil absorption system. By the 1940s, septic tank systems were relatively inexpensive to build and were popular nationwide in areas that did not have centralized wastewater systems[3] (Amador and Loomis, 2020).

In the 1960s, older septic systems began failing due to cracks and rust found in septic tanks. There were also concerns that the sewage from the soil absorption system was seeping into the groundwater causing local governments to start regulating the placement of absorption systems. The design of the septic tank chambers and soil absorption systems for modern septic tank systems have improved, but septic tanks still

[3] Centralized wastewater systems include sewer collection pipes, wastewater pump stations, and wastewater treatment plants.

need to be regulated and only implemented in areas that fulfill ideal conditions that do not pose risks to contaminating groundwater or surface water (Amador and Loomis, 2020).

Some communities have converted areas of clustered septic tank systems to centralized wastewater collection and treatment to protect water resources and accommodate growth and development. However, septic tank systems are still common throughout the U.S. and provide environmental, public health, and economic benefits to certain communities. More than 60 million people across the United States are currently served by septic tank systems. Septic tank systems are common in New Hampshire, Maine, North Carolina, South Carolina, and Kentucky (EPA, 2017).

2.3.2 Advantages and Disadvantages of Septic Tank Systems

Septic tanks are a simple, passive OSWT system that can reliably manage and dispose of domestic wastewater at a low cost to homeowners with proper siting and maintenance. As with any technology, there are both advantages and disadvantages. Septic tank systems and other OSWT systems can provide upgraded wastewater treatment in comparison to existing cesspools and without implementing costly, centralized or decentralized wastewater infrastructure projects.

The biggest advantages of septic tank systems as an option for occurrence of cesspool upgrades in Hawaiʻi are their simplicity, reliability, and relative low cost. Once they are installed there is no power required and only periodic monitoring and maintenance are necessary. Another big benefit is that a properly designed, well-maintained system can last for decades.

A disadvantage is that there are several site-specific factors that must be considered, including natural soil type and permeability bedrock, groundwater, and site topography for septic tank systems to work effectively. Septic tank systems also have space requirements that can be significant and may not be appropriate for small lots. Most states have adopted regulations pertaining to setbacks from water supply and lot lines, as well as appropriate distance from groundwater, surface water, and coastal areas. During project planning, the characteristics of the influent wastewater should also be considered.

Improperly functioning systems can introduce nitrogen, phosphorus, organic matter, and bacterial and viral pathogens into surrounding areas, groundwater, and/or coastal water. Accumulated sludge and scum must be removed on a regular basis of every three years to prevent carryover of these materials into downstream processes, especially soil absorption systems which can become clogged and generally cannot be cleaned/serviced. Septic tank systems may not be an option for all cesspool conversions in Hawaiʻi.

Homeowners should be cautious of what they put down their drains to avoid overwhelming their septic tank systems with trash, non-degradable materials, or chemicals that could create non-settling suspensions that could clog soil absorption systems. If installed and maintained appropriately, septic tank systems may be a good option for some homeowners in Hawaiʻi that need to convert their existing cesspools.

2.4 Design Considerations and Best Practices for Ideal Septic Tank System Performance

Since its invention, septic tank systems have improved as an OSWT technology. When properly planned/sited, designed, constructed, and maintained, septic tanks can provide sufficient treatment of domestic wastewater prior to release to the subsurface environment. Septic tank systems are prevalent across the United States mainland, and the world. Some systems also exist in Hawaiʻi and are monitored and regulated by DOH. The following section discusses design, siting, performance, and maintenance considerations for septic tank systems.

2.4.1 Design and Siting Considerations

Design considerations for septic tank systems include septic tank volume, geometry, material, compartmentalization, and inlet/outlet design. Siting considerations include depth to groundwater table or location relative to surface waters, lot size, soil characteristics, and slope. The following sections discuss design and siting considerations for septic tank systems as they apply to Hawaiʻi for cesspool conversions.

2.4.1.1 Tank Volume

Selection of the septic tank volume is typically based on the number of bedrooms or number of residents in the home. Typically, 250 gallons of septic tank capacity must be added for each bedroom. If the house has a garbage grinder or a hundred gallon or greater tub will require an extra 250 gallons of septic tank capacity. Given that there are many multi-generational and extended family households in Hawaiʻi, a per capita wastewater generation rate could also be considered for household designs. Based on water use demand estimates noted in the Honolulu Board of Water Supply's (BWS) Water Master Plan, water conservation has decreased per capita water demands over the last three decades. The estimated per capita water demands for 2020 is 150 gallons per capita per day (gpcd) (BWS, 2016). Assuming a minimum hydraulic retention time[4] of 24 hours, the required septic tank volume can be calculated based on number of residents. Many states have established 1,000 gallons as the minimum volume for a septic tank (EPA, 2002).

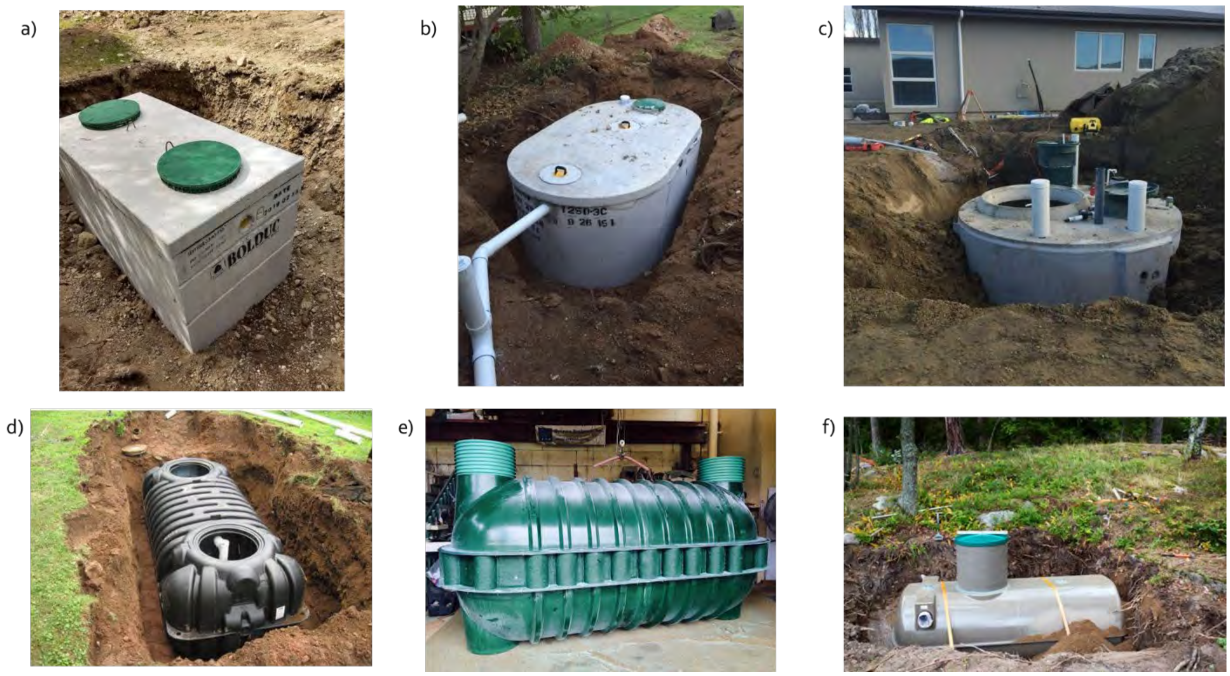
Current OSWT system regulations state that the total wastewater flow per individual system shall not exceed 1,000 gallons per day with a maximum bedroom count of five (HAR 11-62-31.1). The minimum septic tank size is 1,000 gallons for four or less bedrooms and 1,250 gallons for five bedrooms (HAR 11-62-33.1).

2.4.1.2 Tank Geometry, Compartmentalization, and Material

The shape of the septic tank or its geometry impacts the treatment efficacy of the system. The septic tank geometry is important since the treatment mechanism is a physical process where solids settle out of wastewater and primarily liquid waste exits the tank. If the tank geometry does not allow for proper settling of solids, the waste could flow out of the septic tank and potentially clog the soil absorption system and/or contaminate the soils.

Septic tanks can have rectangular, oval, or cylindrical shapes, and be made of concrete, plastic (polyethylene), fiberglass reinforced polyethylene (FRP), or steel. Figure 2.4 shows septic tanks of different shapes and materials. Elongated tanks with a length-to-width ratio of 3:1 or more have been shown to have improved solids removal. However, with improved solids removal, more frequent pumping and maintenance of the septic tank is required (septic tank system maintenance is discussed further in Section 2.3.3). Cylindrical or vertical tanks tend to be less effective in solids removal but have the benefit of a smaller, more compact footprint. A common, specified minimum liquid depth below the outlet invert is 36 inches as shallower depths can result in solids washing out of the septic tank to the soil absorption system and require more frequent pumping maintenance (EPA, 2002).

[4] Hydraulic retention time is the average time that domestic wastewater is stored in the septic tank prior to flowing out of the septic tank and into the leach field.



Notes:

(a) Rectangular, Concrete Tank
(b) Oval, Concrete Tank
(c) Cylindrical, Concrete Tank
(d) Rectangular, Plastic Tank
(e) Fiberglass, Oval Tank
(f) Steel, Horizontal, Cylindrical Tank

Figure 2.4 Examples of Different Septic Tank Shapes and Materials

Septic tanks are required to have at least two compartments (see Figure 2.2). The access risers act as necessary air vents for each compartment to allow for gases generated by biological activity within the compartments to escape.

Septic tank materials can vary and considerations to the homeowners include cost (material, installation, shipping), and structural strength and durability. Table 2.1 is a summary of the advantages and disadvantages of the different septic tank materials. Coated steel tanks are not typically installed since they can corrode easily; thus, steel tanks were excluded from the comparison table.

Septic tanks less than 6,000 gallons are typically prefabricated; however, concrete tanks can be pre-casted or cast-in-place. Concrete tanks are the most durable in comparison to plastic and FRP tanks and are less likely to fail due to structural collapse and/or floatation during flooding. Concrete tanks can be cast-in-place for a custom-shaped tank. However, concrete tanks are typically more expensive than plastic or FRP tanks due to greater shipping and installation costs. Concrete tanks typically require a crane for installation, so contractors will need to be able to get a crane on site. Also, concrete can be subject to corrosion over time with exposure to sewage gases. A coating can be applied to the interior of the tank to help prevent or slow corrosion.

Table 2.1 Comparison of Septic Tank Materials

Septic Tank Material	Advantages	Disadvantages
Concrete	• Durable • Less susceptible to collapse and floatation • May be cast-in-place for custom shape	• Precast tanks can be more expensive than plastic or FRP due to shipping and installation costs • Typically requires use of a crane for installation • Concrete may corrode over time due to acidic sewer gases
Plastic (polyethylene)	• Less expensive than precast concrete tanks (lower shipping and installation costs) • Variety of manufacturers and sizes for desired footprint • Plastics are typically resistant to corrosion • May not require a crane for installation	• Plastic tanks may deform depending upon quality of the plastic and potential structural weaknesses of the material • If not installed properly, plastic tanks can float if flooded
Fiberglass-reinforced polyester (FRP)	• Less expensive than precast concrete tanks (lower shipping and installation costs) • Variety of manufacturers and sizes for desired footprint • Fiberglass is typically resistant to corrosion • May not require a crane for installation • More rigid and sturdy than plastic tanks	• Less structurally strong than concrete tanks • If not installed properly, fiberglass tanks can float if flooded

Plastic tanks are typically made of polyethylene and typically less expensive than concrete tanks due to lower material and shipping costs. There are many different plastic septic tank manufacturers that provide a wide variety of tank sizes and shapes. Plastic tanks may not require the use of a crane since they are lighter in weight than precast concrete tanks. Plastics are also more resistant to corrosion than concrete. The disadvantage of plastic tanks is that they can deform due to structural weaknesses in the material and if they are not installed properly. Plastic tanks can float or shift due to flooding or wet soil conditions.

Similar to plastic, FRP tanks are typically less expensive than concrete tanks due to lower shipping and installation costs. There are many manufacturers that can provide a wide variety of FRP tank volumes and shapes. FRP is resistant to corrosion and may not require a crane for installation. FRP tanks are typically more rigid and sturdy than plastic tanks, but not as structurally strong as concrete tanks. Another disadvantage of FRP tanks is that they can shift under flooding or wet soil conditions.

Current OSWT regulations require that septic tanks meet IAPMO material and property standards for prefabricated septic tanks (IAPMO ANSI Z1000-2013) and shall be approved and listed by IAPMO (HAR 11-62-33.1).

2.4.1.3 Inlet/Outlet/Internal Design

Inlet and outlet baffles can be added to septic tanks to improve hydraulic performance and enhance solids entrapment. A minimum of 2 to 3 inches of drop across the tank from inlet to outlet is recommended to avoid backing up the sewer to the home should the outlet become obstructed. Also, a minimum of 9 inches of headspace is recommended to provide room for scum/floatable waste storage and ventilation. It is recommended that septic tank effluent screens[5] be installed on the tank outlet to prevent larger solids from passing through the tank. Mesh or slotted screens of 1/32 to 1/8 inch are typically used. An access port directly above the outlet is required to remove, inspect, and clean the effluent screens (EPA, 2002).

2.4.1.4 Soil Absorption System Considerations

Determining the soil absorption system size entails striking a balance amongst allowing the septic tank effluent to percolate through the soil without creating subsurface flooding of the soils or ponding and allowing for adequate travel time for the effluent to reach the groundwater table. As the septic tank effluent percolates through the soil, additional treatment of pollutants occurs in the soil column via physical and biological processes.

The required size of the soil absorption system depends upon the design flow rate of the septic tank system, and the percolation or infiltration rates of the soil. The soil percolation rate is a measure of how long it takes for water to drain through soil. Current regulations for OSWT systems require a percolation test at a minimum depth of 3 ft (HAR 11-62-31.2). Typically, clay soils have low percolation rates as it can take a long time for water to drain (60 minutes per inch) (min/in.); whereas sandy, well-drained soil have high percolation rates (5 min/in.). Soil absorption system sizing guidance provided in current wastewater regulations are shown in Appendix A.

EPA provided guidance on soil absorption system sizing with recommended maximum hydraulic and organic loading rates. Appendix B shows maximum loading rates recommended for varying soil conditions for septic tank systems (EPA, 2002).

Once the required area for the soil absorption system is determined, the footprint needs to be accounted for along with the septic tank installation footprint. Note that it is not recommended that structures (homes, sheds, garages, etc.) are constructed over the soil absorption system area as the soil/structural integrity is compromised when saturated with septic tank effluent. However, it is common for soil absorption systems to be constructed with adequate protection under driveways.

2.4.1.5 Siting Considerations

There are several site conditions to consider before installing a septic tank system for cesspool conversions. The site conditions account for the requirements of the complete septic tank system, including the septic tank and the soil absorption system. Some of the key site considerations include lot size, depth to the groundwater table, soil type, distance to the nearest water body, and slope of the property. Table 2.2 summarizes the ideal, acceptable, and unfavorable site conditions for septic tank system installation. Each site condition is discussed in the following sections.

[5] Effluent screens may also be referred to as effluent filters.

Table 2.2 Conditions for Septic Tank and Soil Absorption System Installation

Site Condition or Design Parameter	Ideal condition	Acceptable	Unfavorable conditions
Lot size	Large lot size(> 10,000 square foot, [sf])	10,000 sf (minimum)	Inadequate space for soil absorption system (Less than 10,000 sf)
Depth to Groundwater Table	Deep water table level	Absorption trench must be a minimum of 3 ft from the seasonal high groundwater table (HAR 11-62-34(a)(1)).	Shallow groundwater table (within 3 ft of the seasonal high groundwater table)
Soil Type	Medium soil percolation rate Sand or Silt	Slow soil percolation rate feasible Silty clay	Low or high percolate rate Gravel or clay
Distance from water	>> 50 ft from coastal waters and/or drinking water supplied		In flood zone or < 50 ft from coastal waters or drinking water supplies
Slope	Sloped down between 1/8 in. per foot and 1/4 in. per foot	No slope is feasible Sloped down greater than 3 in. per foot feasible Maximum slope of 8 percent	Sloping upward

Lot size can prove to be a limiting factor in the feasibility of installing a septic tank system. The space requirements of the septic tank and soil absorption system may prove to be several thousands of square feet. Many states have different standards regarding the minimum acceptable lot size. The current minimum lot size for OSWT systems in Hawai'i is 10,000 sf (HAR 11-62-31). Lots that do not have sufficient area for septic tank systems may need to utilize alternative OSWT technologies. Current regulations have minimum horizontal spacing requirements for OSWT systems, including septic tanks and soil absorption systems or soil absorption systems. Appendix C includes a summary of current spacing requirements (HAR 11-62, Appendix D, Table II).

Water table depth plays a key role for septic tanks with soil absorption systems. If the water table is too shallow, the septic tank effluent will not have enough seepage time to strip nutrients and bacteria before it enters the groundwater. This can lead to pollution in rivers, streams, and near-shore waters and potentially harm drinking water sources downstream. Also, if the groundwater table is too shallow, it is possible that during heavy usage or storms, the groundwater table may rise and flood the septic tank site. Figure 2.5 shows how major flooding in Hanalei, Kaua'i caused an installed septic tank to rise out of the ground. Besides dislodging installed septic tanks, rising groundwater levels or surface flooding could lead to significant pollution to the groundwater and surface water as the raw wastewater is released. Another consideration is that groundwater levels are anticipated to rise both along the coastlines and inland areas of Hawai'i with rising sea levels due to climate change (Rotzoll and Fletcher, 2012).

Current regulations state that the seasonal high groundwater level must be no less than 3 ft from the bottom of the soil adsorption system. With a minimum adsorption trench depth of 18 inches, the minimum depth to seasonal high groundwater level is 4.5 ft for septic tank systems (HAR 11-62-34).

To protect surface waters and potable water supplies, current OSWT system regulations require minimum horizontal separations. The minimum horizontal distance between soil absorption systems and coastal waters, streams, ponds, lakes or other surface waters is 50 ft. The minimum horizontal distance from potable drinking water supplies, such as groundwater wells or surface water sources is 1,000 ft (HAR 11-62, Appendix D, Table II).

Figure 2.5 Significant Rainfall in April 2018 Caused a Septic Tank to Float in Hanalei, Kauaʻi[6]

Another consideration in siting septic tank systems is the slope of the site. Ideally, the septic tank system is sited and designed such that the wastewater flows by gravity from the house, to the septic tank, to the soil absorption system at the appropriate, evenly distributed rates. If the slope of the site is too steep, it may be difficult to design the septic tank system and wastewater may flow too quickly through the soil absorption system pipes and back up at the end of the pipes, even if installation is feasible.

Current regulations state that soil absorption systems cannot be installed on land with a slope gradient greater than 8 percent. The maximum length of the trench distribution line is 100 ft, with a minimum number of two trenches. The minimum trench width is 18 inches, and the maximum trench width is 36 inches. The bottom of the trench must be a minimum of 18 inches below the finished grade (HAR 11-62-34).

2.4.2 Septic Tank System Performance

When designed and sited appropriately, and properly maintained, septic tank systems can provide water quality benefits beyond that which can be achieved by cesspools. Table 2.3 presents the typical characteristics of raw domestic wastewater, septic tank effluent, and following soil absorption systems. Available cesspool effluent water quality data is extremely limited. However, it is widely accepted that cesspools are not designed to provide wastewater treatment; cesspool effluent quality can be expected to be similar to that of raw domestic wastewater quality.

[6] Photo by Dolan Eversole. Featured in Ka Pili Kai, Kaʻū 2019, www.hawaiiseagrant.org

Properly designed septic tanks effectively provide similar treatment as primary treatment in conventional wastewater treatment plants. Studies have shown that septic tanks are able to remove TSS and some BOD (Metcalf and Eddy, 1991). The amount of nitrogen removal is only 10-20 percent through septic tanks. Soil absorption systems provide further reductions in TSS, BOD, fecal coliform, and some total nitrogen removal (up to 40 percent). In comparison, cesspools provide some TSS and BOD removal, and no nitrogen removal.

Common requirements for OSWT systems located in areas where surface water or groundwater could be contaminated are for a minimum of 50% nitrogen removal. Some states set numeric limitations of 19 or 20 mg/L of total N. These types of removals cannot be achieved with conventional septic tank systems. Other treatment options exist for such locations. TM 3 will discuss other OSWT technologies that can provide improved total N removal.

Table 2.3 Typical Water Quality Data for Raw Residential, Septic Tank Effluent, and Following Soil Absorption System

Contaminant	Typical Raw Residential Wastewater(1)	Typical Septic Tank Effluent Quality(2)	Typical Effluent Quality Following Soil Absorption System(2)
Total Nitrogen, mg N/L(4)	14-40	39-82	~1
TSS (mg/L)	100-400	49-161	~4
BOD (mg/L)	100-400	132-217	<30
Fecal Coliform, MPN/100 mL(3)	~10^6	1-10^6	~13

Notes:
(1) From Table 2-1 (Water Resources Research Center (WRRC) University of Hawai'i-Manoa, 2008).
(2) From Table 4-1 in the Onsite Wastewater Treatment Survey and Assessment Study (WRRC, 2008).
(3) MPN/100 mL = most probable number per 100 milliliters.

2.4.3 Maintenance

Septic tank systems do not require significant maintenance since it is a passive system. Maintenance activities include regular inspections, septage pumping, and periodic cleaning of the effluent filter/screen. These maintenance activities are discussed further in the following section.

EPA guidance recommends that septic systems be inspected at least every 3 years by a professional. The inspector should look for leaks, check for signs of backup, inspect mechanical components, inspect/clean the effluent filter/screen, and empty the tank by pumping out the septage, if necessary.

The inspector should also observe the level of the scum (upper) and sludge (lower) layers within the tank. If the scum later is within 6 inches of the outlet, or if the sludge layer is within 12 inches of the outlet tee, the septic tank should be pumped. Maintaining a log of the scum and sludge layers will help the homeowner to determine how frequent septage pumping may be required. EPA guidance recommends that septic tanks are pumped every three years (EPA, 2005).

Homeowners can also take the following steps to maintain their soil absorption system (EPA, 2005):

- **Plant grasses.** Only grasses should be planted near the septic tank and soil absorption system as roots from larger shrubs or trees could damage the drain field.
- **Do not drive on the soil absorption system unless it is designed for that action.** Avoid driving vehicles over the soil absorption system as the additional load will compact the soil and potentially damage the septic tank or underlying pipes.

- **Manage stormwater.** Keep roof drains and other stormwater drains away from the drain field to avoid flooding and potentially backing up the septic tank system.
- **Avoid toxic and clogging chemicals.** Avoid the use of toxic chemicals/cleaners and disposing of excess paint or cleaning of painting brushes. Latex paints, in particular, can cause clogs within the septic tank system.
- **Reduce food waste and solids.** Reduce use of garbage disposals and food waste disposed in kitchen sinks, which contribute to sludge production and more frequent septage pumping. Minimize washing solids and grit (such as sand) down the drain.

2.5 Relative Cost of Installing and Maintaining Septic Tank Systems

Septic tank systems can be installed and maintained for relatively lower cost than other OSWT systems. Septic tanks generally have no power costs. Maintenance costs include periodic inspection, pumping of solids/scum, and cleaning the effluent filter. Maintenance is generally needed every 2-3 years. For a well-maintained septic tank the replacement interval can be as long as 60 years.

Septic tank installation costs depend on the type of tank material. Plastic and FRP tanks are typically less expensive than concrete tanks. Other installation cost considerations include the cost for cleaning out, filling and closing the old cesspool and preparing the land for the new septic tank and soil absorption system as well as restoring the landscape after installation is complete.

Installation costs of septic tank systems can vary based upon site specific, non-standard conditions, such as poor soils, unknown underground utilities, undocumented structures, large tree removal, placement in traffic bearing areas, and contractor availability (Babcock et al. 2019). Compared to other, more mechanical OSWT systems, septic tank systems are relatively cheaper to install and operate. Actual costs can only be determined following engineering analysis of the specific property and receipt of bids from a licensed contractor.

2.6 Recommendations for Further Evaluation of Septic Tank Systems for Converting Cesspools in Hawaiʻi

Septic tanks are a viable solution to convert cesspools due to their low cost and ease of maintenance. However, there are many factors that must be considered before deciding to use septic tanks. The conditions in Table 2.2 outline the ideal, acceptable, and unfavorable conditions for septic tank system installation.

Hawaiʻi's existing wastewater regulations include a sufficient amount of guidance for septic tank system application and installation (HAR 11-62-31). As discussed previously, existing regulations provide guidance on design requirements for the septic tank volume, compartmentalization, inlet and outlet design, as well as the soil absorption system design. However, there are two design considerations that DOH may consider reviewing or evaluating in the future:

- **Depth to groundwater table.** One aspect of septic tank system guidance that is recommended for reevaluation is the requirement for the depth to the groundwater table for the soil adsorption system. The evaluation of the depth to the groundwater should be based on the amount of separation required to assure adequate treatment to protect drinking water supplies.

- **Allowable "density" of septic tank systems or numeric limits for total N.** Septic tank systems are known to provide water quality benefits over cesspools. However, septic tank systems do not provide significant treatment for total nitrogen. Upgrading cesspools to septic tank systems in areas with a high density within a small area may not provide significant protection to groundwater or near surface water quality. Limiting the number of septic tank systems allowed within a certain area may help to provide groundwater and near surface water quality protection. Another way to protect water quality is to implement a numeric limit for total N discharged from OSWT.

Figure 2.6 is an example decision tree to help homeowners determine if a septic tank system is a potential option for them to convert their cesspool. The first question asks about the cesspool location relative to coastal waters, surface waters, and potable water supplies based on current regulations. The second question asks if the property is listed in the Priority 1 or Priority 2 areas shown in the 2018 DOH Act 125 Report[7].

If the first two sets of criteria are met, the minimum lot size question is posed, followed by slope of the property, and depth to the groundwater table. A minimum of 10 ft depth to the groundwater table was selected as an example. As described above, further evaluation of the requirement of depth to the groundwater table is warranted. This decision tree can be modified as needed but may be a helpful tool for homeowners to determine if upgrading their cesspool to a septic tank system is feasible.

[7] Cesspools located in the Priority 1 areas pose significant risk of human health impacts, drinking water impacts, or draining to sensitive waters. Priority 2 areas have potential impact on drinking water quality.

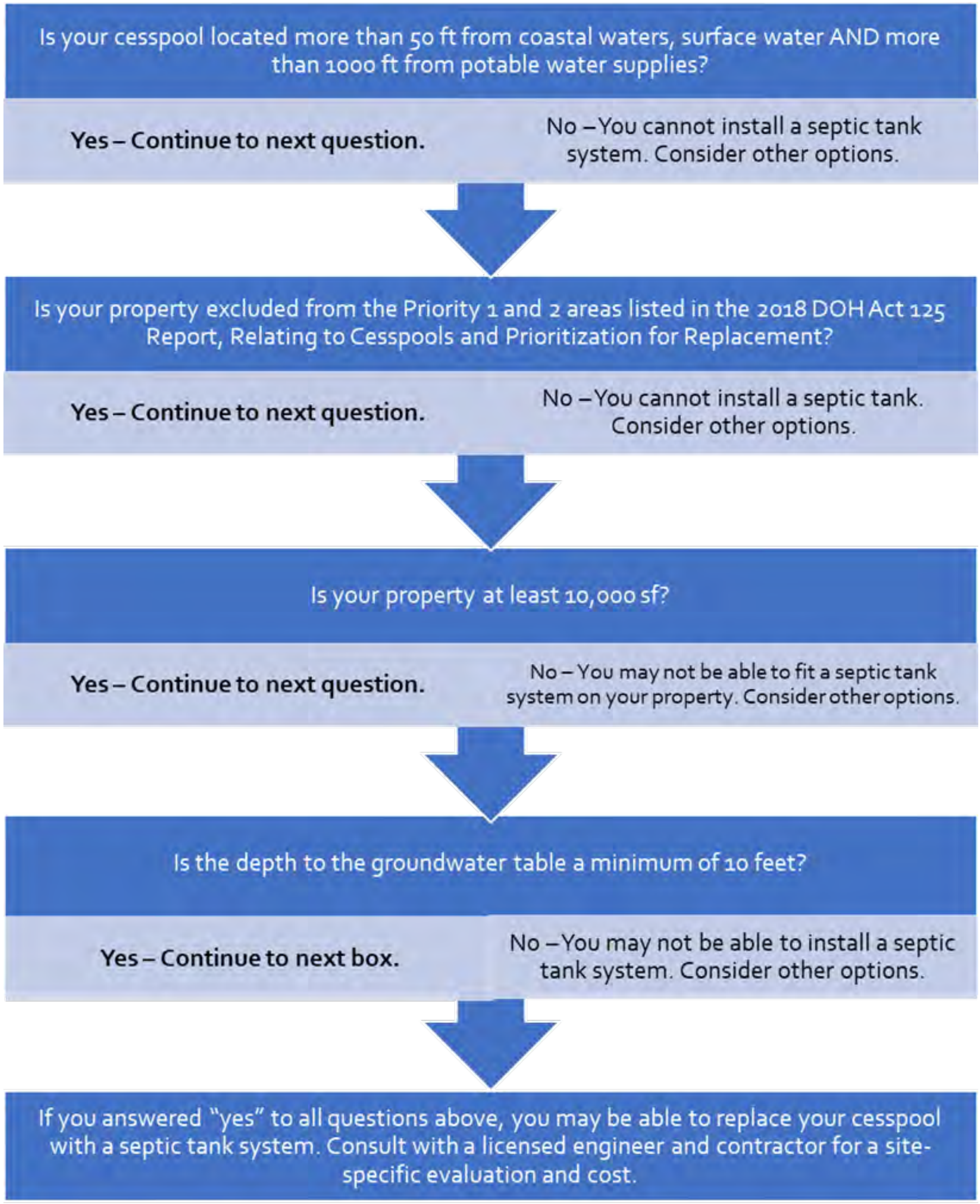


Figure 2.6 Decision Tree to Determine if a Septic Tank System is Feasible for Cesspool Conversion

2.7 References

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Appendix A

SOIL ABSORPTION SYSTEM SIZING GUIDANCE BY VARYING PERCOLATION RATE

Table A.1 Soil absorption System Sizing Guidance by Varying Percolation Rate (HAR 11-62, Appendix D, Table III)

Percolation rate (min/in.) less than or equal to	Required absorption area (sf/bedroom or 200 gallons)	Percolation rate (min/in.) less than or equal to	Required absorption area (sf/bedroom or 200 gallons)
1	70	31	253
2	85	32	257
3	100	33	260
4	115	34	263
5	125	35	267
6	133	36	270
7	141	37	273
8	149	38	277
9	157	39	280
10	165	40	283
11	170	41	287
12	175	42	290
13	180	43	293
14	185	44	297
15	190	45	300
16	194	46	302
17	198	47	304
18	202	48	306
19	206	49	308
20	210	50	310
21	214	51	312
22	218	52	314
23	222	53	316
24	226	54	318
25	230	55	320
26	243	56	322
27	238	57	324
28	242	58	326
29	246	59	328
30	250	60	330

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Appendix B

SUGGESTED HYDRAULIC AND ORGANIC LOADING RATES FOR SIZING INFILTRATION SURFACES

Table B.1 Suggested Hydraulic and Organic Loading Rates for Sizing Infiltration Surfaces (from EPA, 2002)

Texture	Structure		Hydraulic loading (gal/ft²-day)		Organic loading (lb BOD/1000ft²-day)	
	Shape	Grade	BOD=150	BOD=30	BOD=150	BOD=30
Coarse sand, sand, loamy coarse sand, loamy sand	Single grain	Structureless	0.8	1.6	1.00	0.40
Fine sand, very fine sand, loamy fine sand, loamy very fine sand	Single grain	Structureless	0.4	1.0	0.50	0.25
Coarse sandy loam, sandy loam	Massive	Structureless	0.2	0.6	0.25	0.15
	Platy	Weak	0.2	0.5	0.25	0.13
		Moderate, strong				
	Prismatic, blocky, granular	Weak	0.4	0.7	0.50	0.18
		Moderate, strong	0.6	1.0	0.75	0.25
Fine sandy loam, very fine sandy loam	Massive	Structureless	0.2	0.5	0.25	0.13
	Platy	Weak, mod., strong				
	Prismatic, blocky, granular	Weak	0.2	0.6	0.25	0.15
		Moderate, strong	0.4	0.8	0.50	0.20
Loam	Massive	Structureless	0.2	0.5	0.25	0.13
	Platy	Weak, mod., strong				
	Prismatic, blocky, granular	Weak	0.4	0.6	0.50	0.15
		Moderate, strong	0.6	0.8	0.75	0.20
Silt loam	Massive	Structureless		0.2	0.00	0.05
	Platy	Weak, mod., strong				
	Prismatic, blocky, granular	Weak	0.4	0.6	0.50	0.15
		Moderate, strong	0.6	0.8	0.75	0.20
Sandy clay loam, clay loam, silty clay loam	Massive	Structureless				
	Platy	Weak, mod., strong				
	Prismatic, blocky, granular	Weak	0.2	0.3	0.25	0.08
		Moderate, strong	0.4	0.6	0.50	0.15
Sandy clay, clay, silty clay	Massive	Structureless				
	Platy	Weak, mod., strong				
	Prismatic, blocky, granular	Weak				
		Moderate, strong	0.2	0.3	0.25	0.08

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Appendix C

SPACING REQUIREMENTS FOR OSWT SYSTEMS

Table C.1 Spacing Requirements for OSWT Systems (HAR 11-62, Appendix D, Table II, July 1, 2014)

Minimum Horizontal Distance From	Cesspool (ft)	Treatment Unit (ft)	Seepage Pit (ft)	Soil Adsorption System (ft)
Wall line of any structure or building	5	5	5	5
Property Line	9	5	9	5
Stream, the ocean at the shoreline certification, pond, lake, or other surface water body	50	50	50	50
Large trees	10	5	10	10
Treatment unit	5	5	5	5
Seepage pit	18	5	12	5
Cesspool	18	5	18	5
Soil absorption system	5	5	5	5
Potable water sources serving public water systems	1,000	500	1,000	1,000

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Hawai'i State Department of Health
Cesspool Conversion Technology Research

Technical Memorandum 3
ONSITE TREATMENT TECHNOLOGIES EVALUATION

FINAL | June 2020

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UNIVERSITY OF HAWAI'I AT MĀNOA

Hawai'i State Department of Health
Cesspool Conversion Technology Research

Technical Memorandum 3
ONSITE TREATMENT TECHNOLOGIES EVALUATION

FINAL | June 2020

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SIGNATURE 04/30/2022 EXPIRATION DATE OF THE LICENSE

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Abbreviations

ALTT	alternative zero-discharge toilets
ATU	aerobic treatment unit – with nitrification
ATU-DN	ATU with denitrification for N removal
BOD_5	5-day biochemical oxygen demand
BR	bedroom
BW	black water sewage
Carollo	Carollo Engineers, Inc.,
$CBOD_5$	5-day carbonaceous biochemical oxygen demand
CCWG	Cesspool Conversion Working Group
CFU	colony forming unit (on petri dishes)
DIS	disinfection system
DOH	Hawai'i State Department of Health
DRIP	drip irrigation/dispersal system
ELM	Eliminate nitrogen removal system
Engineer	Licensed Civil Engineer in the state of Hawai'i
EPA	US Environmental Protection Agency
ET	evapotranspiration
ETI	evapotranspiration-infiltration
FC	fecal coliform bacteria
FOG	fats, oil, and grease
gpd	gallons per day
GRAY	graywater recycling system
GW	graywater
HAR	Hawai'i Administrative Rules
ITUFL	Innovative treatment units for N removal developed in FL
LCA	Life-cycle-cost analysis
LSTMA	layered soil treatment systems developed in MA
mgd	million gallons per day
mg/L	milligrams per liter
N	nitrogen
N/A	not applicable
NJDEP	New Jersey Department of Environmental Protection
NSF	National Sanitation Foundation
NSF40	NSF Standard 40 for secondary level treatment
NSF245	NSF Standard 245 for enhanced nitrogen removal
NTX	NITREX nitrogen removal system

O&M	operation and maintenance
OSDS	onsite treatment and disposal system
OSWT	onsite wastewater treatment and disposal system
OWTS	onsite wastewater treatment system
PBY	Presby disposal system – standard
PBY-DN	Presby disposal system with N removal
RAW	raw sewage
RGSWA	recirculating gravel system WA
RSF	recirculating sand filter
SABS	soil absorption system
SBR	sequencing batch reactor
SDWB	Safe Drinking Water Branch
SEEP	seepage pit
ST	septic tank
TM	technical memorandum
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
UIC	underground injection control
UV	ultraviolet light
WET	constructed wetland system
WQ	water quality
WWB	Wastewater Branch

Technical Memorandum 3

ONSITE TREATMENT TECHNOLOGIES EVALUATION

3.1 Executive Summary

Hawai'i's Act 132 requires the upgrade of all 88,000 existing residential cesspools by the year 2050. As a result, it is expected that these existing onsite sewage disposal systems will be replaced by a variety of engineered treatment and disposal units, some of which are already approved for use in Hawai'i, and others that may be emerging and innovative in nature.

Onsite wastewater treatment and effluent disposal system(OSWT) is regulated by the Hawai'i Department of Health Wastewater Branch (DOH WWB). Regulations are contained in Hawai'i Administrative Rules (HAR) 11-62 (effective March 21, 2016), and include procedures, design criteria, standards and restrictions for design and installation of approved standard OSWT technologies (see Appendix A). Complete systems require both a treatment technology and a disposal technology and there are multiple alternatives for both types. In addition, there are many site characteristics, property restrictions, treatment requirements, and other factors that must be considered.

This Technical Memorandum 3 (TM03) includes an evaluation of potential OSWT and disposal technologies which may be considered for the upgrade of existing cesspools. Technologies evaluated are shown in Table ES.1. This study does not attempt or purport to contain evaluations of every technology in existence today. Instead, it focuses on the most common technologies available in Hawai'i that are either approved for use or are promising innovative and emerging technologies that are documented well enough to be considered feasible and likely available during the timeframe of the Act 132 (i.e. 2050).

The technologies were evaluated by several criteria that can be grouped into the following categories:

- Type of technology
- Approval status
- Siting restrictions
- Treatment performance
- Replacement interval and types of costs likely to be incurred
- Benefits and challenges involved with implementation

The intent of this TM is to provide guidance to the Cesspool Conversion Working Groupon as to the applicability, performance, and relative costs of different OSWT technologies that may be considered for cesspool conversions required under Act 132. Ultimately, homeowners should seek more specific guidance from a properly licensed civil engineer (engineer) and general construction contractor. The engineer will need to prepare various studies and designs before a construction permit can be issued and constructed upgrades can begin. This will involve going through several steps to evaluate and select processes for the specific property that are both technically feasible and cost effective. These steps are outlined in Figure ES.1.

Table ES.1 Onsite Wastewater Treatment and Disposal Technologies Evaluated

Technology	Approval Status
Treatment	
Septic Tank	Approved(1)
Aerobic Treatment Unit with nitrification (ATU-N)	Approved(1)
ATU with nitrification and denitrification (ATU-N-DN)	Approved(1)
Chlorine Disinfection	Approved(1)
UV Disinfection	Approved(1)
Recirculating Sand Filter	Approval Required(2)
Eliminite	Innovative(3)
NITREX	Innovative(3)
Recirculating Gravel Filter System (WA)	Emerging(4)
Disposal	
Absorption Systems (Bed/Trench)	Approved(1)
Seepage Pit	Approved(1)
Presby Advanced Enviro-Septic	Approved(1)
Evapotranspiration	Approval Required(2)
Constructed Wetland	Approval Required(2)
Drip Irrigation	Approval Required(2)
Passive Treatment Units (medium and high treatment) (FL)	Innovative(3)
Disposal by Layered Soil Treatment ("Layer Cake") Systems (MA)	Emerging(4)
Disposal by Nitrification/Denitrification Biofilter (NY)	Emerging(4)

Notes:
(1) Technology approved by DOH in HAR 11-62.
(2) Technology mentioned in HAR 11-62, but design review is required.
(3) "Innovative" technologies are commercially available outside of Hawai'i, but do not have established regulatory design criteria and would require design review by DOH WWB.
(4) "Emerging" technologies are at a research stage and/or pilot-testing and/or full-scale probationary approval in other states. They are not commercially available and do not have established regulatory design criteria. DOH WWB does not currently have a process for approving these technologies.

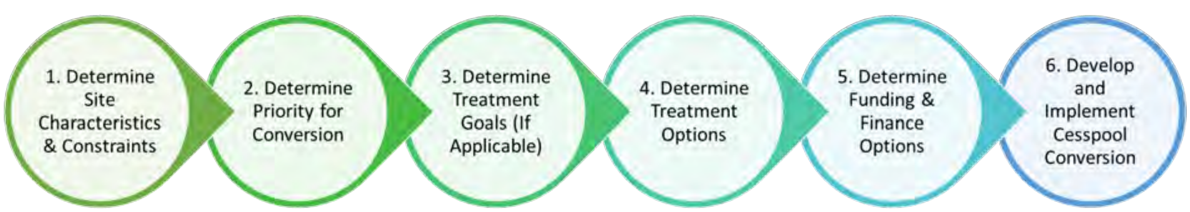

Figure ES.1 Stepwise Approach to Cesspool Conversions for Individual Homeowners

OSWT and disposal technologies can be utilized in many combinations, and in some cases, two or even three different treatment technologies may be needed in sequence ("treatment train"). A set of 35 treatment trains were created, each of which is a set of treatment and disposal technologies that work together to meet requirements and optimize other considerations. Potential treatment trains are summarized in Table ES.2.

There are many other possible treatment trains beyond the listed, those options perceived to be impractical, ineffective, or overly expensive were not included. The ones shown are considered the most feasible and practical.

Of the 34 treatment trains presented:

- 16 treatment trains utilize technologies that are currently approved in Hawai'i
  - Using these technologies should result in faster DOH WWB approval
  - Some technologies are for small properties (less than 10,000 square feet [sf])
  - Some technologies can be used for Priority 1 systems
  - Some technologies meet National Sanitation Foundation (NSF)40[1] water quality criteria
  - Some technologies meet both NSF40 and NSF245[2] criteria
  - Some technologies provide robust disinfection of bacteria
- 19 treatment trains incorporate septic tanks into the treatment system
- 10 treatment trains involve alternative toilets and graywater recycling systems
  - Black and grey water are source-separated
  - Some use septic tanks
  - Some use aerobic treatment units (ATUs) or aerobic treatment units with denitrification (ATU DN)

[1] NSF40 Residential Onsite Systems is a standard for residential wastewater systems with rated capacities between 400 and 1500 gallons per day.
[2] NSF245 Nitrogen Reduction is a standard that defines total nitrogen reduction requirements for wastewater treatment systems with rated capacities between 400 and 1500 gallons per day.

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Table ES.2 Feasible Treatment Trains That Combine Treatment and Disposal Technologies to Meet Different Goals

No.	Treatment Train Name	Source	Treatment 1	Treatment 2	Treatment 3	Disposal	Notes	NSF40	NSF245 (N removal)	Coliform (pathogen removal)
1	1a	RAW	ST			SABS	Standard conventional/traditional system			
2	1b	RAW	ST			PBY	Presby disposal system	Y		
3	2	RAW	ST			SEEP	By DOH approval, only for lots too small for absorption systems			
4	3a	RAW	ST			WET	DOH design review required			
5	3b	RAW	ST			ET	DOH design review required, zero discharge			Y
6	3c	RAW	ST	RSF		SABS	DOH design review required			Y
7	3d	RAW	ST	RSF		DRIP	DOH design review required			
8	4	RAW	ST	RSF	DIS	SEEP	By DOH approval, only for lots too small for absorption systems and/or near surface water			Y
9	5a	RAW	ATU			SABS	Standard conventional/traditional system	Y		
10	5b	RAW	ATU			WET	DOH design review required	Y		
11	5c	RAW	ATU			DRIP	DOH design review required	Y		
12	6	RAW	ATU			SEEP	By DOH approval, only for lots too small for absorption systems	Y		
13	7a	RAW	ATU-DN			SABS	For properties near surface water	Y	Y	
14	7b	RAW	ATU-DN			WET or DRIP	By DOH approval, for properties near surface water	Y	Y	
15	7c	RAW	ATU-DN			ET	By DOH approval, for properties near surface water, zero discharge	Y	Y	Y
16	8	RAW	ATU-DN	DIS		SEEP	For properties near surface water	Y	Y	Y
17	9a	RAW	ST	ELM		SABS or WET or ET	Innovative treatment system, not currently DOH approved			
18	9b	RAW	ST	NTX		SABS or WET or ET	Innovative treatment system, not currently DOH approved			
19	9c	RAW	ST	ITUFL		SABS or WET or ET	Innovative treatment system, not currently DOH approved			
20	10	RAW	ST	ELM or NTX or ITUFL	DIS	SEEP	Innovative treatment system, only for lots too small for absorption systems and/or near surface water, not currently DOH approved			F
21	11a	RAW	ST	RGSWA		SABS or WET or ET	Emerging filtration system, not currently DOH approved			
22	11b	RAW	ST	LSTMA		SABS or WET or ET	Emerging filtration system, not currently DOH approved			
23	11c	RAW	ST	NDBFNY		SABS or WET or ET	Emerging filtration system, not currently DOH approved			
24	12	RAW	ST	RGSWA or LTSMA or NDBFNY	DIS	SEEP	Emerging treatment system, only for lots too small for absorption systems and/or near surface water, not currently DOH approved			F
25	13a	BW GW	ALTT GRAY	ST		SABS SEEP	Meets current graywater guidelines			
26	13b	BW GW	ALTT GRAY	ST		DRIP SEEP	Meets current graywater guidelines, DOH design review required			

No.	Treatment Train Name	Source	Treatment 1	Treatment 2	Treatment 3	Disposal	Notes	NSF40	NSF245 (N removal)	Coliform (pathogen removal)
27	13c	BW GW	ALTT GRAY	ST		ET SEEP	Meets current graywater guidelines, DOH design review required			Y
28	13d	BW GW	ALTT GRAY	ATU		SABS SEEP	Meets current graywater guidelines	Y		
29	13e	BW GW	ALTT GRAY	ATU		DRIP SEEP	Meets current graywater guidelines, DOH design review required	Y		
30	13f	BW GW	ALTT GRAY	ATU		ET SEEP	Meets current graywater guidelines, DOH design review required	Y		Y
31	13g	BW GW	ALTT GRAY	ATU-DN		SABS SEEP	Meets current graywater guidelines	Y	Y	
32	13h	BW GW	ALTT GRAY	ATU-DN		DRIP SEEP	Meets current graywater guidelines, DOH design review required	Y	Y	
33	13i	BW GW	ALTT GRAY	ATU-DN		ET SEEP	Meets current graywater guidelines, DOH design review required	Y	Y	Y
34	13j	BW GW	ALTT GRAY	w/Kitchen Sink limits		None SEEP	Requires changes to graywater Guidelines	F	F	F

Notes/Acronymns:
Y Yes
N No
F Future

ALTT Alternative Zero-discharge Toilets (composting, incinerating, nano-membrane)
ATU Aerobic Treatment Unit with nitrification
ATU-DN ATU with denitrification
BW Black Water Sewage
DIS Disinfection system (chlorine or UV)
DRIP Drip irrigation system
ELM Eliminite nitrogen removal system (innovative)
ET Evapotranspiration (zero-discharge) system
GRAY Graywater recycling system
GW Graywater
GWT Graywater Recycle Tank
ITUEL Innovative Treatment Units Developed in Florida
LSTMA Layer Soil Treatment Systems developed in Massachusetts
NDBFNY Emerging Nitrifying/Denitrifying Biofilters Developed in New York
NSF245 National Sanitation Foundation Standard 245 for enhanced nitrogen removal
NSF40 National Sanitation Foundation Standard 40 for secondary level treatment
NTX NITREX nitrogen removal system (innovative)
PBY Presby disposal system - standard
PBY-DN Presby system with De-Nyte nitrogen removal
RAW Raw Sewage
SABS Absorption System - trenches or beds, traditional or gravelless
SEEP Seepage Pit
ST Septic Tank
RGSWA Recirculating Gravel System (WA) (emerging)
WET Constructed Wetland System

Table ES.3 Costs of Retrofits Completed Since 2016 under State Tax Credit Program

Type	Size	No.	Cost ($)			
			Mean	Median	Low	High
Septic Tank + Absorption System	1 BR	2	19,803	19,803	10,813	28,792
	2 BR	3	16,435	12,400	10,500	26,406
	3 BR	13	18,817	14,790	9,399	45,797
	4 BR	13	21,989	19,800	9,787	45,550
	5 BR	42	23,688	22,850	8,925	52,356
	Total	73	22,114	21,945	8,925	52,356
Aerobic Treatment Unit	2 BR	1	18,706	ND	ND	ND
	3 BR	2	22,500	22,500	20,000	25,000
	5 BR	5	33,298	26,339	21,760	59,585
	Total	8	28,774	23,380	18,706	59,585
Septic Tank + Presby System	3 BR	1	24,160	ND	ND	ND
	4 BR	1	32,500	ND	ND	ND
Total		**2**	**28,330**	**ND**	**ND**	**ND**

Notes/Acronyms:
BR bedroom
ND Insufficient data available to provide additional statistics.

3.2 Introduction and Background

According to the US Environmental Protection Agency (EPA), cesspools are underground excavations that receive sanitary wastewater from bathrooms, kitchens, and washers. The structure usually has an open bottom and perforated sides (unlined). Domestic wastewater flows into the structure and the solid waste collects at the bottom of the cesspool and the liquid waste flows out through the perforations. Cesspools are not designed to treat wastewater but rather to retain solids and allow liquid wastes to percolate into the subsurface which may be hydraulically connected to groundwater and surface water.

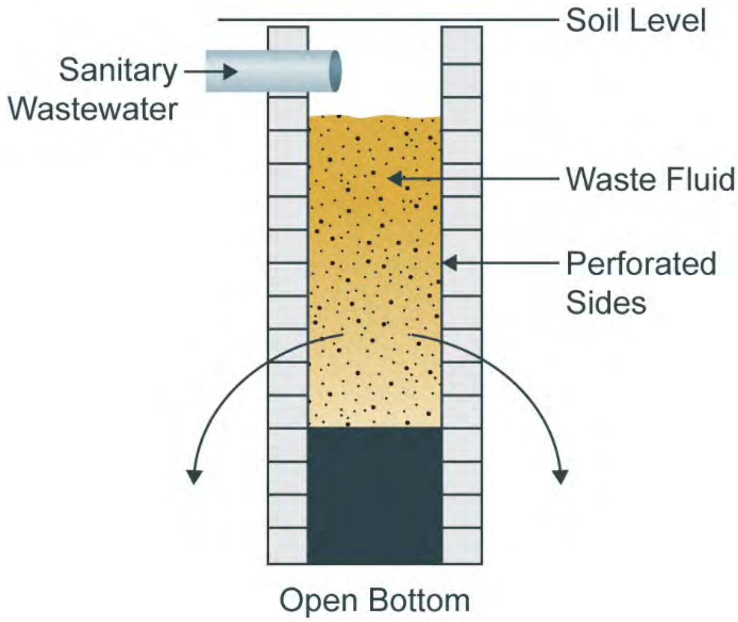

Figure 3.1 Cesspool Schematic

Throughout Hawai'i, there are approximately 88,000 cesspools for single-family, residential wastewater disposal. In 2018, the Hawai'i State Legislature passed Act 132, which states that by January 1, 2050 all cesspools in the state of Hawai'i, unless granted exemption, shall upgrade or convert to a preferred waste treatment system or connect to a sewer system. There are generally three options for cesspool conversions including:

- **Connection to existing or new centralized sewer systems.** In the large municipal areas of Hawai'i, homes and businesses are connected to county or privately owned, sewer collection and treatment systems, where the wastewater flows to a large centralized treatment facility for treatment and disposal. Centralized sewer collection and treatment systems are cost effective because of economies of scale, treating the water either for discharge to the Pacific Ocean or for water reuse applications (e.g., golf course irrigation). However, there are significant capital investments required by counties or private developers, and connections to centralized systems may not be feasible for many cesspool conversions.
- **Connection to decentralized sewer systems.** Decentralized sewer systems (also "cluster" wastewater systems) are similar to centralized sewer systems, but typically have a smaller collection system service area and wastewater treatment facility. Decentralized treatment can range from passive treatment with soil dispersal to more sophisticated, mechanical treatment, such as membrane

bioreactors. Within the rural portions of Hawaiʻi, which are extensive, the costs to dig and construct long sewer systems from remote locations to a centralized treatment facility are substantial.

- **Conversion of cesspools to new OSWT and disposal systems.** A 1999 survey conducted by DOH showed that approximately 19 percent of the households in Hawaiʻi had OSWT and disposal systems, including cesspools. Since many of the cesspools are in rural areas without centralized wastewater systems, conversion to OSWT and disposal may be the most cost-effective option for some homeowners.

The scope of this TM03 is limited to evaluating OSWT and disposal systems as cesspool conversion options. Evaluations of centralized and decentralized sewer options will be investigated separately.

Act 132 also allowed for the creation of the Cesspool Conversion Working Group (CCWG), with the DOH Director or designee as the chairperson. Other CCWG members include: the DOH wastewater branch chief or their designee; four members of the county wastewater agencies for Hawaiʻi, Honolulu, Kauaʻi, and Maui; a member representing the wastewater industry appointed by the president of the senate; a member of the financial and banking sectors appointed by the speaker of the house of representatives; members of the University of Hawaiʻi Institute of Marine Biology and Water Resources Research Center; a member of the Hawaiʻi Associate of Realtors appointed by the Speaker of the house of representatives; a member of the Surfrider Foundation appointed by the President of the senate; one representative appointed by the Speaker of the house of representatives; and one Senator appointed by the President of the senate.

The CCWG subsequently retained the Carollo Engineers, Inc. (Carollo) team to support the cesspool conversion technologies and finance research as a part of the Cesspool Conversion strategy for the state of Hawaiʻi.

There are several parts of the cesspool conversion technologies portion of this project. Besides the cesspool conversion technologies and finance research, the CCWG is also developing strategies for public outreach and education, and data prioritization and validation as it relates to cesspool conversions. Figure 3.2 shows a stepwise process to facilitate homeowners with cesspools in determining how to upgrade their existing cesspools. The CCWG is working to develop strategies and tools to aid cesspool conversions and the overall strategy is anticipated to be complete by 2022.

The first two products of the Cesspool Conversions Technologies Research were Technical Memorandum 1 (TM01) – Assessment of Onsite Treatment Technology Testing and Approval Procedures Utilized by Other States, and Technical Memorandum 2 (TM02) – Septic Tank Systems Review. The purpose of this TM03 is to evaluate existing OSWT technologies and disposal systems to upgrade cesspools at individual residences. This TM helps to support Step No. 4 Determine Treatment Options shown in Figure 3.2.

Figure 3.2 Stepwise Approach to Cesspool Conversions for Homeowners

3.2.1 Methodology

The data and information for this TM03 was gathered from prior products of the team members, including the DOH/Safe Drinking Water Branch (SDWB)-funded study *Investigation of Cesspool Upgrade Alternatives in Upcountry Maui* completed in October 2019, internet research of technology matrices employed in other states, and information available in textbooks, the technical literature, and from vendor websites. The data was gathered from publicly available resources that are considered current and up to date. However, this report does not attempt or purport to contain evaluations of every technology and variety of technology available for this type of application. Instead, it focuses on the most common technologies available in Hawai'i that are either approved for use or are promising innovative and emerging technologies that are not yet approved for sale in Hawai'i but are well documented enough to be considered likely available during the 30-year timeframe of the Act 132 cesspool ban.

3.2.2 Risk to Environment and Human Health

The legislation passed to ban cesspools (Act 132) was based upon an understanding by the DOH WWB of the existing and potential risks of the 88,000 cesspools to the environment and public health. The DOH WWB created a set of four priority categories for the upgrade of cesspools (Table 3.1). The categories were then used to assign priority categories to geographic areas around the State (Table 3.2). The following risk factors were considered in formulating the priority categories:

- Density of cesspools in an area
- Soil characteristics
- Proximity to drinking water sources, streams, and shorelines
- Other groundwater inputs including agriculture and injected wastewater
- Physical characteristics of coastal waters that may compound the impacts of wastewater in bays and inlets

Table 3.1 shows that the highest risk areas (Priority 1) should be addressed as soon as possible, rather than waiting until closer to 2050 due to high risk. Table 3.2 shows that Priority 1 areas include 8,140 cesspools which comprise a little less than 10 percent of the 88,000 cesspools in Hawai'i. These priority categories and assignments were presented by the DOH WWB and the US EPA to the 2018 Hawai'i Legislature and they are subject to evaluation and possible revision through the activities of the CCWG. Cesspool upgrades located in Priority 1 areas may require technologies that remove nitrogen and may also require disinfection (if near surface water). The specific requirements are site specific and will be determined the DOH WWB Director. These restrictions will limit the number of appropriate technologies available for properties in these areas.

Table 3.1 Cesspool Priority Area Definitions and Actions to Take

Category	Definition	Characteristics	Action to Take
Priority 1	Significant risk of human health impacts, drinking water impacts, or draining to sensitive waters	Cesspools appear to contribute to documented impacts to drinking water or human health and appear to impact sensitive streams or coastal waters.	Address these cesspools as soon as possible using any means possible. Such action represents a significant reduction in risk to public health.
Priority 2	Potential to impact drinking water	Cesspools are within the area of influence of drinking water sources and have a high potential to impact the sources.	Homeowners can use Act 120 tax credits[3] to upgrade cesspools located within 500 ft of waters. Actions should be taken simultaneous to or following actions under Priority 1.
Priority 3	Potential impacts on sensitive waters	Cesspools in these areas cumulatively represent an impact to an area that includes sensitive State water or coastal ecosystems (coral reefs, impaired waterways, water with endangered species, or other vulnerabilities).	Homeowners can use Act 120 tax credits(3) to upgrade cesspools located within 500 feet of waters. Actions should be taken simultaneous to or following actions under Priority 2.
Priority 4	Impacts not identified	Comprehensive health and environmental risks have not yet been assessed, or the risk of affecting public or environmental health currently appears low.	Action should be taken as possible: if homeowners independently initiate action or if a supporting agency has available funds.

[3] Current Act 120 tax credits expire on December 31, 2020 (https://health.hawaii.gov/wastewater/home/taxcredit/)

Table 3.2 Initial Priority Upgrade Areas Established by DOH WWB

Geographic Area	Priority Level Assigned	Number of Cesspools	Estimated Effluent Discharge (mgd)
Upcountry area of Maui	1	7,400	4.4
Kahaluu area of Oahu	1	740	0.44
Keaau area of Hawaiʻi Island	2	9,300	4.9
Kapaa/Wailua area of Kauai	2	2,900	2.2
Poipu/Koloa area of Kauai	2	3,600	2.6
Hilo Bay area of Hawaiʻi Island	3	8,700	5.6
Coastal Kailua/Kona area of Hawaiʻi Island	3	6,500	3.9
Puako area of Hawaiʻi Island	3	150	0.60
Kapoho area of Hawaiʻi Island	3	220	0.12
Hanalei Bay area of Kauai	3	270	0.13
Diamond Head area of Oahu	3	240	0.17
Ewa area of Oahu	3	1,100	0.71
Waialua area of Oahu	3	1,080	0.75
Waimanalo area of Oahu	3	530	0.35
	Total Assigned:	**42,730**	**26.87**
Hawaiʻi Island Un-Assigned	NA	24,430	12.18
Kauai Un-Assigned	NA	6,930	4.57
Maui Un-Assigned	NA	4,800	3.5
Oahu Un-Assigned	NA	7,610	5.08
Molokai Un-Assigned	NA	1,400	0.80
	Total Un-Assigned:	**45,170**	**26.13**

3.2.3 Approved Technologies in Hawaiʻi

There are somewhat limited statistics for on-site systems currently in operation in Hawaiʻi. All the systems in the ground and operating are by definition approved. Table 3.3 has a breakdown of these different OSWT systems by island, the estimated discharge flows, the discharge of nitrogen, and the discharge of phosphorus. Table 3.3 only includes information for the following types of systems:

- Cesspools
- Septic tanks + absorption systems
- Septic tanks + seepage pits
- Aerobic treatment units

There are no data available on other approved technologies including (of which there are thought to be very few):

- Disinfection systems
- Recirculating sand filters
- Constructed wetland systems
- Drip irrigation systems
- Seepage pits

Table 3.3 The Number of OSWT and Disposal Systems in Hawai'i from 2018 DOH/EPA Report to Hawai'i Legislature

Island	Housing Units	Number of Cesspools	Septic + Absorption	Septic + Seepage Pit	ATU	Total OSDS units	Estimated Cesspool Effluent Discharge (mgd)	Estimated Total OSDS Effluent Discharge (mgd)	Estimated Total N Flux (kg/d)	Estimated Total P Flux (kg/d)
Hawai'i	82,000	49,344	8,951	694	68	58,982	27.4	34.6	6,607	1,848
Kauai	29,800	13,688	3,107	190	304	18,011	9.5	12.5	2,115	607
Maui	65,200	12,242	4,105	559	75	16,883	7.9	11.6	1,869	554
Oahu	336,900	11,253	2,620	534	199	14,606	7.5	9.7	1,732	500
Molokai	3,700	1,442	477	33	4	1,956	0.8	1.2	206	59
Total	**517,600**	**87,969**	**19,170**	**2,730**	**650**	**110,438**	**53.0**	**69.9**	**12,529**	**3,568**

3.3 Description of Onsite Wastewater Treatment Technologies

The following sections provide descriptions and characteristics of the various treatment technologies evaluated. The various treatment technologies have four levels of approval noted:

- **Approved.** These technologies are already approved for use in HAR 11-62 and are rapidly approved by DOH WWB upon receipt of required submittals for review.
- **Approval Required.** These technologies are mentioned in HAR 11-62; however, detailed design calculations must be submitted and design review is required by DOH WWB prior to site-specific approval.
- **Innovative.** These technologies are commercially available outside of Hawai'i, but do not have established regulatory design criteria and would require design review by DOH WWB.
- **Emerging.** These technologies are at a research stage and/or pilot-testing and/or full-scale probationary approval in other states. They are not commercially available and do not have established regulatory design criteria. DOH WWB does not currently have a process for approving these technologies.

3.3.1 Septic Tanks

A septic tank serves as both a settling and skimming tank and partial anaerobic treatment. It is an approved technology by DOH WWB. The baffles in the tank cause solids settle to the bottom and create a layer of sludge, while fats, oils, grease (FOG), and other floatables rise to the top and create a layer of scum (Figure 3.3). Based on Hawai'i's design requirements, a screen should also be installed on the effluent end to enhance solids removal and prevent clogging of the downstream disposal system. If high quality effluent is desired, a septic tank could be used to pretreat wastewater prior to a secondary treatment step, such as an ATU.

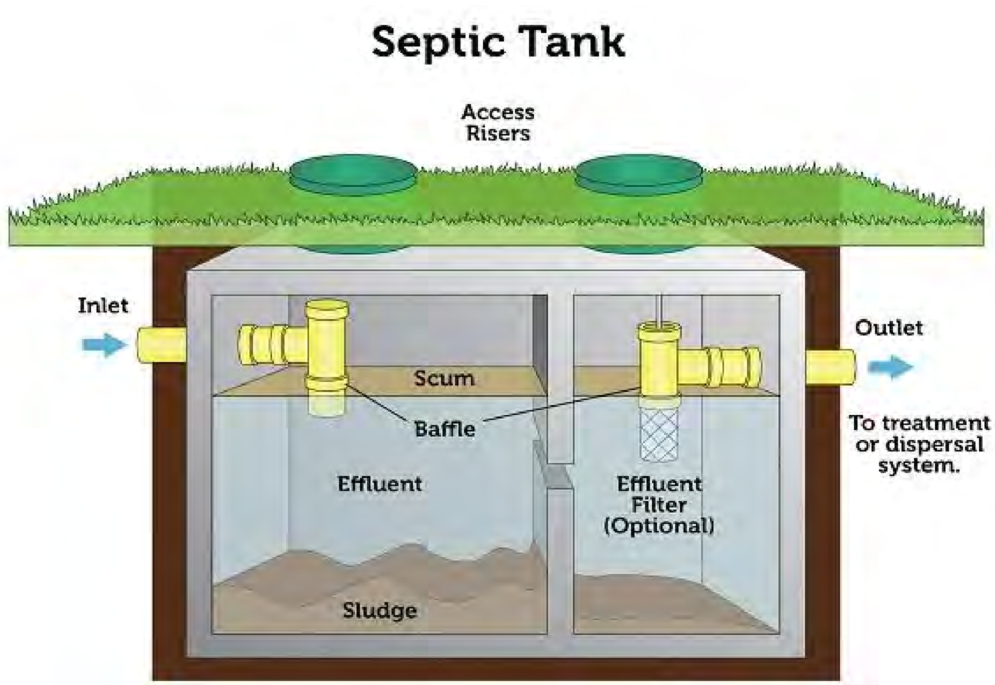

Figure 3.3 Septic Tank with Two Chambers (United States Environmental Protection Agency, 2018)

The benefits, challenges, and operations and maintenance (O&M) requirements are summarized as follows:

- Benefits
  - Power is not required to operate a septic tank.
- Challenges
  - Accumulated sludge and scum must be removed on a regular basis to prevent carryover of these materials into downstream processes.
  - The effluent filter must be cleaned periodically to prevent clogging.
  - Odor – objectionable odors can be emitted.
- Operation and Maintenance
  - The solids that accumulate in the septic tank need to be removed periodically, depending on the loading rate (e.g., how many people use the system) and wastewater characteristics. Solids removal is conducted with a septic pumping and hauling truck and consists of removal of the settled sludge, liquid contents, and scum layer. The liquid and solid contents from the septic tank must be hauled to an approved wastewater treatment facility for where a fee is collected for treatment.
  - Septic tanks that are regularly serviced and maintained can have the solids removed on an as needed basis (estimated 5 to 10 years), whereas septic tanks that are not regularly serviced may require more frequent solids removal (estimated 1 to 2 years). Technologies that are being developed for measuring water level and solids depth will make remote monitoring more feasible.

3.3.2 Aerobic Treatment Units (ATUs)

There are many varieties of ATUs which are manufactured all over the world. ATUs are an approved technology by DOH WWB. There are a small number of Hawai'i-produced units, many mainland-produced and numerous from all over the world, including Japan/Asia, and Europe. The most popular here are locally produced, mainland-produced, and Japan-produced brands. Depending on the application, ATUs can provide or not provide total nitrogen (N) removal. Both ATU types are discussed in the following sections.

3.3.2.1 Without Nitrogen Removal

An ATU is a self-contained OSWT system that is designed to provide full secondary biological treatment by retaining solids, aerobically decomposing organic matter over time, and allowing effluent to discharge into an approved disposal system. There are many types of ATUs, and the following will describe the most commonly used: suspended-growth flow-through ATUs and combined attached and suspended growth ATUs. ATUs typically include primary treatment and biological secondary treatment (oxidation of 5-day biochemical oxygen demand [BOD_5] to carbon dioxide) in different compartments. These units typically include nitrification in the aerobic zone (conversion of ammonia to nitrate).

A suspended-growth flow-through ATU is a biological treatment system where microorganisms are kept in suspension by mixing air with wastewater influent and concentrated underflow or sludge (from a clarifier) in an aeration tank (Figure 3.4). If there is no integral primary settling basin, a separate septic tank or pre-loader should be installed upstream of the ATU. The purpose of this additional tank is to remove readily settleable solids and floating matter that will reduce suspended solids loading.

From the aeration tank, the mixture is passed into a secondary clarifier, where microorganisms settle to the bottom, forming a layer of sludge. The clarified liquid effluent is passed to a disposal system. Some of the sludge solids in the settling basin will decompose, while the remainder accumulates and must periodically be removed (pumped out) and properly/legally disposed of offsite.

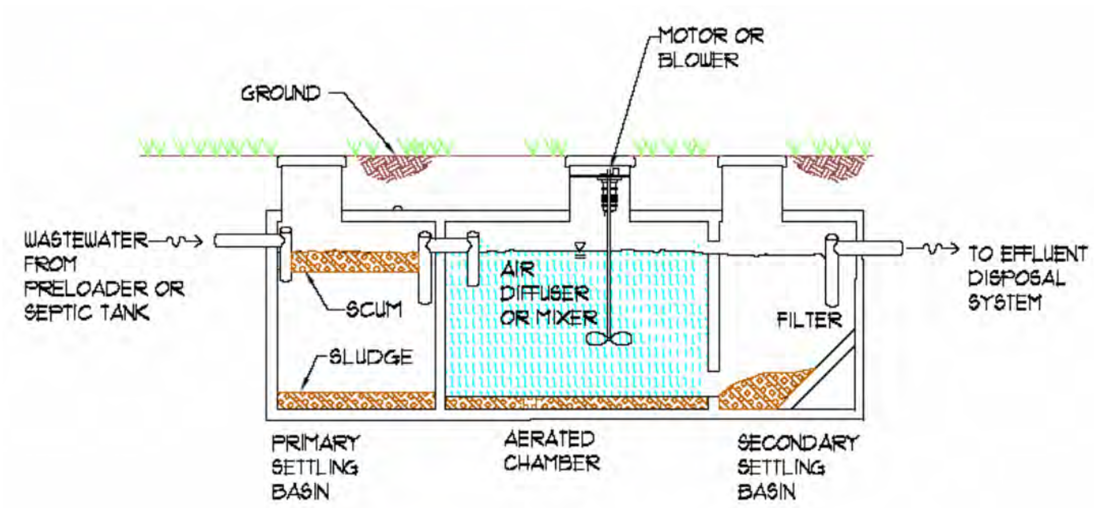

Figure 3.4 Schematic of Suspended-Growth Flow-Through ATU

A combined attached and suspended-growth flow-through ATU is a biological treatment system where the aerated part of the unit contains plastic media where microorganisms can attach and grow and other microorganisms are kept in suspension by mixing air with wastewater influent and concentrated underflow or sludge (from a clarifier) in an aeration tank (Figure 3.5). This setup allows microorganisms to form a slime layer on the surface of submerged plastic media which essentially allows incorporation of more biomass in the same volume. Wastewater is treated as it passes through the media. The system is similar to the suspended-growth flow-through ATU, except that the aerated chamber contains submerged plastic media.

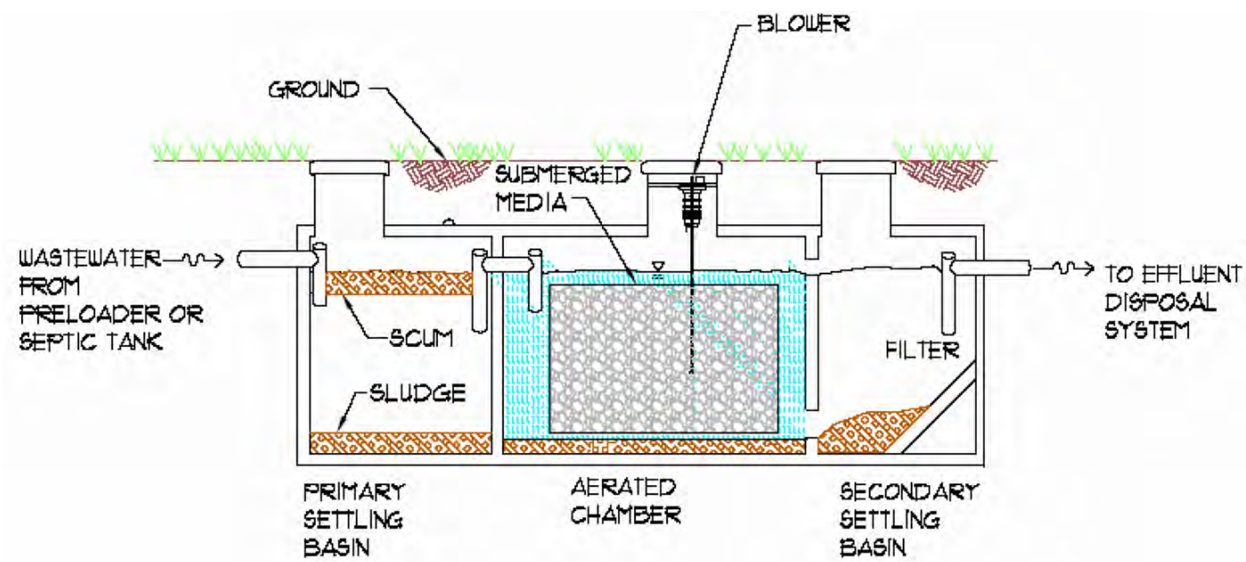

Figure 3.5 Schematic of Combined Attached and Suspended Growth ATU

- Benefits
  - These types of ATUs can achieve effluent quantity of BOD_5 concentrations of 5-25 milligrams per liter (mg/L) and total suspended solids (TSS) concentrations of 5-25 mg/L.
  - Since the biological process takes place in an aerobic environment where free oxygen is available, complete nitrification of ammonia will occur in the ATU.

- Challenges
  - Consideration should be given to determine how best to use available site slopes to allow gravity flow from the preloader (if present) to the ATU to the disposal system.
  - Power is needed to operate the blowers, controls, and monitoring and alarm systems in the ATU.
  - Denitrification does not occur due to absence of an anaerobic environment. Therefore, effluent quantities of nitrate-N range from 10 to 60 mg/L. Because this type of ATU alone cannot remove nitrogen, the pairing with a denitrifying disposal method may be necessary.
  - ATUs are sensitive to high and low temperatures, heavy loading of solids, toxic chemicals (including chemical cleansers), power failures, and large influent flow variability.
  - Odor – objectionable odors can be emitted – this can be mitigated with separated venting
- Operation and Maintenance
  - Trained professionals should inspect the system every four to six months, along with sludge/scum pumping, as needed.

3.3.2.2 With N removal

Some ATUs include both nitrification and denitrification capabilities. Flow-through type systems look just like the previous ATUs but add a recirculation pump to return nitrified water to the front of the system where it mixes with raw wastewater under anaerobic conditions and it is held there to allow denitrification. Another type of system is the sequencing batch reactor (SBR) described below.

In an SBR-type ATU, all the aerobic, anaerobic, and clarifying processes occur within a single tank. The operating sequence includes at least the four following steps (Figure 3.6), which can be cycled several times per day (e.g. one cycle every 4 hours):

1. Fill: tank is filled with raw wastewater to a predetermined volume.
2. Aeration: air is added for mixing and suspension of the microorganisms and the wastewater and for microbial oxidation of the waste including conversion of N into nitrate via nitrification
3. Settle: aeration is turned off and the microorganisms/sludge settles to the tank bottom; concurrently, the contents become anaerobic which allows denitrification of the nitrate into nitrogen gas.
4. Decant: clarified portion is decanted as effluent. Cycle repeats.

These ATUs are designed to operate continuously using a control system of times, level sensors, and microprocessors.

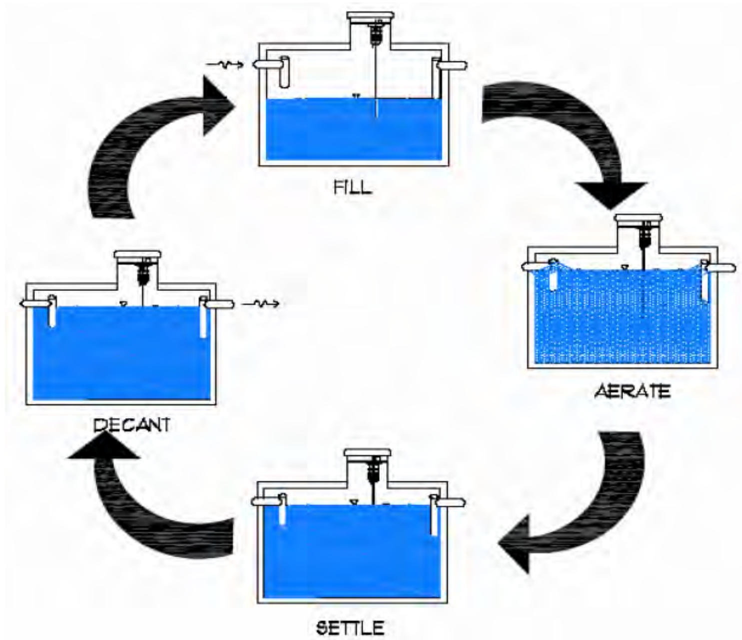

Figure 3.6 Cycles of an SBR-Type ATU

- Benefits
  - This type of ATU that can achieve effluent quantity of BOD_5 concentrations of 5-25 mg/L and TSS concentrations of 5-25 mg/L.
  - An SBR can provide both nitrification and denitrification through cycles of an aeration step and settling and decanting steps.
  - At least 50 percent of influent nitrogen can normally be removed (up to 80 percent under ideal conditions).
- Challenges
  - Consideration should be given to determine how best to use available site slope to allow gravity flow from the preloader (if present) to the ATU to the disposal system.
  - Power is needed to operate the blowers, controls, and monitoring and alarm systems in the ATU.
  - Accumulated sludge and scum must be removed on a regular basis to prevent carryover of these materials into the downstream disposal system.
  - ATUs are sensitive to high and low temperatures, heavy loading of solids, toxic chemicals (including chemical cleansers), power failures, and large influent flow variability.
  - Odor – objectionable odors can be emitted – this can be mitigated with separated venting
- Operation and Maintenance
  - Trained professionals should inspect the system every four to six months, along with sludge/scum pumping, as needed.

3.3.3 Alternative Toilets

Alternative toilets with zero discharge of were developed for use in remote locations lacking water and/or electricity and generally not for heavy daily use. Approval by DOH WWB is required for use of these systems. Alternative toilet options include composting, incinerating, chemical, and nano-membrane (Gates-type) toilets. The most commonly seen are composting toilets and incinerating toilets, which are discussed below. The amount of hands-on homeowner maintenance required, the high potential for odors, and the level of sophistication involved should be evaluated carefully when considering such systems.

3.3.3.1 Composting Toilets

A typical composting toilet (Figure 3.7), is comprised of a composting reactor tank or bin connected to one or more waterless toilets in the house. For very small families, there are self-contained units with the compositing bin immediately under the toilet seat. Daily residential use may overload these smaller systems, so extra capacity will be necessary. Alternatively, a centralized tank reactor with a rotating drum could be located in a basement or underground structure adjacent to the house. The reactor tank or bin contains and controls the decomposition of excrement, toilet paper, and carbon-based bulking agents such as wood chips, straw, hay, or grain hulls. Bulking agent materials break down quickly to prevent buildup of aerobic bacteria and fungi. Composting reactor tanks or bins may be single-chambered, continuous process, or multi-chamber batch units (National Small Flows Clearinghouse, 2000). The owner must remove and dispose of aged compost frequently, turn the composting waste with every use, and replenish bulking agents and odor control fluid.

No other liquid besides urine is present in the bin, allowing for aerobic decomposition of waste. Temperature should be properly maintained between 78 and 113 degrees Fahrenheit for optimal decomposition rates. An exhaust system driven by a fan vents odor, carbon dioxide, and moisture from the reactor bin to the outdoors (the fan could be electricity-driven or a swamp cooler type). The decomposing material needs to be turned frequently to break up the mass and to keep the pile porous and aerated. The final material is about 10 to 30 percent of its original volume and must be properly disposed as municipal solid waste (recycling/reuse on the property is not allowed in Hawai'i).

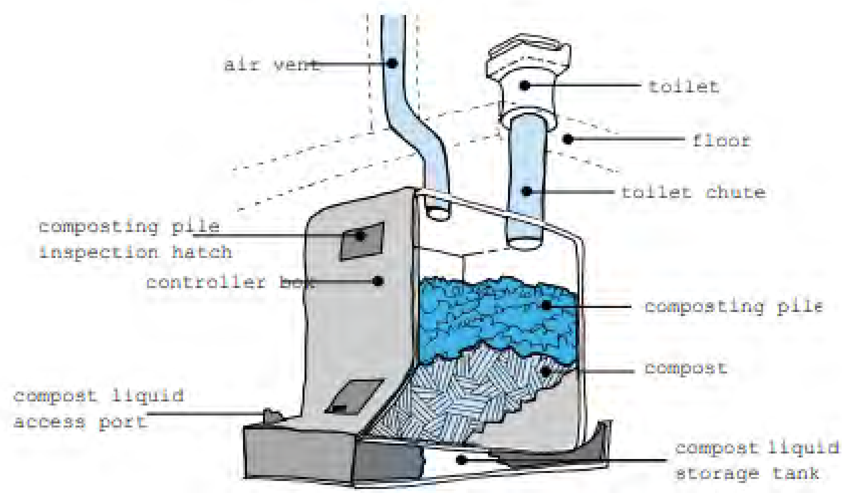

Figure 3.7 Composting Toilet (National Small Flows Clearinghouse, 2000)

- Benefits
  - As a zero-discharge system, nitrogen will not be released into the groundwater.
  - Since water is not needed for flushing, household water consumption is reduced.
  - System consumes very little power (only the small fan).
  - Residents may be able to install a reduced-size wastewater treatment and disposal system, minimizing costs and disruption to the landscape.

- Challenges
  - A high level of maintenance is required by the owner, such as periodic turning of the compost, daily addition of bulking agents, handling and disposal of compost, and preventing too much liquid in the composter.
  - A power source is generally needed.
  - Composting excrement may be visible in some systems.
  - There can be objectionable odors emitted from these systems.
  - If more than one toilet is desired within the household or property, costs are multiplied accordingly with the number of toilets installed.
- Operation and Maintenance
  - The decomposing material needs to be turned frequently to break up the mass and to keep the pile porous and aerated.

3.3.3.2 Incinerating Toilets

These types of toilets use electricity, oil, natural gas, or propane to burn waste to a sterile ash. A typical setup is depicted in Figure 3.8. A paper-lined upper bowl holds newly deposited waste. The paper liner is replaced after each use. Flushing using a foot pedal causes an insulated chamber cover to lift and swing to the side while the bowl halves separate. The paper liner and its contents deposit into the incinerating chamber. When the foot pedal is released, the chamber cover reseals and the bowl halves close (National Small Flows Clearinghouse, 2000).

A "start" button on the toilet begins the burning process, which occurs after each individual deposit. An electric heating unit cycles on and off for about an hour while a blower motor draws air from the incinerating chamber over a heat-activated catalyst to remove odors. A fan then distributes the air through a vent pipe to the outdoors. The fan is also used to cool the incinerating unit. The entire cycle takes from about 1.5 to 1.75 hours per "flush" or use (National Small Flows Clearinghouse, 2000).

If the incinerating toilet runs on gas, then a toilet bowl is not present, and the waste drops directly into a holding chamber. Prior to the burning process, an anti-foam agent is added to reduce the risk of liquid wastes boiling over. The toilet seat is lifted, and a cover plug is inserted to act as a fire wall (National Small Flows Clearinghouse, 2000).

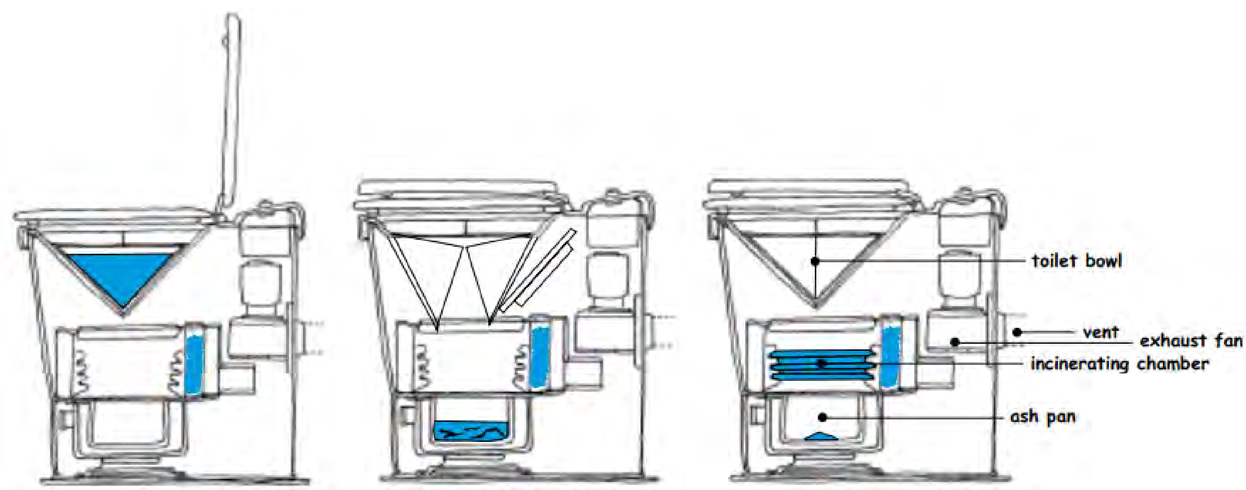

Figure 3.8 Incinerating Toilet Shown with Seat Cover Up, Seat Cover Down and Incinerating Chamber Opened, and Seat Cover Down and Incinerating Chamber Closed (Left to Right) (National Small Flows Clearinghouse, 2000)

Figure 3.9 shows a nano-membrane incinerating toilet. These toilets are currently under development with sponsorship by the Gates Foundation. Commercially units are not yet available at time of completion of this TM. There are several prototypes in laboratories. These systems are designed to be self-contained in terms of no need to add flush water; instead they use membranes to filter the urine and recycle it for flushing. These units do require electricity, and have an incineration function such that the only byproduct is ash.

Figure 3.9 Mock-up Conceptual Nano-membrane-incinerating Toilets

- Benefits
  - As a zero-discharge system, nitrogen will not be released into the groundwater.
  - Since water is not needed for flushing, household water consumption is reduced.
  - Residents may be able to install a reduced-size wastewater treatment and disposal system, minimizing costs and disruption to the landscape.
- Challenges
  - Care must be taken to minimize electrical hazards.
  - A power source is needed.
  - The toilet cannot be used during the incinerating cycle.
  - If more than one toilet is desired within the household or property, costs are multiplied accordingly with the number of toilets installed.
- Operation and Maintenance
  - Regular cleaning of the toilet seat and bowl as needed.
  - Disposal of generated ash in a sealed bag with regular municipal solid waste.
  - Mechanical/electrical inspection, maintenance, and repair requirement are unknown at this time.

3.3.4 Disinfection Units

Wastewater disinfection is a treatment technology that can be used to reduce the possibility of pathogenic organisms entering the environment. This technology is approved by DOH WWB. The most common types of onsite disinfection units use chlorine tablets or ultraviolet radiation. Depending on the pretreatment process, disinfection may be required for some disposal systems, such as drip irrigation.

3.3.4.1 Chlorination

Chlorine is a powerful oxidizing chemical frequently used for disinfection of water or wastewater. Powder or tablets of solid hypochlorite (calcium hypochlorite and sodium hypochlorite) are the forms that can be used in OSWT systems. All forms of chlorine are toxic, corrosive, and require careful handling and storage. For small onsite wastewater treatment systems, the most common type of disinfection equipment is the tablet chlorinator. A typical setup is depicted in Figure 3.10. The tablet chlorinator is the most common disinfection system because it does not require electricity, is easy to operate and maintain, and is relatively inexpensive.

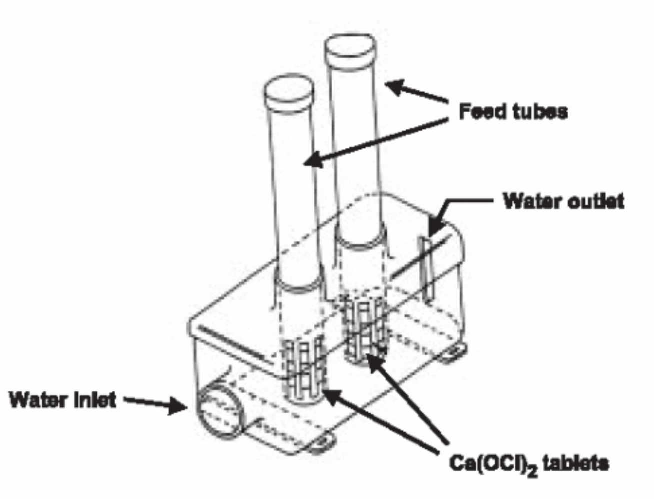

Figure 3.10 Stack-Feed Tablet Chlorinator

- Benefits
  - The main advantages of chlorine are it is ready availability, low cost, and is effective against a wide range of pathogenic organisms. Chlorine can reduce fecal coliforms by 99 to 99.99 percent and can continue to exist as a residual in wastewater effluent.
  - Units are inexpensive and do not require energy to operate.
  - Easy to operate and maintain.
- Challenges
  - Chlorine chemicals need to be stored and handled carefully.
  - Require periodic chemical addition. Chlorine tablet feeder may jam and cause system to not work properly.
  - Residual chlorine released in treated wastewater may have adverse effects on other organisms in the environment.
  - Obtaining the correct type of chlorine tablets can be difficult, Wastewater-type tablets are different than pool-type chlorine tablets which expand when wetted.
- Operation and Maintenance
  - For this system, the operational parameters include the rate at which the chlorine tablets dissolve, the amount of chlorine transferred into solution, the capacity of the chorine tablet reservoir, and the time required between servicing. Systems should be inspected monthly to ensure operation. For a typical system, tablets may need to be added every 4 to 6 months.

3.3.4.2 Ultraviolet Radiation

Ultraviolet (UV) disinfection employs mercury-type lamps separated from the water by a quartz sleeve contained in a flow through stainless-steel reaction vessel (pipe). UV light acts as a physical disinfection agent due to the germicidal properties of UV in the range of 240 to 270 nanometers. The radiation penetrates the cell wall of microorganisms and causes cellular mutations that prevent reproduction. Effectiveness of UV disinfection depends on the clarity of the treated wastewater, UV intensity, time of exposure, and reactor configuration. A typical setup is depicted in Figure 3.11.

Figure 3.11 An ultraviolet disinfection system (steel cylinder to the right of the control box) used to treat sand filter effluent before landscape irrigation

- Benefits
  - UV successfully inactivates most bacteria, viruses, spores, and cysts.
  - In contrast to chlorine chemicals, this method does not involve handling or storing of hazardous or toxic chemicals.
  - Does not leave residual chemical or toxicity in the water.
  - Not space intensive.
- Challenges
  - A continuous power supply is required to operate the UV bulbs.
  - Periodic cleaning of the quartz sleeves is required to ensure transmission of the UV radiation into the wastewater (monthly minimally).
  - Bulbs must be replaced (typically annually)
  - UV treatment is rendered ineffective in wastewater with low clarity due to bacteria being shielded by high turbidity and total suspended solids.
- Operation and Maintenance
  - UV disinfection systems require that the lamps be cleaned and/or changed periodically to maintain a high level of treatment. Because the system uses electrical power it will need regular inspection to ensure correct operation

3.3.5 Recirculating Sand Filter

A Recirculating Sand Filter (RSF) is a treatment technology, in which septic tank effluent is pressure distributed (such as by spray nozzles) to the top of a bed of sand, which is biologically treated as it percolates through (Figures 3.12 and 3.13). Approval by DOH WWB is required to use this technology. Carbon oxidation, nitrification, and denitrification can all occur. A portion of the water is pumped back to the pump chamber or the treatment process, and another portion passes on to a dispersal system such as drip irrigation or a seepage pit. The nitrate in the recirculated water undergoes denitrification under anaerobic conditions (Barnstable County Department of Health and Environment, 2018).

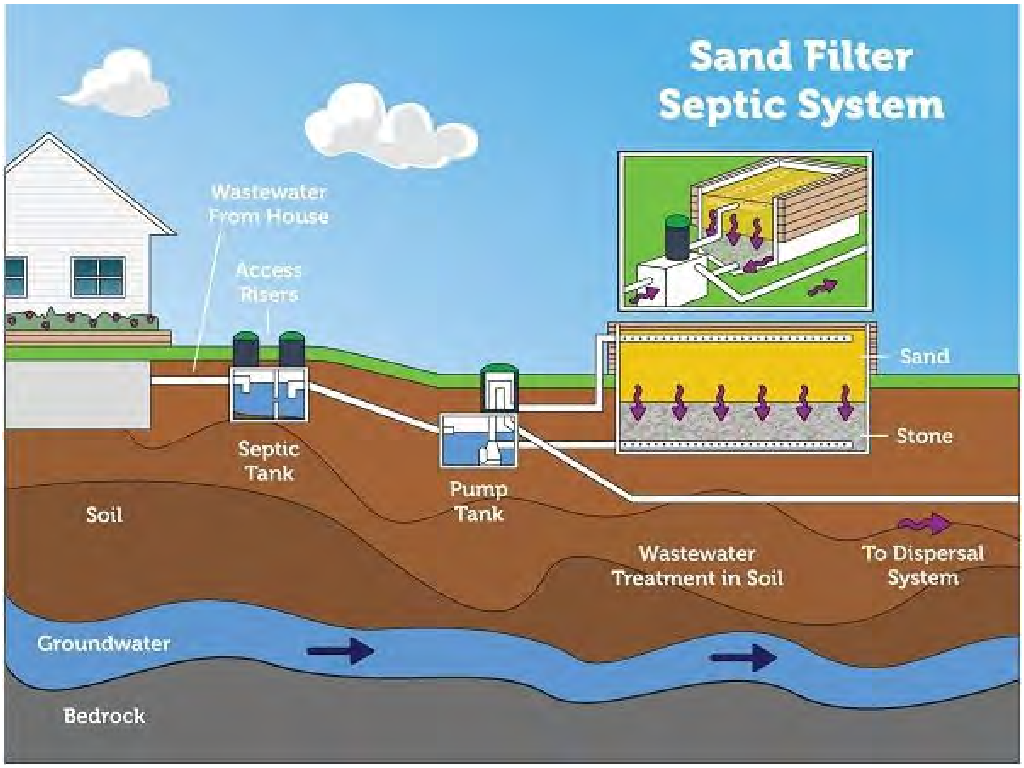

Figure 3.12 RSF with Primary Treatment by Septic Tank (United States Environmental Protection Agency, 2018)

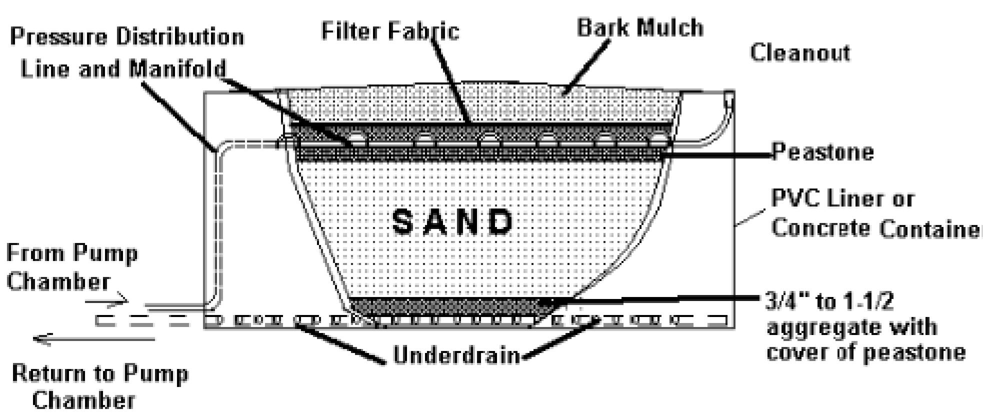

Figure 3.13 Profile Schematic of a RSF

- Benefits
  - RSFs can remove up to 50 percent total nitrogen.
- Challenges
  - Large land area may be required.
  - Filters need to be covered to protect against odor, debris, algae fouling, and precipitation.
  - A pump is needed for recirculating the wastewater.

- Operation and Maintenance
  - Operational costs include electricity for the pump and labor. The filter should be inspected every 3 to 4 months, and the top layer of the filter media should be removed and replaced periodically.

3.3.6 Eliminite Innovative Technology

Eliminite is a denitrifying septic system with two 1,500-gallon concrete tanks. This is an innovative technology and approval by DOH WWB is required for use. As depicted in Figure 3.14, the Eliminite system uses patented, proprietary treatment media called MetaRocks® to remove nitrogen. MetaRocks® provide a surface for nitrifying and denitrifying bacteria to thrive. The first 1,500-gallon tank is used as a septic tank, and the second tank has two chambers to house the MetaRocks® and provide BOD_5, TSS, and total N removal. The Eliminite system is followed by a disposal system such as absorption or seepage pit (Eliminite, Inc., 2018).

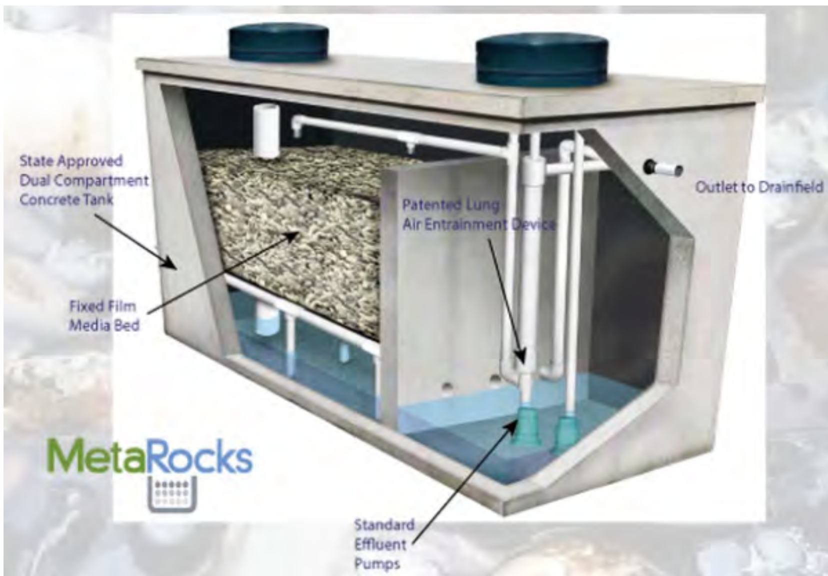

Figure 3.14 Nitrogen Reduction by Eliminite's MetaRocks® (Eliminite, Inc., 2018)

- Benefits
  - Average total nitrogen removal is expected to be 62 percent.
- Challenges
  - Pump operation and electrical power are needed.
  - This innovative technology is new to Hawai'i, so a pilot program with a robust inspection and sampling program would be necessary. Design would need to be reviewed and approved by DOH WWB.
- Operation and Maintenance
  - Make sure recirculation pump is functional and repair/replace as needed
  - Annual inspection of rock media chamber, with cleaning and addition of lost media as needed

3.3.7 NITREX Innovative Technology

NITREX™ reactive media is contained in a tank that receives nitrified wastewater effluent from an ATU or RSF. This is an innovative technology and approval by DOH WWB is required for use. As depicted in Figure 3.15, a typical setup includes wastewater sequentially passing through a septic tank, a nitrifying sand filter, the NITREX™ denitrifying filter tank, and then an absorption bed or trench for disposal. The NITREX™ media can also be placed in a lined excavation instead of a tank. The sand filter serves as a necessary nitrification step so that the NITREX™ can perform denitrification on nitrate-rich effluent (Lombardo Associates, Inc., 2018).

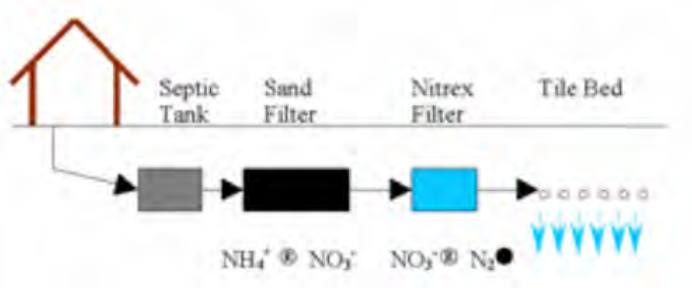

Figure 3.15 Nitrogen Reduction by NITREX™ Filter (Lombardo Associates, Inc., 2018)

- Benefits
  - Average total nitrogen removal is expected to be up to 97 percent.
  - There is no pumping or chemical addition requirement.
  - The NITREX™ media has an expected performance period of 50 years.
  - Virtually no maintenance of the system is needed, but routine inspections and pumping of the upstream septic tank will be necessary.
- Challenges
  - This innovative technology is new to Hawai'i, so a pilot program with a robust inspection and sampling program would be necessary. Design would need to be reviewed and approved by DOH WWB.
- Operation and Maintenance
  - Annual inspection of rock media chamber, with cleaning and addition of lost media as needed.

3.3.8 Recirculating Gravel Filter System (WA)

This is an emerging technology required DOH WWB approval for use. The treatment system is based on a two-step process:

1. Under aerobic conditions, the effluent undergoes nitrification.
2. Under anaerobic conditions, denitrification occurs (Washington State Department of Health and University of Washington Civil and Environmental Engineering Department, 2012).

This system would be placed following a septic tank. Effluent could be transferred to an absorption bed or trench. There are three zones in this system, with effluent continually circulated through the first two zones. With each circulation cycle, a portion of the nitrified effluent is released to the third zone for denitrification. The different zones are denoted by numbers in circles in Figure 3.16:

- Zone 1: The septic tank effluent flows into the recirculating tank. As the effluent level rises in the tank, a float activates a timer to control a pump. The pump sends timed doses of effluent to the recirculating gravel filter in Zone 2.

- Zone 2: The wastewater flows down through the gravel, and ammonia is converted to nitrate. The nitrified effluent exits through a slotted pipe at the bottom and about 80 percent flows back to the recirculating tank in Zone 1 with 20 percent flowing to Zone 3.
- Zone 1: (repeated cycle): The nitrified effluent from Zone 2 mixes with additional septic tank effluent. Serving as a carbon source for bacteria, the septic tank effluent allows for some denitrification to occur here. The effluent is then pumped to Zone 2 to repeat the process.
- Zone 3: This is a vegetated woodchip bed with constant submergence of the woodchips to create an anoxic zone. The bed can also be described as an anoxic subsurface constructed wetland. Denitrification occurs as the effluent flows horizontally through the bed. Plants such as cattails can also provide increased nitrate removal, as well as provide another carbon source. Finally, effluent from this zone would be transferred to a water level control basin and then an absorption system (Washington State Department of Health and University of Washington Civil and Environmental Engineering Department, 2012).

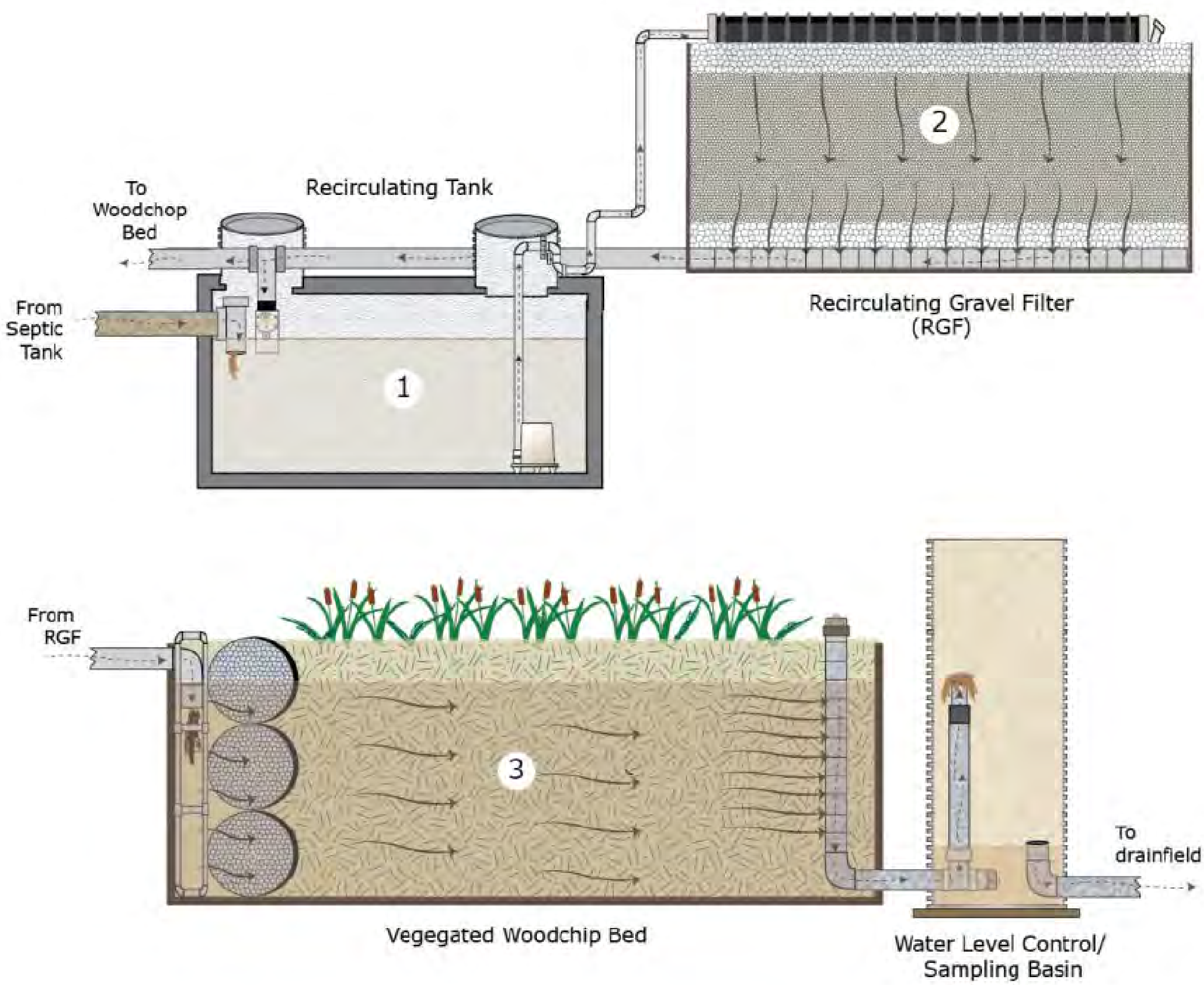

Figure 3.16 Recirculating Gravel Filter with Vegetated Woodbed System (Washington State Department of Health and University of Washington Civil and Environmental Engineering Department, 2012)

- Benefits
  - Average total nitrogen removal is 92 percent.
  - Local materials may be used for the woodbed media.
- Challenges
  - Pump operation and electricity are needed for the recirculation system.
  - This emerging technology is new to Hawai'i, so a pilot program with a robust inspection and sampling program would be necessary. Design would need to be reviewed and approved by DOH WWB.
- Operation and Maintenance
  - Routine inspections should include the pump and control panel, adequacy of pumped dosage frequency, and effluent filter on the septic tank outlet. The septic tank should also be maintained to ensure proper functioning of the subsequent treatment and disposal steps (Washington State Department of Health and University of Washington Civil and Environmental Engineering Department, 2013).

3.4 Description of Onsite Wastewater Disposal Technologies

The following sections of this TM provide descriptions and characteristics of the various disposal technologies that were evaluated. The various disposal technologies have four levels of approval:

- **Approved.** These technologies are already approved for use in HAR 11-62 and are rapidly approved by DOH WWB.
- **Approval Required.** These technologies are mentioned in HAR 11-62, however, design review is required by DOH WWB prior to site-specific approval.
- **Innovative.** These technologies are commercially available outside of Hawai'i, but do not have established regulatory design criteria and would require design review by DOH WWB.
- **Emerging.** These technologies are at a research stage and/or pilot-testing and/or full-scale probationary approval in other states. They are not commercially available and do not have established regulatory design criteria. DOH WWB does not currently have a process for approving these technologies.

3.4.1 Absorption Systems

Absorption systems are an approved subsurface disposal technology that allows treated effluent to percolate into the soil (Figures 3.17, 3.18, and 3.19). Treated effluent comes from a treatment system (usually a septic tank or ATU) and is distributed through perforated pipes laid in either a trench or bed, the bottom surface area of which depends on the hydraulic properties of the native soil. Due to the aerobic conditions in the shallow soil layer, further treatment including filtration of suspended solids and microorganisms, oxidation of organic wastes, and nitrification can occur. The extent of such treatment is dependent upon the characteristics of the native soil, the loading rate, and other factors which can cause treatment to vary from 0 percent to as high as 90 percent.

Absorption systems generally range in depth from 1.5 to 3 feet below grade. Trench widths range from 18 to 36 inches (Figure 3.17), while bed widths are at least 3 feet (Figure 3.18). The major distinction between the two is that in an absorption bed, the entire disposal area is excavated and backfilled with gravel, whereas absorption trenches have distinct areas of undisturbed soil.

Gravelless trench and bed absorption systems utilize plastic dome-shaped segmented chambers buried in the trench/bed in with large open spaces instead of perforated pipes surrounded by gravel (Figure 3.19).

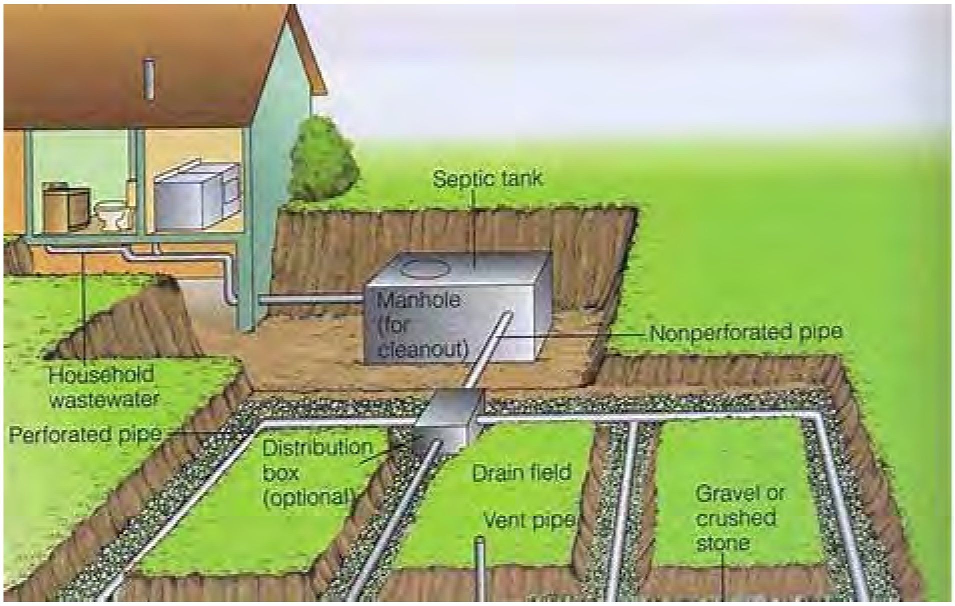

Figure 3.17 Trench Absorption System

Figure 3.18 Absorption Bed Disposal System

Figure 3.19 InfiltaratorTM Gravelless Drainfield System (Infiltratorwater.com, 2020)

- Benefits
  - Absorption systems are the most common type of disposal system and thus there are many products available and experience with installation.
  - When used downstream of a septic tank in good soil, under ideal conditions, absorption trenches can discharge less than 30 mg/L of BOD_5, 30 mg/L of TSS, and 13 coliform forming units per 100 milliliters (CFU/100 mL) of fecal coliform.
  - When deployed downstream of an ATU, absorption trenches can ideally achieve levels of 4 mg/L of BOD_5, 1 mg/L of TSS, and 13 CFU/100 mL of fecal coliform.
  - No power is required, and maintenance is generally not necessary.
- Challenges
  - Trenches cannot be used in terrain where the natural slope is too steep (>12 percent per HAR 11-62).
  - These systems cannot be used if groundwater is too close to the surface (minimum vertical separation of three feet per HAR 11-62).
  - Large amounts of land may be needed, since the effective absorption area is at the bottom of each trench.
  - Root intrusion can adversely impact performance.
  - Overloading, rainfall, or unsuitable soils may cause contaminants to spill out into the surrounding soil, or surface water.
- Operation and Maintenance
  - There are no O&M requirements for absorption systems. The potential to clog the systems is highly dependent on the performance of the upstream treatment operations; therefore, a well-maintained treatment system (e.g. septic tank effluent filter) will keep the absorption system working properly. Observation ports can be installed within the disposal area to check whether the water is percolating into the ground as expected.

3.4.2 Seepage Pit

A seepage pit is an approved disposal technology by DOH WWB and is constructed the same as a cesspool (often it is a former cesspool that has been cleaned and repurposed), but it receives treated wastewater, whereas a cesspool receives untreated wastewater. These systems are generally constructed from reinforced concrete rings, with a diameter of 8 or 10 feet and a height of 2 feet, that are stacked in order to achieve the depth required (usually 15-30 feet) to meet percolation requirements. Each ring has large openings in the sides and looks like Swiss cheese. A concrete lid with a 12-inch inspection port is placed on top. Water percolates out from the sides and the bottom of the unit into the surrounding soil. The effective percolation area is measured as the pit sidewall area.

- Benefits
  - Seepage pits are the simplest and most compact method to percolate water into the ground.
  - They are viable options when the available land area is insufficient for absorption beds or trenches, the terrain is steep, or when an impermeable layer overlies more suitable soil.
  - These units can be maintained (accumulated solids from poorly functioning upstream treatment units can be accessed and pumped out) unlike absorption trenches/beds.
- Challenges
  - Seepage pits generally cannot provide the same level of treatment as absorption bed and trench systems, but there have been few studies.
  - There can be a danger of structural stability including potential cave-ins when converting an old cesspool with un-lined walls or lined walls in poor condition into a seepage pit.
- Operation and Maintenance
  - Proper functioning of a seepage pit relies heavily on maintenance of the upstream treatment process. This prevents clogging of the seepage pit. Otherwise, periodic pumping of any accumulated sludge will be required.

3.4.3 Presby System

The Presby Advanced Enviro-Septic® System is an approved disposal technology that follows a septic tank and has NSF40 certification because it provides additional treatment. It is a network of 10-foot long pipes for further treating and percolating septic tank effluent. It consists of special pipes embedded in a specific type of System Sand. The pipes contain ridges, perforations with skimmers, geotextile fabric, green plastic fiber mat, and Bio-Accelerator® fabric. These work together to treat wastewater as depicted in Figure 3.20 (Presby Environmental, 2018). Without using any electricity or replacement media, the Advanced Enviro-Septic® system can remove BOD_5, TSS, and provide full nitrification. (Presby Environmental, 2018).

Figure 3.20 Presby Advanced Enviro-Septic® Treatment System (Presby Environmental, 2018)

- Benefits
  - Passive system that does not need electricity. There are no moveable parts and no replaceable media.
  - Enhanced treatment and disposal of wastewater are combined in this system.
  - No maintenance of the system is needed, but routine inspections and pumping of the upstream septic tank will be necessary.
- Challenges
  - This technology is still relatively new to Hawaiʻi, so the practical lifespan is unknown.
- Operation and Maintenance.
  - This is a buried, passive system which does not require operation or maintenance (same as an absorption bed).

3.4.4 Evapotranspiration Systems

Evapotranspiration (ET) is a disposal technology (approved with DOH WWB design review) that combines direct evaporation and plant transpiration for wastewater disposal. Pretreated effluent (usually an ATU) is conveyed to a porous bed containing water-tolerant plants (Figure 3.21). Wicking, or capillary action, draws water to the surface, where it is either taken up by the plants and transpired, or evaporated from the surface.

Effluent that is not transpired or evaporated will percolate from the bottom of the bed. This type of system is known as evapotranspiration-infiltration (ETI).

These systems can also be designed with an underlying impermeable liner for a "zero-discharge" system. In this case, disposal is strictly dependent on evaporation and plant transpiration. Additionally, the liner allows the system to be placed above an Underground Injection Control (UIC) line or where there is shallow groundwater or proximate surface water such as a stream, lake or the ocean.

Other components that are typically included are drip or distribution lines, flushing or filtering mechanism, controller to automate dosing cycles, distribution pump, and alternating ET beds.

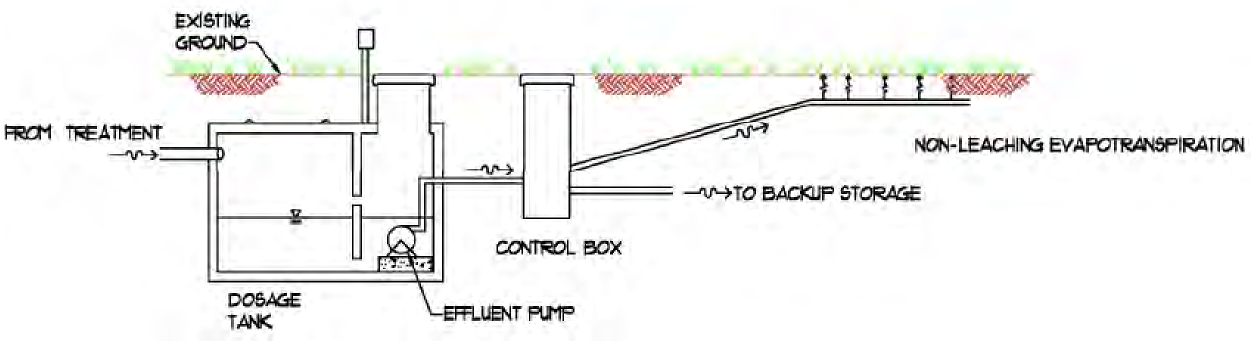

Figure 3.21 Profile of Typical ET System

- Benefits
  - If an impermeable liner is included for a "zero-discharge" system, then 100 percent nitrogen removal is achieved.
- Challenges
  - Large surface areas are needed for year-round disposal. The size is controlled by a water balance based on rainfall and pan evaporation rates.
  - ET systems are more effective in arid climates where evaporation rates are much higher than precipitation rates.
  - Recordkeeping of lysimeter (soil pore water sampler) data is required to ensure proper functioning.
- Operation and Maintenance
  - O&M tasks will include simple inspection of observation wells, electrical costs for pumping, as needed, minor landscaping, and maintaining upstream processes to avoid overflow of solids into the ET bed.

3.4.5 Constructed Wetland Systems

Constructed wetlands are a disposal technology (approved with DOH WWB design review) that is designed and constructed to recreate the processes that naturally treat wastewater by the environment. Septic tank effluent flows (typically by gravity) to an earthen basin or cell containing microorganisms, porous media and plants. A perforated pipe runs along the length of the cell just below the plants to evenly distribute the effluent. A second pipe runs along the length of the cell to collect the effluent as it travels through the porous media, where it then flows through a distribution box and into a drainfield (Figure 3.22). The wastewater flows through the constructed wetland and undergoes filtration, nitrification, denitrification, and absorption. In residential applications, wastewater flows are kept beneath the ground surface to limit potential contact with wastewater.

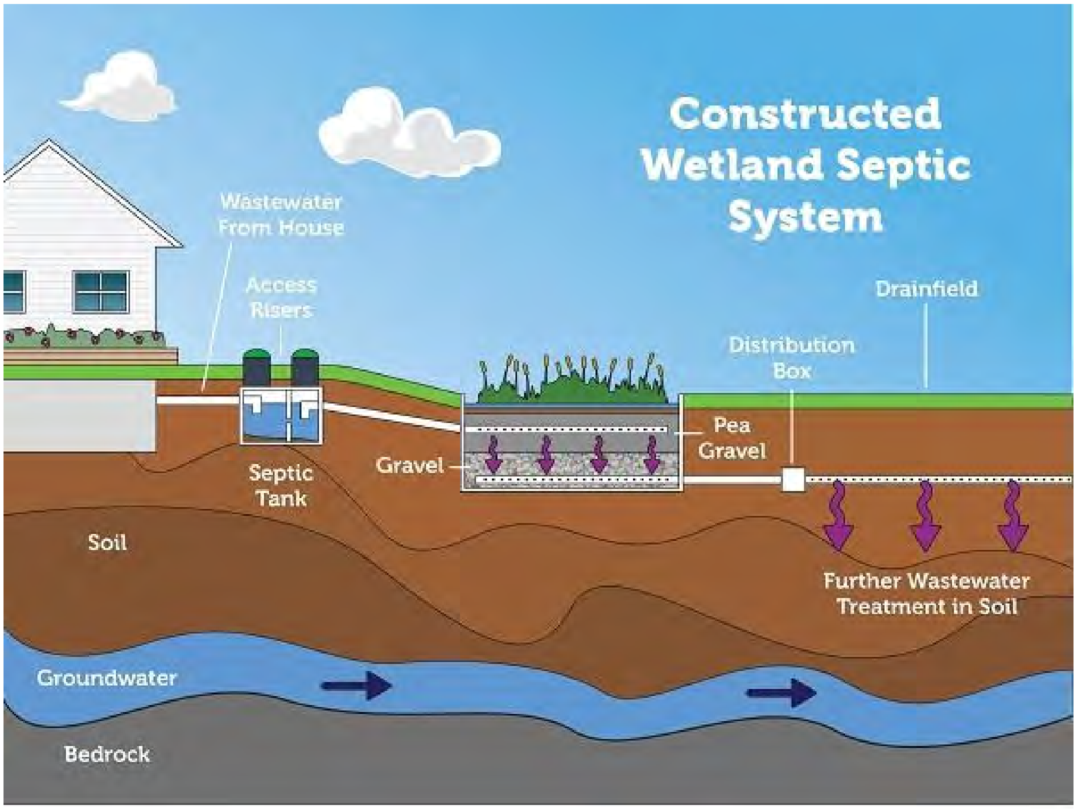

Figure 3.22 Constructed Wetland with Primary Treatment by Septic Tank (United States Environmental Protection Agency, 2018)

- Benefits
  - A constructed wetland provides suitable conditions for denitrification to occur.
  - Power is not required to operate a wetland.
- Challenges
  - Large land area may be required.
  - It is important to maintain an even cross-sectional flow throughout the constructed wetland.
  - The water level should be maintained in the cell during low- or no-flow periods so that the plants do not die.
- Operation and Maintenance
  - Routine maintenance of the vegetation should be done to prevent problems caused by root systems, such as surface ponding. Frequent inspection of the vegetation, inlet distributor, liner, berms or retaining walls, pumps, if present, and drainfield is required. To facilitate this, a maintenance plan should be completed and should detail what is to be done, how it is to be done, and how often it should be done (Beharrell, 2004).

3.4.6 Drip Dispersal Systems

Drip disposal systems (also called drip irrigation systems) are a disposal technology (approved with DOH WWB design review) that use a network of pipes containing emitters commonly spaced 12 inches apart and installed in excavations similar to but shallower than absorption beds. Rather than working by gravity, these systems receive treated effluent in pumped doses from a dosing tank, which allows for controlled loading rates to the shallow root zone of the surrounding soil (Figures 3.23 and 3.24). While some of the treated wastewater percolates into the ground, drip disposal systems act partially as an evapotranspiration system since some of the effluent is taken up by the plants at the ground surface.

Figure 3.23 Drip Irrigation System

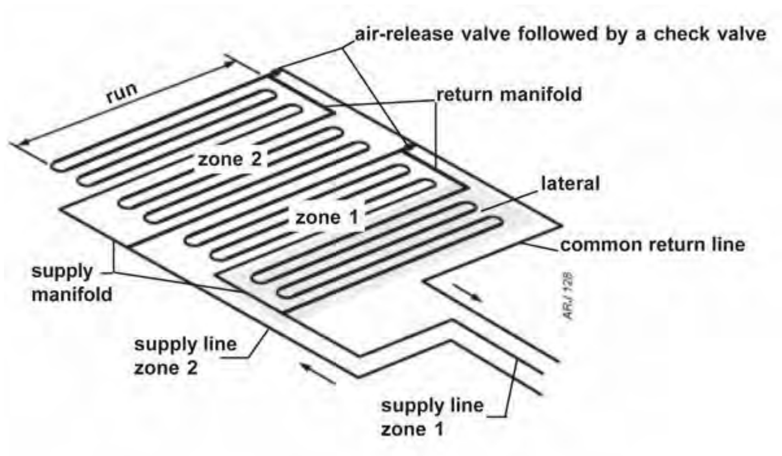

Figure 3.24 Drip Irrigation Zones (Jarrett, 2008)

- Benefits
  - Reliable alternative for areas with low permeability, seasonal high water tables, or severe slopes.
  - Ability to control dose/rest cycles allows for even spacing or dosing of effluent and facilitates wastewater infiltration by spreading it spatially and temporally.
- Challenges
  - In some cases, a large dose tank is needed to accommodate timed dose delivery to the drip absorption area.
  - The septic tank and its effluent filter must be monitored and maintained in order to prevent clogging and possible failure of the drip emitters.
  - Drip disposal systems are active systems, meaning power is required to run pumps, sensors and controls. Regular monitoring and maintenance shall be performed by an authorized service provider as described in an O&M manual provided by the manufacturer. Typical inspections may include observing and reporting of the general condition of the system, water level in tanks, ponding around the system, clogging at pumps and filters, pump cycles, and readings of any meters (New Jersey Department of Environmental Protection [NJDEP], 2008).
- Operation and Maintenance
  - Regular monitoring and maintenance of pump, filter and piping shall be performed by an authorized service provider as described in an O&M manual provided by the manufacturer. Typical inspections may include observing and reporting of the general condition of the system, water level in tanks, ponding around the system, clogging at pumps and filters, pump cycles, and readings of any meters (NJDEP, 2008).

3.4.7 Passive Systems (FL)

Several variations of passive-type systems have been developed during a large research project in the State of Florida. These systems are a disposal technology (innovative – not currently approved in Hawai'i) that follow a septic tank. One type (Figure 3.25) is an in-ground (non-tank confined) variation that treats septic tank effluent which is dosed at low pressure to an in-ground Stage 1 unsaturated biofilter in native soil. The Stage 1 biofilter is underlain by a Stage 2 lignocellulosic biofilter in a lined bed. The effluent is allowed to overflow the liner into surrounding soil. As shown in Figure 3.25, nitrification occurs in Stage 1. Afterwards, the nitrate-rich water travels to the Stage 2 biofilter, which is saturated and therefore an anoxic environment suitable for denitrification. Studies have identified fine sand and lignocellulosic materials from woody plants as candidate media for Stage 2. This configuration had total nitrogen removal of 50 to 70 percent.

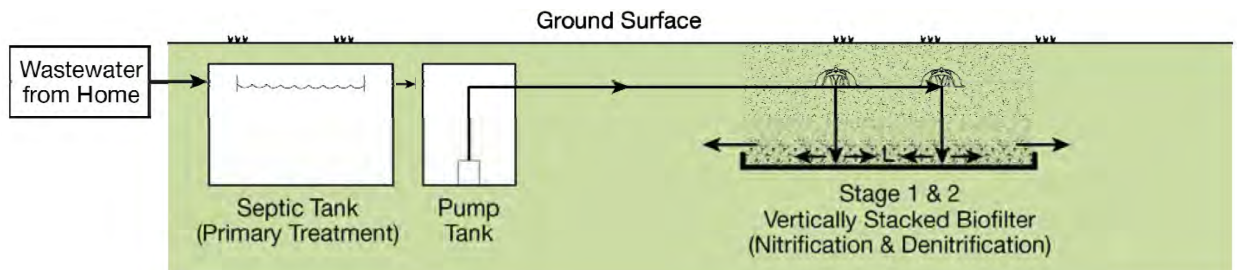

Figure 3.25 Treatment by In-Ground Unsaturated Biofilter in Native Soil Underlain by Saturated Biofilter in Liner and Disposal by Overflow into Surrounding Soil (Hazen and Sawyer, 2015)

A second type evaluated in Florida is shown in Figure 3.26. This system also treats septic tank effluent via secondary treatment in a Stage 1 unsaturated biofilter and Stage 2 saturated biofilter. The denitrified effluent is then disposed of in an absorption bed or trench. The Stage 1 biofilter hydraulics can be either single pass or recirculation. In Figure 3.26, the pump tank can be run either with single pass or with a recycle stream for internal recirculation to spray nozzles located above the surface of the Stage 1 media. The Stage 2 biofilters can contain single or dual media, such as lignocellulosic/sand mixture. This configuration had total nitrogen removal of 85 to 95 percent.

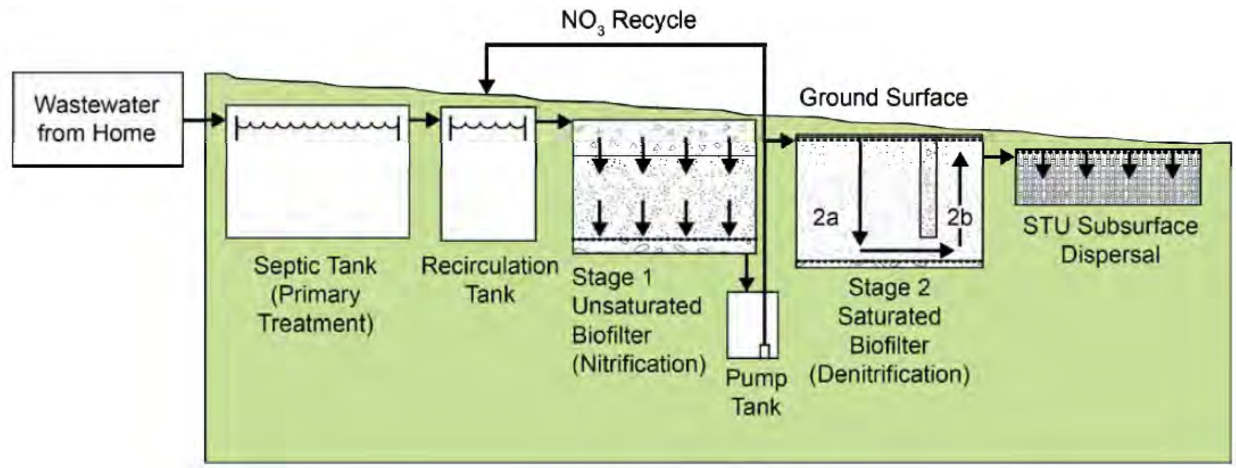

Figure 3.26 Treatment by Recirculating Unsaturated Biofilter and Saturated Biofilter and Disposal by Soil Treatment Unit (Hazen and Sawyer, 2015)

Figure 3.27 shows an in-ground variation of the previously described in-tank based system. Here, septic tank effluent is treated in a Stage 1 unsaturated biofilter stacked on a Stage 2 saturated biofilter. The effluent can continue to another Stage 2 saturated biofilter for further denitrification, or to a soil absorption system. Figure 3.27 shows the additional Stage 2 filter and a drip irrigation soil treatment unit (Hazen and Sawyer, 2015). This configuration has total nitrogen removal of 85 to 95 percent.

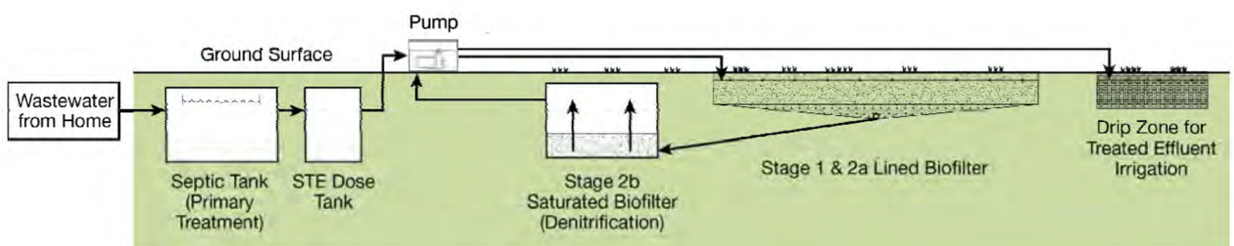

Figure 3.27 Treatment by Unsaturated and Saturated Biofilter in Liner and Second Saturated Biofilter and Disposal by Drip Irrigation (Hazen and Sawyer, 2015)

- Benefits
  - Total N removal depends on the configuration and is expected to be either 50 to 95 percent prior to discharge to the soil absorption system.
  - Local materials may be used for biofilter media.
- Challenges
  - Pump operation and electricity will be needed if a recirculation system is included.
- Operation and Maintenance
  - Routine inspections (twice a year is required by Florida code) include pump operation and electrical connections, hydraulic inspection, flushing and cleaning of distribution lines, biofilter

media life, and the recirculation system. The septic tank must also be maintained to prevent clogging and failure of the subsequent treatment and disposal steps.

3.4.8 Layered Soil Treatment systems (MA)

The layer cake soil treatment system is a disposal technology (emerging – not currently approved in Hawai'i) that treats septic tank effluent in a modified absorption bed or trench (Figure 3.28). The modified absorption bed is a "layer cake" filtration system of 18 inches of sand and 18 inches of a sand and sawdust (or woodchips) mixture. The sand supplies oxygen for nitrification to occur, and the sand and sawdust mixture create an anaerobic environment for denitrification (Hilsman, 2016).

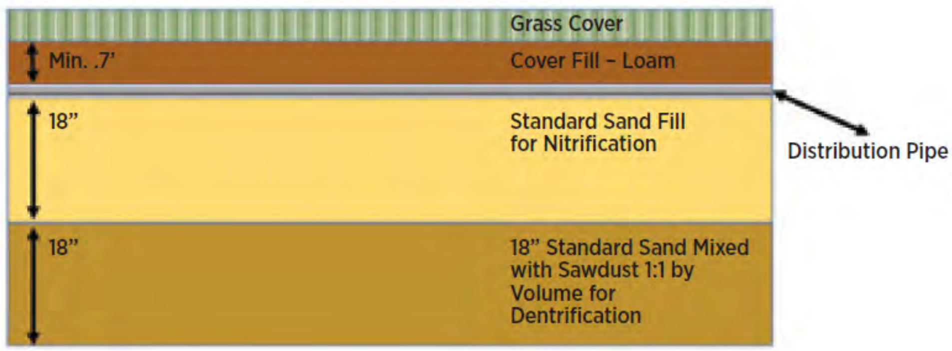

Figure 3.28 Disposal by "Layer Cake" System (Buzzards Bay Coalition, West Falmouth Village Association, Barnstable County Department of Health and the Environment, 2017)

- Benefits
  - Total nitrogen removal is expected to be 50 percent to 90 percent.
  - Local materials may be used for filter media.
  - Low operating and maintenance requirements.
- Challenges
  - Pump operation and electricity may be required for conveying wastewater to the modified leach field if gravity cannot be utilized.
  - The replacement interval of the sawdust/woodchips is unknown but estimated at 50-70 years.
- Operation and Maintenance
  - The septic tank, its effluent filter, and dosing pump must be routinely inspected for proper functioning and to prevent clogging and failure of the layer-cake treatment/disposal system.

3.4.9 Nitrification/Denitrification Biofilters (NY)

Several configurations of biofilter disposal technologies have been researched in New York (emerging – not currently approved in Hawai'i). Septic tank effluent is transferred through a low-pressure distribution system comprised of a low energy pump and parallel, low pressure dosing pipes with drilled orifices (similar to an absorption bed). As the wastewater percolates down, it infiltrates the lined nitrification/ denitrification biofilter underlying the pipes. Nitrification and denitrification occur in the sand and sand/lignocellulose layers, respectively.

One configuration of the biofilter is a 6- to 8-inch soil cover, followed by a 12- to 18-inch nitrifying sand layer, and then a 12- to 18-inch denitrifying sand/sawdust layer, as shown in Figure 3.29. The system is lined to maintain saturation conditions and to allow effluent discharge to a dispersal system. An alternative configuration is presented in Figure 3.30, where the denitrification step is designed in an upflow mode. This removes the need for an underdrain for effluent collection, and the effluent is simply discharges through overflow of the system (The New York State Center for Clean Water Technology, Stony Brook University, 2016).

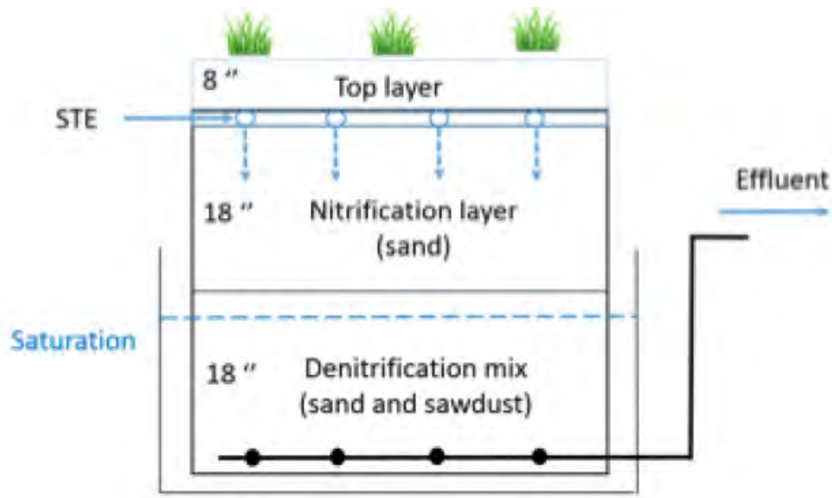

Figure 3.29 Disposal by Lined Nitrification/Denitrification Downflow Biofilter

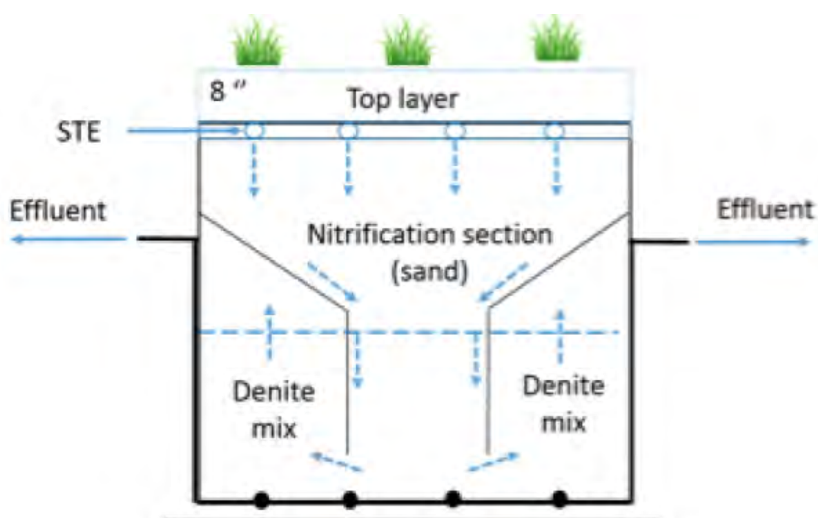

Figure 3.30 Disposal by Lined Nitrification/Denitrification Biofilter with Upflow Denitrification

This setup was designed to address the uncertainty of the wood material lifespan in biofilters. Literature reviews and calculations have indicated that the wood sources should persist for many decades; however, passive nitrogen reduction biofilters have not been in existence for more than a decade. Therefore, the lifespan of these wood sources remains an open question.

- Benefits
  - Total nitrogen removal is expected to be up to 90 percent.
  - Processes are primarily driven by gravity and capillary forces.
  - Saturated nature of sand and sawdust layer should minimize oxidation and degradation of the wood source over time.

  - Local materials can be used for the biofilter media.
  - Woodchip biofilter tank allows for convenient replacement of woodchips.
- Challenges
  - Pump operation and electricity needed for sending wastewater to the woodchip biofilter tank.
- Operation and Maintenance
  - The septic tank, its effluent filter, and pump, if included, must be routinely inspected and maintained for proper functioning and to prevent clogging and failure of downstream biofilters.

3.4.10 Graywater Reuse

A graywater reuse system (Figure 3.31) is a way to divert a large portion of a home's wastewater away from unnecessary treatment to beneficial reuse for yard irrigation. Graywater is all household drainage other than toilets and the kitchen sink (as currently defined in the Hawai'i Guidelines). Toilet and kitchen sink drainage are considered black water that must be treated in an OSWT system. The untreated graywater is stored in a holding tank and used for yard irrigation and the tank must have an overflow pipe connected to a disposal system. The DOH will likely approve a repurposed cesspool (cleaned and converted into seepage pit) for the graywater overflow. If a home also installed alternative toilets with zero discharge (composting, incinerating, and/or nano-membrane in the future), then all black water except for kitchen sink water would be eliminated and an OSWT system would almost be unnecessary. In the future, kitchen sink drainage could possibly be reclassified as graywater provided certain restrictions are met (e.g. no in-sink grinders are allowed, restrictions on disposal of chemicals and other materials that would foul/compromise a graywater storage tank) which would make an OSWT system unnecessary. Currently, a household with an alternative toilet and a graywater reuse system for other sources of water must still have a wastewater treatment and disposal system.

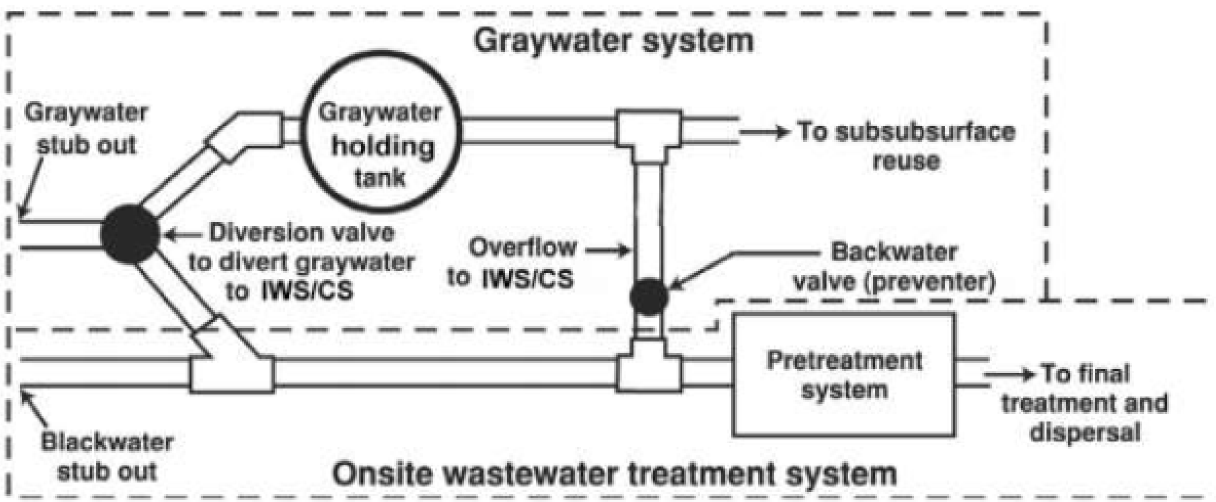

Figure 3.31 Onsite Wastewater Treatment and Disposal Requirement for Graywater System (Hawaii State Department of Health, 2009)

3.5 Technology Evaluation Criteria and Technology Evaluations

For the evaluation of technologies that can meet the goals of this project, several criteria were considered, as listed below:

- **The type of technology**, recognizing that both treatment and disposal systems are needed, the technologies were divided accordingly:

  - Treatment. The OSWT technology provides a level of pollutant reduction.
  - Disposal. The technology is a means for releasing the treated water back to the environment.
- **The approval status of the technology**, recognizing that lack of approval is not a disqualification for consideration of the OSWT or disposal technology, but DOH approval is required prior to installation:
  - Approved in HAR 11-62 (see Appendix A).
  - Design review by DOH is required per HAR 11-62 (see Appendix A).
  - Innovative[4] or Emerging[5].
- **The various residential site restrictions**, as the available land area for treatment and the soil characteristics will dictate which OSWT and disposal technologies are feasible. The following site constraints were considered:
  - Minimum separation from water table.
  - Minimum lot size[6].
  - Minimum soil percolation rate.
  - Maximum ground slope.
  - Location relative to flood zones.
  - Proximity to surface waters.
- **The treatment performance of the technologies**, as some systems provide for better treatment than others. The following performance characteristics were considered:
  - Applicability to areas with high cesspool density. If many cesspools were converted utilizing a single technology, would there be adverse effects to public health or the environment?
  - Potential treatment targets
  - NSF40 or similar systems. Particulate material, which may or may not be organic and thus may or may not biodegrade, also represents a pollutant to water systems. OSWT technologies with NSF40 certification can reliably treat for removal/reduction of organics (measured by BOD_5) and particulates (measured by TSS).
  - NSF245 or similar systems. Nutrients in wastewater, which may impact ground water or surface water quality (primary concern is nitrogen, but phosphorus was also evaluated). If released into aquatic systems in excess, nutrients can cause an imbalance in those systems by stimulating algae growth which has subsequent oxygen impacts and degrade water quality. OSWT technologies with NSF245 certification can reliably reduce nitrogen levels by 50 percent.
  - Removal of fecal coliform. Bacteria, often represented by fecal coliform, are indicative of potential pathogens in the wastewater. Consideration was given to the potential for fecal coliform reduction by OSWT technologies.
- **The costs and maintenance of the different systems**, noting that some systems are more robust and will last longer with less maintenance than others:
  - Construction cost.
  - Operation and maintenance (O&M) costs.

[4] "Innovative" technologies are commercially available outside of Hawai'i, but do not have established regulatory design criteria and would require design review by DOH WWB.
[5] "Emerging" technologies are at a research stage and/or pilot-testing and/or full-scale probationary approval in other states. They are not commercially available and do not have established regulatory design criteria. DOH WWB does not currently have a process for approving these technologies.
[6] Lot size is assumed to be the area for an individual property versus multiple properties.

The technology evaluation criteria were separated into the following categories:

1. Site Conditions
2. Separation Distances
3. Performance
4. Operations and Maintenance
5. Cost
6. Benefits and Challenges

The following sections provide more detail on each technology evaluation criteria category.

3.5.1 Site Conditions

Table 3.4 shows the site conditions that affect selection of the OSWT and disposal technologies and the symbology used in the technologies evaluations. These include:

1. **Proximity of the groundwater table.** There should be at least three feet separation from the bottom of the unit to the seasonal high water table (HAR 11-62).
2. **Minimum lot size.** It should be at least 10,000 square feet (sf) of usable land area, not including land area under buildings. For properties smaller than 10,000 square feet created before 1991, only one system is allowed per property. Because the design must assume 200 gpd per bedroom, and the maximum flow per disposal system is 1,000 gpd, the maximum number of bedrooms for a 10,000 sf property is 5. Larger properties (e.g. 20,000 sf) can have 10 bedrooms served by two OSDSs, etc. (HAR 11-62).
3. **Soil percolation rate.** The soil percolation rate must be no slower than 60 minutes per inch (min/in).
4. **Maximum ground slope.** The maximum site slope is 8 percent for an absorption bed and 12 percent for an absorption trench (HAR 11-62).
5. **Location in a regulated flood zone.** The zones where impacts will occur in a 100-year flood (and thus require flood insurance) include the following designations: A, AE, AH, AO, V, VE, and AEF. Zones of less or unstudied risk include: XS, X, and D.
6. **Proximity to inland or coastal waters.** There should be at least 50 feet separation between the unit and any surface water, including a stream, the ocean shoreline, pond, lake or other surface water body. Other minimum separation distances are shown in Table 3.4.

Table 3.4 Site Condition Considerations

Site Consideration	Symbology Shown in Technology Evaluation	Symbology Description
Proximity to the Groundwater Table	Y	Technology may be installed under conditions with high groundwater table.
	Y if >3 ft	Technology may be installed under conditions where the groundwater table depth is greater than 3 ft.
Minimum Lot Size	Y	Technology may be installed in lots with areas less than 10,000 sf.
	Y if >minimum absorption area required by HAR	Technology may be installed in lots with areas less than 10,000 sf if the minimum absorption area as required by HAR 11-62 is provided.
Soil Percolation Rate	Y	Technology may be installed where soil percolation rate is greater than 60 min/in.
	Y if < 60 min/in	Technology may be installed where soil percolation rate is less than 60 min/in.
Maximum Ground Slope	Y	Technology may be installed where maximum ground slope is 8 percent for absorption beds, and 12 percent for absorption trenches (HAR 11-62).
	Y if <12 percent (Trench used if 8 percent <slope <12 percent)	Technology may be installed where maximum ground slope is 8 percent for absorption beds, and 12 percent for absorption trenches (HAR 11-62).
	Y if ≥ 12 percent and absorption system not feasible	Technology may be installed where maximum ground slope is 12 percent and an absorption system is not feasible.
	Y if <12 percent	Technology may be installed where maximum ground slope is 12 percent.
Location in a Regulated Flood Zone	Y	Technology may be installed at a property that is within the 100-year flood zone as defined by federal insurance rate maps (FIRM).
	N	Technology may not be installed within the 100-year flood zone as defined by FIRM.
Proximity to Inland or Coastal Waters	Y	Technology may be installed regardless of proximity of the installation location to inland or coastal waters.
	Y if >50 feet away	Technology may be installed if the installation location is greater than 50 feet from inland or coastal waters.

With these site conditions in mind, it is possible to sort through the broad range of treatment and disposal options, as done in Tables 3.5 and 3.6, for OSWT and disposal options, respectively. Each of the technologies were described previously.

Table 3.5 Site Conditions for Different Treatment Technologies

Option	Technology Status	Proximity to Groundwater	Lot Size	Soil Permeability	Maximum Ground Slope	Location in a Regulated Flood Zone	Proximity to Coastal Waters
Septic Tank	Approved(1)	Y (with anchoring)	Y	Y	Y	N	Y if >50 feet away
ATU with nitrification (ATU-N)	Approved(1)	Y	Y	Y	Y	N	Y if >50 feet away
ATU with nitrification and denitrification (ATU-N-DN)	Approved(1)	Y	Y	Y	Y	N	Y if >50 feet away
Chlorine Disinfection	Approved(1)	Y	Y	Y	Y	N	Y if >50 feet away
UV Disinfection	Approved(1)	Y	Y	Y	Y	N	Y
Recirculating Sand Filter	Approval required(2)	Y	Y	Y	Y	N	Y if >50 feet away
Eliminite	Innovative(3)	Y	Y	Y	Y	N	Y if >50 feet away
NITREX	Innovative(3)	Y	Y	Y	Y	N	Y if >50 feet away
Recirculating Gravel Filter System (WA)	Emerging(4)	Y	Y	Y	Y	N	Y if >50 feet away

Notes:
(1) Technology approved by DOH in HAR 11-62.
(2) Technology mentioned in HAR 11-62, but design review is required.
(3) "Innovative" technologies are commercially available outside of Hawai'i, but do not have established regulatory design criteria and would require design review by DOH WWB.
(4) "Emerging" technologies are at a research stage and/or pilot-testing and/or full-scale probationary approval in other states. They are not commercially available and do not have established regulatory design criteria. DOH WWB does not currently have a process for approving these technologies.

Table 3.6 Site Conditions for Different Disposal Technologies

Technology	Technology Status	Proximity to Groundwater	Lot Size	Soil Permeability	Maximum Ground Slope	Location in a Regulated Flood Zone	Proximity to Coastal Waters
Absorption Systems (Bed/Trench)	Approved(1)	Y if >3 feet	Y if >minimum absorption area required by HAR	Y if < 60 min/in	Y if <12 percent (Trench used if 8 percent <slope <12 percent)	N	Y if >50 feet away
Seepage Pit	Approved(1)	Y if >3 feet	Y	Y if < 60 min/in	Y if ≥ 12 percent and absorption system not feasible	N	Y if >50 feet away
Presby Advanced Enviro-Septic	Approved(1)	Y if > 3 ft	Y if >minimum absorption area required by HAR	Y if < 60 min/in	Y	N	Y if >50 feet away
Evapotranspiration	Approval Required(2)	Y	Y	Y	Y if <12 percent	N	Y if >50 feet away
Constructed Wetland	Approval Required(2)	Y if >3 ft	Y	Y	Y if <12 percent	N	Y if >50 feet away
Drip Irrigation	Approval Required(2)	Y if > 3ft	Y if >minimum absorption area required by HAR	Y	Y	N	Y if >50 feet away
Passive Treatment Units (medium and high treatment) (FL)	Innovative Technology	Y if > 3 ft	Y	Y	Y	N	Y if >50 feet away
Disposal by Layered Soil Treatment ("Layer Cake") Systems (MA)	Emerging Technology	Y if >3 ft	Y	Y	Y if <12 percent	N	Y if >50 feet away
Disposal by Nitrification/Denitrification Biofilter (NY)	Emerging Technology	Y if > 3 ft	Y	Y	Y	N	Y if >50 feet away

Notes:
(1) Technology approved by DOH in HAR 11-62.
(2) Technology mentioned in HAR 11-62, but design review is required.
(3) "Innovative" technologies are commercially available outside of Hawai'i, but do not have established regulatory design criteria and would require design review by DOH WWB.
(4) "Emerging" technologies are at a research stage and/or pilot-testing and/or full-scale probationary approval in other states. They are not commercially available and do not have established regulatory design criteria. DOH WWB does not currently have a process for approving these technologies.

3.5.2 Separation Distances

Table 3.7 shows the minimum separation distances between cesspools, seepage pits, septic tanks, treatment units, soil absorption systems, and features including: structures, large trees, property lines, surface water bodies and potable water wells. These required separation distances are used when determining appropriate locations for OSWT and disposal technologies on a specific property. These minimum separation distances should be considered when determining feasibility of OSWT and disposal technologies.

Table 3.7 Minimum Separation Distances between OSDSs and Several Features from HAR 11-62

Minimum Horizontal Distance from:	Cesspool (feet)	Treatment Unit (feet)	Seepage Pit (feet)	Soil Absorption System (feet)
Wall line of any structure or building	5	5	5	5
Property line	9	5	9	5
Stream, the ocean at the shoreline certification, pond, lake, or other surface water body	50	50	50	50
Large trees	10	5	10	10
Treatment unit	5	5	5	5
Seepage pit	18	5	12	5
Cesspool	18	5	18	5
Soil absorption system	5	5	5	5
Potable water sources serving public water systems	1,000	500	1,000	1,000

3.5.3 Treatment Performance

Table 3.8 shows the treatment performance considerations that affect selection of the OSWT, and disposal technologies and the symbology used in the technologies' evaluations.

Tables 3.9 and 3.10 show summaries of the treatment performance of OSWT and disposal technologies, respectively. A review of the different technologies is presented subsequent to this section.

It is noted that a combination of a treatment technology followed by a disposal technology are required to meet DOH rules in Hawai'i. Sometimes more than one treatment technology may be required (e.g. ATU plus disinfection). Performance of treatment technologies is based upon recognized standards for removal of conventional water quality parameters including BOD_5, TSS, and pH; as well as other constituents such as total N, phosphorus (P), and fecal coliform bacteria (FC).

The National Sanitation Foundation Standard 40 (NSF40) includes detailed testing protocols and performance criteria for BOD_5, TSS, and pH. This standard requires secondary-level wastewater treatment that cannot be achieved in a septic tank alone. NSF certifies treatment units for a fee and maintains an online list of approved technologies (for an annual fee)[7]. NSF40 can be achieved in an ATU or with a septic tank combined with a Presby system and possibly also with a septic tank combined with several of the innovative and emerging technologies evaluated. The NSF245 standard encompasses NSF40 and adds to it a requirement of at least 50 percent removal of total N. This can be accomplished by an ATU designed as such (generally at greater cost) and/or by an advanced Presby system and possibly several of the innovative and emerging technologies.

[7] www.NSF.org

Table 3.8 Treatment Performance Considerations for Different OSWT and Disposal Technologies

Performance Metric	Symbology Shown in Technology Evaluation	Symbology Description
Application to Areas with High Cesspool Density	N	Technology should not be installed in areas with more than approximately 1 unit per acre because a higher level of treatment is necessary to avoid negative cumulative impacts
	Y	Technology may be installed in locations with 1 or more units per acre
Water Quality meets NSF40 criteria for CBOD5, TSS, and pH	Y	Technology is certified by the National Sanitation Foundation (NSF) as passing a 6-months performance test and meeting effluent water quality standards that include average $CBOD_5$ concentrations of less than 25 mg/L, TSS less than 30 mg/L, and pH between 6 and 9.
	N	Technology does not have NSF40 certification.
	N/A	Technology is not designed or intended to meet this metric
	Goal	Technologies for which meeting this standard is a goal, but certification has not yet been granted
Water Quality meets NSF245 criteria for total Nitrogen Removal	Y	Technology is certified by NSF as passing a 6-months performance test and meeting effluent water quality standards for NSF40 plus an average of at least 50 percent total nitrogen removal.
	N	Technology does not have NSF245 certification.
	N/A	Technology is not designed or intended to meet this metric
	Goal	Technologies for which meeting this standard is a goal, but certification has not yet been granted
Phosphorus Removal	Low	Technology may remove 10-20 percent of P due to bacteria uptake during metabolism of wastewater organic material
	Medium	Technology utilizes sand or sandy soil which facilitates some limited P removal by adsorption (20-30 percent)
	High	Technology utilizes clayey/silty/alluvial soils which facilitates significant P removal by adsorption (>50 percent)
	Medium/High	Technology utilizes a range of media types between Medium and High to remove P in a wide range
	Complete	Technology discharges zero quantity of P to the environment
	N/A	Technology is not designed or intended to remove P
Fecal Coliform Removal	Low	Technology may remove a portion of the fecal coliform ranging from 0 percent to less than 90 percent
	Medium	Technology may remove approximately 90 percent of fecal coliform.
	High	Technology may remove up to 99.99999 percent of fecal coliform
	Medium/High	Technology may remove between 99 and 99.99 percent of fecal coliform
	Complete	Technology discharges zero quantity of fecal coliforms to the environment
	N/A	Technology is not designed or intended to remove fecal coliforms

Table 3.9 Treatment Performance of OSWT Technologies

Technology	Technology Status	Application to Areas w/ High Cesspool Density	Water Quality meets NSF40 criteria for CBOD5, TSS, and pH(5)	Water Quality meets NSF245 for Total Nitrogen Removal(6)	Phosphorus Removal(7)	Fecal Coliform Removal
Septic Tank	Approved(1)	N	N	N	Low	Low
ATU with nitrification (ATU-N)	Approved(1)	Y	Y	N	Low	Medium
ATU with nitrification and denitrification (ATU-N-DN)	Approved(1)	Y	Y	Y	Low	Medium
Chlorine Disinfection	Approved(1)	Y	N	N	N/A	High
UV Disinfection	Approved(1)	Y	N	N	N/A	High
Recirculating Sand Filter	Approval Required(2)	Y	N	N	Low	Low
Eliminite	Innovative Technology(3)	Y	Goal	Goal	Low	Medium
NITREX	Innovative Technology(3)	Y	Goal	Goal	Low	Medium
Recirculating Gravel Filter System (WA)	Emerging Technology(4)	Y	Goal	N	Low	Low

Notes:
(1) Technology approved by DOH in HAR 11-62.
(2) Technology mentioned in HAR 11-62, but design review is required.
(3) "Innovative" technologies are commercially available outside of Hawai'i, but do not have established regulatory design criteria and would require design review by DOH WWB.
(4) "Emerging" technologies are at a research stage and/or pilot-testing and/or full-scale probationary approval in other states. They are not commercially available and do not have established regulatory design criteria. DOH WWB does not currently have a process for approving these technologies.
(5) National Sanitation Foundation (www.NSF.org), NSF Standard 40 testing protocol Class A effluent requirements.
(6) NSF Standard 245 testing protocol specifies at least 50 percent removal of total nitrogen (TN)
(7) Phosphorus removal is low during biological treatment (less than 20 percent), phosphorus removal is primarily due to absorption in soil.

Table 3.10 Treatment Performance of Disposal Technologies

Technology	Technology Status	Application to Areas w/ High Cesspool Density	Water Quality meets NSF40 criteria for CBOD5, TSS, and pH [5]	Water Quality meets NSF245 for Total Nitrogen Removal[6]	Phosphorus Removal[7]	Fecal Coliform Removal
Absorption Systems (Bed/Trench)	Approved[1]	Y	N/A	N/A	Medium/High[8]	Medium/High[8]
Seepage Pit	Approved[1]	N	N/A	N/A	Medium/High[8]	Medium/High[8]
Presby Advanced Enviro-Septic	Approved[1]	Y	Y	Y	Medium/High[8]	Medium/High[8]
Evapotranspiration	Approval Required[2]	Y	Y	Y	Complete	Complete
Constructed Wetland	Approval Required[2]	N	N/A	N/A	Medium	Medium
Drip Irrigation	Approval Required[2]	Y	N/A	N/A	Medium/High[8]	Medium/High[8]
Passive Treatment Units (medium and high treatment) (FL)	Innovative Technology[3]	Y	Goal	Goal	Medium/High[8]	Medium/High[8]
Disposal by Layered Soil Treatment ("Layer Cake") Systems (MA)	Emerging Technology[4]	Y	Goal	Goal	Medium/High[8]	Medium/High[8]
Disposal by Nitrification/Denitrification Biofilter (NY)	Emerging Technology[4]	Y	Goal	Goal	Medium/High[8]	Medium/High[8]

Notes:

(1) Technology approved by DOH in HAR 11-62.
(2) Technology mentioned in HAR 11-62, but design review is required.
(3) "Innovative" technologies are commercially available outside of Hawai'i, but do not have established regulatory design criteria and would require design review by DOH WWB.
(4) "Emerging" technologies are at a research stage and/or pilot-testing and/or full-scale probationary approval in other states. They are not commercially available and do not have established regulatory design criteria. DOH WWB does not currently have a process for approving these technologies.
(5) National Sanitation Foundation (www.NSF.org), NSF Standard 40 testing protocol Class A effluent requirements.
(6) NSF Standard 245 testing protocol specifies at least 50 percent removal of total nitrogen (TN)
(7) Phosphorus removal is low during biological treatment (less than 20 percent), phosphorus removal is primarily due to absorption in soil.
(8) Depends on soil type: for sandy soil = medium removal for all others = high

3.5.4 Operations and Maintenance

Table 3.11 shows the O&M considerations that affect selection of the OSWT, and disposal technologies and the symbology used in the technologies' evaluations.

Tables 3.12 and 3.13 show the summaries of the O&M considerations of OSWT and disposal technologies, respectively. A review of the different technologies is presented subsequent to this section.

Tables 3.12 and 3.13 show the approximate replacement intervals of 20, 30 or 60 years for each technology and a relative O&M quantity assessment for each treatment and disposal technology which ranges from None to Low to Medium to High. Tables 3.12 and 3.13 also include descriptions of the specific required O&M activities along with suggested intervals. Almost all cesspool replacement treatment and disposal technologies have O&M requirements, but the amount and frequencies are different. O&M requirements also have associated costs which add to the annual cost of the system and must be considered in a life-cycle-cost analysis (LCA).

Table 3.11 O&M Considerations for Different OSWT and Disposal Technologies

Performance Metric	Symbology Shown in Technology Evaluation	Symbology Description
Replacement Interval	20	Technology lifespan is estimated as 20 years prior to replacement with a new unit.
	30	Technology lifespan is estimated as 30 years prior to replacement with a new unit.
	60	Technology lifespan is estimated as 60 years or longer.
Operation and Maintenance Quantity	None	Technology does not require inspections, measurements, adjustments, repairs, cleaning, pumping, or inputs such as power or chemicals.
	Low	Technology requires inspection and pumping only every 2 to 4 years and may require minor landscape maintenance.
	Medium	Technology has a small pump, and requires annual cleaning and repair as needed
	High	Technology has one or more pumps, require more than annual inspections and adjustments, possibly require measurements, require annual cleaning, pumping and repair as needed.

Table 3.12 Operation and Maintenance Requirements for OSWT Technologies

Technology	Technology Status	Replacement Interval	O&M Level of Effort	Operations Requirements	Maintenance Requirements
Septic Tank	Approved[(1)]	60	Low	None	Inspection and pumping every 2 to 4 years
ATU with nitrification (ATU-N)	Approved[(1)]	30	High	Provide continuous electricity; Semi-annual inspection, measurements, and adjustments	Annual cleaning, repair (if needed) and pumping
ATU with nitrification and denitrification (ATU-N-DN)	Approved[(1)]	30	High	Provide continuous electricity; Semi-annual inspection, measurements, and adjustments	Annual cleaning, repair (if needed) and pumping
Chlorine Disinfection	Approved[(1)]	20	Medium	Check and add chlorine tablets every 2 to 4 weeks	Annual cleaning, repair (if needed)
UV Disinfection	Approved[(1)]	20	High	Provide continuous electricity to UV unit	Monthly cleaning of UV quartz sleeve, replace bulb as needed
Recirculating Sand Filter	Approval Required[(2)]	30	Medium	Provide continuous electricity to recirculation pump	Annual cleaning, repair (if needed)
Eliminite	Innovative Technology[(3)]	30	Medium	Provide continuous electricity to recirculation pump	Annual inspection, cleaning and rake-up of media as needed
NITREX	Innovative Technology[(3)]	30	Medium	Provide continuous electricity to recirculation pump	Annual inspection, cleaning and make-up of media as needed
Recirculating Gravel Filter System (WA)	Emerging Technology[(4)]	30	Medium	Provide continuous electricity to recirculation pump	Annual cleaning, repair (if needed)

Notes:
(1) Technology approved by DOH in HAR 11-62.
(2) Technology mentioned in HAR 11-62, but design review is required.
(3) "Innovative" technologies are commercially available outside of Hawai'i, but do not have established regulatory design criteria and would require design review by DOH WWB.
(4) "Emerging" technologies are at a research stage and/or pilot-testing and/or full-scale probationary approval in other states. They are not commercially available and do not have established regulatory design criteria. DOH WWB does not currently have a process for approving these technologies.

Table 3.13 Operation and Maintenance Requirements for Disposal Technologies

Technology	Technology Status	Replacement Interval	O&M Level of Effort	Operations Requirements	Maintenance Requirements
Absorption Systems (Bed/Trench)	Approved(1)	60	None	None	None
Seepage Pit	Approved(1)	60	Low	Low	Inspection and pumping every 2 to 4 years
Presby Advanced Enviro-Septic	Approved(1)	60	None	None	None
Evapotranspiration	Approval Required(2)	60	Low	Provide continuous electricity to small dosing pump	Trim vegetated area of ET system, replace plants as needed
Constructed Wetland	Approval Required(2)	30	Medium	Provide continuous electricity to small dosing pump	Trim vegetation in wetland, replace plants as needed, control insects and mosquitos
Drip Irrigation	Approval Required(2)	30	Medium	Provide continuous electricity to small dosing pump	Annual cleaning, repair (if needed) of pump
Passive Treatment Units (medium and high treatment) (FL)	Innovative Technology(3)	60	None	None	None
Disposal by Layered Soil Treatment ("Layer Cake") Systems (MA)	Emerging Technology(4)	60	None	None	None
Disposal by Nitrification/Denitrification Biofilter (NY)	Emerging Technology(4)	60	None	None	None

Notes:
(1) Technology approved by DOH in HAR 11-62.
(2) Technology mentioned in HAR 11-62, but design review is required.
(3) "Innovative" technologies are commercially available outside of Hawai'i, but do not have established regulatory design criteria and would require design review by DOH WWB.
(4) "Emerging" technologies are at a research stage and/or pilot-testing and/or full-scale probationary approval in other states. They are not commercially available and do not have established regulatory design criteria. DOH WWB does not currently have a process for approving these technologies.

3.5.5 Estimated Cesspool Retrofit Costs

In an attempt to estimate the cost of actual cesspool retrofits, data was analyzed from 83 total conversions throughout the State since 2016. Cost information was based on original receipts that were submitted to DOH WWB in order for the homeowner to qualify for the State Tax Credit Program. The resulting information is presented on Table 3.14. As indicated, the cost of conversion ranged from approximately $9,000 to as much as $60,000, depending on the type and size of system installed.

These large cost ranges illustrate that there are many factors involved in the cost of a cesspool retrofit which can include different site conditions (soil type, access, slope, etc.), different material costs, and different market conditions (e.g. number of available contractors). Such data show that it is challenging to come up with a "typical" cost, because there are so many variables – basically each project is different and generalizing costs is very difficult. We can observe that larger systems cost more, that ATU systems cost more than septic systems, and that the septic + Presby systems cost as much as the ATUs (however, there are only two data points).

Relative costs of the various treatment and disposal technologies are presented in Tables 3.15 and 3.16, respectively. It includes the relative capital costs (engineering, permitting, equipment and installation), operation costs (electricity), and maintenance costs (monitoring, upkeep, pumping).

Table 3.14 Costs of Retrofits Completed Since 2016 under State Tax Credit Program

Type	Size	No.	Cost ($)			
			Mean	Median	Low	High
Septic Tank + Absorption System	1 BR	2	19,803	19,803	10,813	28,792
	2 BR	3	16,435	12,400	10,500	26,406
	3 BR	13	18,817	14,790	9,399	45,797
	4 BR	13	21,989	19,800	9,787	45,550
	5 BR	42	23,688	22,850	8,925	52,356
	All	73	22,114	21,945	8,925	52,356
Aerobic Treatment Unit	2 BR	1	18,706	ND	ND	ND
	3 BR	2	22,500	22,500	20,000	25,000
	5 BR	5	33,298	26,339	21,760	59,585
	All	8	28,774	23,380	18,706	59,585
Septic Tank + Presby System	3 BR	1	24,160	ND	ND	ND
	4 BR	1	32,500	ND	ND	ND
Total		**2**	**28,330**	**ND**	**ND**	**ND**

Notes/Acronyms:
BR bedroom
ND Insufficient data available to provide additional statistics.

Table 3.15 Relative Costs of Various OSWT Technologies

Technology	Technology Status	Cost ($)		
		Construction	Operation	Maintenance
Septic Tank	Approved(1)	$$	0	$$$
ATU with nitrification (ATU-N)	Approved(1)	$$$	$$$	$$$
ATU with nitrification and denitrification (ATU-N-DN)	Approved(1)	$$$$	$$$	$$$
Chlorine Disinfection	Approved(1)	$	$$	$
UV Disinfection	Approved(1)	$	$$	$$$
Recirculating Sand Filter	Approval Required(2)	$$	$$$	$$$
Eliminite	Innovative Technology(3)	$$$	$$$	$$
NITREX	Innovative Technology(3)	$$/$$$	0	$$$
Recirculating Gravel Filter System (WA)	Emerging Technology(4)	$$	$$$	$$$

Notes:
(1) Technology approved by DOH in HAR 11-62.
(2) Technology mentioned in HAR 11-62, but design review is required.
(3) "Innovative" technologies are commercially available outside of Hawai'i, but do not have established regulatory design criteria and would require design review by DOH WWB.
(4) "Emerging" technologies are at a research stage and/or pilot-testing and/or full-scale probationary approval in other states. They are not commercially available and do not have established regulatory design criteria. DOH WWB does not currently have a process for approving these technologies.

Table 3.16 Relative Costs of Various Disposal Technologies

Technology	Technology Status	Cost ($)		
		Construction	Operation	Maintenance
Absorption Systems (Bed/Trench)	Approved(1)	$	0	0
Seepage Pit	Approved(1)	$ convert, $$$ new	0	$$$
Presby Advanced Enviro-Septic	Approved(1)	$$$	0	$
Evapotranspiration	Approval Required(2)	$$	$$	$$
Constructed Wetland	Approval Required(2)	$$	$$$	$$$
Drip Irrigation	Approval Required(2)	$$	$$$	$$
Passive Treatment Units (medium and high treatment) (FL)	Innovative Technology(3)	$$	0	0
Disposal by Layered Soil Treatment ("Layer Cake") Systems (MA)	Emerging Technology(4)	$$	0	0
Disposal by Nitrification / Denitrification Biofilter (NY)	Emerging Technology(4)	$$	0	0

Notes:
(1) Technology approved by DOH in HAR 11-62.
(2) Technology mentioned in HAR 11-62, but design review is required.
(3) "Innovative" technologies are commercially available outside of Hawai'i, but do not have established regulatory design criteria and would require design review by DOH WWB.
(4) "Emerging" technologies are at a research stage and/or pilot-testing and/or full-scale probationary approval in other states. They are not commercially available and do not have established regulatory design criteria. DOH WWB does not currently have a process for approving these technologies.

3.5.6 Benefits and Challenges

Tables 3.17 and 3.18 show a compilation of benefits and challenges of implementing the OSWT and disposal technologies, respectively. All the benefits and challenges of the OSWT and disposal systems need to be considered on a case by case basis.

Table 3.17 Benefits and Challenges of OSWT Technologies

Technology	Technology Status	Implementation Benefits	Implementation Challenges
Septic Tank	Approved(1)	Relatively simple, familiar, lower-cost installation; no electricity requirement and no operation requirements; long-interval pumping requirements; minimal site restrictions; long life	Minimal treatment performance
ATU with nitrification (ATU-N)	Approved(1)	Relatively simple, familiar installation; minimal site restrictions; high treatment performance	Higher cost installation; electricity required, periodic inspection and maintenance required; annual pumping likely required; shorter life
ATU with nitrification and denitrification (ATU-N-DN)	Approved(1)	Same as ATU w/N	Same as ATU w/N
Chlorine Disinfection	Approved(1)	Complete disinfection of pathogens achieved if maintained	Requires regular inspection for chemical use and replenishment (weekly); hazardous chemical storage required in cool dry location; chemical cost/availability
UV Disinfection	Approved(1)	Complete disinfection of pathogens achieved if maintained	Requires electricity; requires regular maintenance cleaning of bulbs (monthly) and regular replacement of bulbs (1-2 years)
Recirculating Sand Filter	Approval Required(2)	Enhanced biological treatment following a septic tank prior to disposal in seepage pit; medium cost; green option	Unfamiliar installation; design approval required; electricity required for dosing and recirculation pumps; maintenance of plantings required
Eliminite	Innovative Technology(3)	May achieve NSF 40 and NSF 245	High cost; approval process unclear; electricity may be required for dosing pump; maintenance unknown; lifespan unknown/untested
NITREX	Innovative Technology(3)	May achieve NSF 40 and NSF 245	High cost; approval process unclear; electricity may be required for dosing pump; maintenance unknown; lifespan unknown/untested
Recirculating Gravel Filter System (WA)	Emerging Technology(4)	May achieve NSF 40 and NSF 245	High cost; approval process unlearns; electricity required for circulation pump; maintenance unknown; lifespan unknown/untested

Notes:
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(2) Technology mentioned in HAR 11-62, but design review is required.
(3) "Innovative" technologies are commercially available outside of Hawaiʻi, but do not have established regulatory design criteria and would require design review by DOH WWB.
(4) "Emerging" technologies are at a research stage and/or pilot-testing and/or full-scale probationary approval in other states. They are not commercially available and do not have established regulatory design criteria. DOH WWB does not currently have a process for approving these technologies.

Table 3.18 Benefits and Challenges of Disposal Technologies

Technology	Technology Status	Implementation Benefits	Implementation Challenges
Absorption Systems (Bed/Trench)	Approved(1)	Relatively simple, familiar, lower-cost installation; no operation requirements; no maintenance requirements; long life	Cannot be used on small lots or large slopes or shallow groundwater or near water bodies; size related to local soil type; performance varies widely due to loading rate and soil type
Seepage Pit	Approved(1)	Can be a converted (cleaned and rehabilitated) cesspool at very low cost; no operation requirements; long-interval pumping requirements; minimal site restrictions; long life	Minimal treatment performance
Presby Advanced Enviro-Septic	Approved(1)	Installed in absorption bed following a septic tank; achieves NSF40; achieves NSF245 at additional cost; no operation requirements; no maintenance requirements; long life	Higher cost
Evapotranspiration	Approval Required(2)	Zero discharge (non-polluting) option; can be used where there is shallow groundwater or poor soils, and near water bodies; medium cost; long life	Design approval required; electricity required for dosing pump; maintenance of plantings required
Constructed Wetland	Approval Required(2)	Enhanced biological treatment following a septic tank prior to disposal in seepage pit; medium cost; green option	Unfamiliar installation; design approval required; electricity required for dosing pump; maintenance of plantings required
Drip Irrigation	Approval Required(2)	Can be used on small lots and steep slopes	High cost; design approval required; electricity required; maintenance required; specialized installation required
Passive Treatment Units (medium and high treatment) (FL)	Innovative Technology(3)	May achieve NSF 40 and NSF 245; no maintenance	High cost; approval process unclear; lifespan unknown/untested
Disposal by Layered Soil Treatment ("Layer Cake") Systems (MA)	Emerging Technology(4)	May achieve NSF 40 and NSF 245; no maintenance	High cost; approval process unlearn; lifespan unknown/untested
Disposal by Nitrification/Denitrification Biofilter (NY)	Emerging Technology(4)	May achieve NSF 40 and NSF 245	High cost; approval process unclear; electricity may be required for dosing pump; maintenance unknown; lifespan unknown/untested

Notes:
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(2) Technology mentioned in HAR 11-62, but design review is required.
(3) "Innovative" technologies are commercially available outside of Hawai'i, but do not have established regulatory design criteria and would require design review by DOH WWB.
(4) "Emerging" technologies are at a research stage and/or pilot-testing and/or full-scale probationary approval in other states. They are not commercially available and do not have established regulatory design criteria. DOH WWB does not currently have a process for approving these technologies.

3.6 Recommendations

The CCWG and their advisors will be developing a broader strategy to facilitate homeowners with the cesspool upgrades. The following sections provide initial recommendations to facilitate the development of the broader strategy relative to developing guidance on OSWT and disposal technology selection.

3.6.1 Approach to selecting OSWT and disposal technologies

Several different types of OSWT and disposal technologies were described and evaluated in this TM. In this section, an evaluation/ selection process of treatment and disposal technologies is suggested. In order to implement an OSWT and disposal system to replace a cesspool on a piece of property, the homeowner will have to hire a contractor and an engineer. These could be hired together or separately. If separately, the homeowner would hire the engineer first to complete the detailed site investigation and soil testing, complete the design and submit plans and reports to the DOH WWB for approval. Once approved, the homeowner would find a contractor holding the correct licenses and having experience installing OSWT and disposal systems. The contractor would submit the paperwork to obtain a building permit and would not begin work until the permit it granted from the County building department (in Honolulu: Department of Planning and Permitting). The engineer will have to do his/her work before a construction permit can be issued and construction of cesspool upgrades can begin. The engineer will go through the steps in the selection process.

This document can be used to inform and guide the homeowner through the process to see what the possibilities are, the different levels of performance and costs, and the benefits/challenges of what is likely possible for upgrade of a cesspool on their property. The suggested steps are as follows:

1. Gather site characteristics including conducting soil tests.
2. Check site restrictions to rule out un-feasible treatment and disposal options.
3. Check priority category – if Priority 1 – check with DOH WWB whether nitrogen removal is required.
4. Check performance levels for feasible treatment and disposal options.
5. Look at relative costs for combinations of feasible treatment and disposal options.
6. Consider benefits and challenges of feasible combinations of treatment and disposal and create a ranked list of feasible systems.
7. Homeowner: discuss ranked list with an experienced engineer. Engineer: prepare preliminary sketches/plans and submittals and meet with DOH WWB to discuss any issues.

3.6.2 Treatment trains

Several different OSWT and disposal technologies have been described in this report and could be paired in many combinations. In addition, in some cases, two or even three different treatment technologies may be needed in sequence. Overall, what is required is to determine a treatment train of processes to meet required objectives and desired outcomes and costs. A treatment train is a set of treatment and disposal technologies that work together to meet requirements and optimize other considerations. We have prepared a set of typical/feasible/practical/logical treatment trains (and possible future treatment trains) to meet the various treatment requirements (See Table 3.19). The following can be noted about the 35 treatment trains shown in Table 3.19:

- Treatment trains 1 through 16 all utilize technologies that are currently approved in Hawai'i
  - 1a, 1b, , 5a, 7a and 8 do not require DOH design review
  - 3a, 3b, 3c, 3d, 5b, 5c, 7b and 7c require DOH design review
  - 2, 4, 6 only apply to properties that are too small for absorption systems

  - 1c, 3b, 3c, 3d, 4, 5b, 7a, 7b, 7c and 8 could possibly be used in a Priority 1 designated cesspool upgrade area depending on site conditions
  - 9 of the treatment trains would meet NSF40 water quality criteria
  - 4 of the treatment train would meet both NSF40 and NSF 245
  - 5 of the treatment trains would completely remove coliform bacteria
- Treatment trains 17 through 24 all utilize septic tanks plus an additional innovative/emerging treatment technology that are not currently approved in Hawai'i and are designated as F (future)
- Treatment trains 25 through 34 all involve alternative toilets and graywater recycling systems
  - In each case black water and graywater are source-separated
  - 13a, 13b and 13c utilize septic tanks
  - 13d, 13e, 13f, 13g, 13h and 13i utilize ATUs or ATU-DNs
  - 13j requires no treatment unit, but requires changes to the graywater guidelines and is designated as F (future)

There are many other "possible" treatment trains, however, most/all would be illogical or overly expensive, and the ones shown are considered the most feasible and practical.

3.6.3 Develop Tools for Homeowners

The characteristics of several different type of treatment and disposal technologies have been described in this TM and the building blocks for a technology evaluation database is included. A helpful tool that could be developed for homeowners is a web or mobile device application ("app") to help them determine what OSWT and disposal options are most applicable for their cesspool conversion. The app could also integrate cesspool conversion funding and finance options and coordinated with mapping and other databases/tools through the other CCWG subgroups (e.g. data prioritization and validation, and public outreach).

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Table 3.19 Feasible Treatment Trains that Combine Treatment and Disposal Technologies to Meet Different Goals

No.	Treatment Train Name	Source	Treatment 1	Treatment 2	Treatment 3	Disposal	Notes	NSF40	NSF245 (N removal)	Coliform (pathogen removal)
1	1a	RAW	ST			SABS	Standard conventional/traditional system			
2	1b	RAW	ST			PBY	Presby disposal system	Y		
3	2	RAW	ST			SEEP	By DOH approval, only for lots too small for absorption systems			
4	3a	RAW	ST			WET	DOH design review required			
5	3b	RAW	ST			ET	DOH design review required, zero discharge			Y
6	3c	RAW	ST	RSF		SABS	DOH design review required			Y
7	3d	RAW	ST	RSF		DRIP	DOH design review required			
8	4	RAW	ST	RSF	DIS	SEEP	By DOH approval, only for lots too small for absorption systems and/or near surface water			Y
9	5a	RAW	ATU			SABS	Standard conventional/traditional system	Y		
10	5b	RAW	ATU			WET	DOH design review required	Y		
11	5c	RAW	ATU			DRIP	DOH design review required	Y		
12	6	RAW	ATU			SEEP	By DOH approval, only for lots too small for absorption systems	Y		
13	7a	RAW	ATU-DN			SABS	For properties near surface water	Y	Y	
14	7b	RAW	ATU-DN			WET or DRIP	By DOH approval, for properties near surface water	Y	Y	
15	7c	RAW	ATU-DN			ET	By DOH approval, for properties near surface water, zero discharge	Y	Y	Y
16	8	RAW	ATU-DN	DIS		SEEP	For properties near surface water	Y	Y	Y
17	9a	RAW	ST	ELM		SABS or WET or ET	Innovative treatment system, not currently DOH approved			
18	9b	RAW	ST	NTX		SABS or WET or ET	Innovative treatment system, not currently DOH approved			
19	9c	RAW	ST	ITUFL		SABS or WET or ET	Innovative treatment system, not currently DOH approved			
20	10	RAW	ST	ELM or NTX or ITUFL	DIS	SEEP	Innovative treatment system, only for lots too small for absorption systems and/or near surface water, not currently DOH approved			F
21	11a	RAW	ST	RGSWA		SABS or WET or ET	Emerging filtration system, not currently DOH approved			
22	11b	RAW	ST	LSTMA		SABS or WET or ET	Emerging filtration system, not currently DOH approved			
23	11c	RAW	ST	NDBFNY		SABS or WET or ET	Emerging filtration system, not currently DOH approved			
24	12	RAW	ST	RGSWA or LTSMA or NDBFNY	DIS	SEEP	Emerging treatment system, only for lots too small for absorption systems and/or near surface water, not currently DOH approved			F
25	13a	BW GW	ALTT GRAY	ST		SABS SEEP	Meets current graywater guidelines			
26	13b	BW GW	ALTT GRAY	ST		DRIP SEEP	Meets current graywater guidelines, DOH design review required			

No.	Treatment Train Name	Source	Treatment 1	Treatment 2	Treatment 3	Disposal	Notes	NSF40	NSF245 (N removal)	Coliform (pathogen removal)
27	13c	BW GW	ALTT GRAY	ST		ET SEEP	Meets current graywater guidelines, DOH design review required			Y
28	13d	BW GW	ALTT GRAY	ATU		SABS SEEP	Meets current graywater guidelines	Y		
29	13e	BW GW	ALTT GRAY	ATU		DRIP SEEP	Meets current graywater guidelines, DOH design review required	Y		
30	13f	BW GW	ALTT GRAY	ATU		ET SEEP	Meets current graywater guidelines, DOH design review required	Y		Y
31	13g	BW GW	ALTT GRAY	ATU-DN		SABS SEEP	Meets current graywater guidelines	Y	Y	
32	13h	BW GW	ALTT GRAY	ATU-DN		DRIP SEEP	Meets current graywater guidelines, DOH design review required	Y	Y	
33	13i	BW GW	ALTT GRAY	ATU-DN		ET SEEP	Meets current graywater guidelines, DOH design review required	Y	Y	Y
34	13j	BW GW	ALTT GRAY	w/Kitchen Sink limits		None SEEP	Requires changes to graywater Guidelines	F	F	F

Notes/Acronymns:
Y Yes
N No
F Future

ALTT Alternative Zero-discharge Toilets (composting, incinerating, nano-membrane)
ATU Aerobic Treatment Unit with nitrification
ATU-DN ATU with denitrification
BW Black Water Sewage
DIS Disinfection system (chlorine or UV)
DRIP Drip irrigation system
ELM Eliminite nitrogen removal system (innovative)
ET Evapotranspiration (zero-discharge) system
GRAY Graywater recycling system
GW Graywater
GWT Graywater Recycle Tank
ITUEL Innovative Treatment Units Developed in Florida
LSTMA Layer Soil Treatment Systems developed in Massachusetts
NDBFNY Emerging Nitrifying/Denitrifying Biofilters Developed in New York
NSF245 National Sanitation Foundation Standard 245 for enhanced nitrogen removal
NSF40 National Sanitation Foundation Standard 40 for secondary level treatment
NTX NITREX nitrogen removal system (innovative)
PBY Presby disposal system - standard
PBY-DN Presby system with De-Nyte nitrogen removal
RAW Raw Sewage
SABS Absorption System - trenches or beds, traditional or gravelless
SEEP Seepage Pit
ST Septic Tank
RGSWA Recirculating Gravel System (WA) (emerging)
WET Constructed Wetland System

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Appendix A

HAWAI'I ADMINISTRATIVE RULE, TITLE 11 DEPARTMENT OF HEALTH, CHAPTER 62 WASTEWATER SYSTEMS

Rules Amending Title 11
Hawaii Administrative Rules

(MAR 21 2016)

1. Chapter 62 of Title 11, Hawaii Administrative Rules, entitled "Wastewater Systems" is amended and compiled to read as follows:

"HAWAII ADMINISTRATIVE RULES

TITLE 11

DEPARTMENT OF HEALTH

CHAPTER 62

WASTEWATER SYSTEMS

Subchapter 1 Prohibitions and General Requirements

Subchapter 2 Wastewater Treatment Works

Subchapter 3 Individual Wastewater Systems

Subchapter 4 Wastewater Sludge Use and Disposal

Subchapter 5 Wastewater Management Permits and Registration

SUBCHAPTER 1

PROHIBITIONS AND GENERAL REQUIREMENTS

§11-62-01 Preamble. The department of health seeks to ensure that the use and disposal of wastewater and wastewater sludge does not contaminate or pollute any valuable water resource, does not give rise to public nuisance, and does not become a hazard or potential hazard to the public health, safety, and welfare.

The department of health seeks to migrate towards an ultimate goal of regional sewage collection, treatment and disposal systems that are consistent with state and county wastewater planning policies. Off-site treatment and disposal systems, followed in priority by on-site systems, meeting health and environmental standards will be allowed whenever they are consistent with state and county wastewater planning policies and on the premise that these systems will eventually connect to regional sewage systems. Individual wastewater systems may be utilized in remote areas and in areas of low population density. Hawai`i is long overdue in eliminating construction of wastewater disposal systems depositing untreated sewage into the environment, such as cesspools. Indeed, the department stated in its prior rules back in the 1990's, with the agreement of all counties' wastewater advisory committees, that installation of new cesspools should end after the year 2000.

The department of health seeks to work in close partnership with the counties to manage wastewater to prevent pollution and harm to public health, safety and welfare. Each county may participate in the implementation of these rules through the recommendations of a county wastewater advisory committee to the director.

The department of health seeks to advance the use of recycled water and wastewater sludge consistent with public health and safety and environmental quality. The state department of health acknowledges that when properly treated and used, all recycled water and wastewater sludge are valuable resources with environmental and economic benefits and can be used to conserve the State's precious resources. The director acknowledges that the most highly treated recycled water and exceptional quality wastewater sludge can be used for a wide variety of applications with the appropriate restrictions and when best management practices and other requirements of this chapter are met. [Eff 12/10/88; am and comp 12/09/2004; am and comp MAR 21 2016] (Auth: HRS §§321-11, 322-8(a), 342D-4, 342D-5, 342E-3)(Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-50, 342E-3)

§11-62-02 <u>Purpose and applicability.</u> (a) This chapter seeks to ensure that the use and disposal of wastewater and wastewater sludge from wastewater systems:

(1) Do not contaminate or pollute any drinking water or potential drinking water supply, or the waters of any beaches, shores, ponds, lakes, streams, groundwater, or shellfish growing waters;
(2) Do not encourage the harborage of insects, rodents, or other possible vectors;
(3) Do not give rise to nuisances;
(4) Do not become a hazard or a potential hazard to public health, safety and welfare;
(5) Contribute to the achievement of wastewater management goals contained in approved county water quality management plans;
(6) Reinforce state and county planning policies; and
(7) Are consistent with the State's administration of the National Pollutant Discharge Elimination System.

(b) This chapter seeks to advance the appropriate uses of recycled water and wastewater sludge.

(c) This chapter allows and does not preempt provisions in county codes, rules or ordinances that are not inconsistent with these rules, including, without limitation:

(1) Plumbing requirements in county plumbing codes or rules, including county adoptions of all or parts of the Uniform Plumbing Code;

(2) Sanitary sewer system and wastewater treatment works use permission and pretreatment requirements in county ordinances or rules regarding the introduction of fats, oils, grease, septage, sludge, or wastewater into sanitary sewers or wastewater treatment works, requirements on the use of grease traps, and requirements on wastewater and wastewater sludge pumping and hauling;

(3) Storm sewer system use permission requirements in county ordinances or rules; or

(4) Water recycling requirements in county ordinances or rules, including requirements for connection to or use of available recycled water. [Eff 12/10/88; am and comp 12/09/2004; am and comp MAR 21 2016] (Auth: HRS §§321-11, 322-8(a), 342D-4, 342D-5, 342E-3) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-50, 342E-3; HRS ch. 340E; 33 U.S.C. §§1311, 1342, 1345; 40 CFR Parts 122, 123, 501, 503)

§11-62-03 <u>Definitions.</u> As used in this chapter:

"Activated sludge process" means a biological wastewater treatment process in which a mixture of wastewater and microorganisms is agitated with induced aeration. Aeration supplies dissolved oxygen and wastewater supplies the organic substrate necessary for microorganism growth. This process includes sedimentation units which follow the aeration and where settled solids are withdrawn for disposal or returned to the aeration unit.

"Aerobic treatment unit system" shall have the same meaning as defined in Chapter 235, HRS.

"Aerosol" means a solid suspended in air with or without preceding evaporation.

"Bedrock" means a continuous horizontal layer of hardened mineral deposits that does not support the growth of common plant life.

"Bedroom" means any room within a dwelling that is or might reasonably be used as a sleeping room. A room is presumed to be a bedroom if it has a superficial floor area not less than seventy square feet and is provided with windows or skylights with an area of not less than one-tenth of the floor area or ten square feet, whichever is greater.

"Best management practices" or "BMPs" means the most effective, practical schedules of activities, prohibitions of conduct, maintenance procedures, and other specifications of conduct to prevent or reduce the pollution. BMPs also include treatment requirements, operating procedures, and practices to site runoff, spillage or leaks, sludge or waste disposal, and drainage from raw material storage.

"BOD_5" means five days biochemical oxygen demand as measured by a standard test indicating the quantity of oxygen utilized by wastewater under controlled conditions of temperature and time.

"Building" means a structure, permanent or temporary, built, erected, and framed of component structural parts used or designed for the housing, shelter, workplace, enclosure or support of persons, animals or property of any kind.

"Building modification" means any change to an existing building's configuration that may result in the increase in wastewater flows or change in the wastewater characteristics.

"Cesspool" means an individual wastewater system consisting of an excavation in the ground whose depth is greater than its widest surface dimension, which receives untreated wastewater, and retains or is designed to retain the organic matter and solids discharging therein, but permits the liquid to seep through its bottom or sides to gain access to the underground formation.

"Collection system" means the conveyance system, which includes the building and street sewer laterals, Interceptor sewer, sewage pump station, and force main, used to transport the sewage to the treatment unit.

"Composite sample" means sample(s) collected on regular intervals in proportion to the existing flow or volume and then combined to form a sample that represents the flow or volume over a period of time or space.

"Compost toilet" means a non-flush, waterless toilet that employs an aerobic composting process to treat toilet wastes.

"Confined work areas" means any area having a limited means of egress, which is subject to the accumulation of toxic or flammable contaminants or has an oxygen deficient atmosphere. Confined work areas include, but are not limited to, storage tanks, process vessels, bins, ventilation or exhaust ducts, sewers, underground utility vaults, tunnels, pipelines, and open top spaces more than four feet in depth such as pits, tubs, vaults and vessels.

"Construction" in the context of a wastewater system means the building of the system in the ground; construction is not completed until the system has been fully installed so that it is ready for hookup.

"Contractor" means the installer of a wastewater system or any part of a wastewater system.

"County" means any county of the state.

"Critical Wastewater Disposal Area (CWDA)" means an area where the disposal of wastewater has or may cause adverse effects on human health or the environment due to existing hydrogeological conditions.

"Department" means the department of health.

"Director" means the director of health or the director's duly authorized agent, including a contractor of the director.

"Disinfection" means a process to destroy, neutralize, or inhibit the growth of pathogenic microbes.

"Disposal system" means any sewer, sewer outfall, sewer lateral, seepage pit, cesspool, injection well, soil absorption system, disposal trench, or other facility used in the disposal of wastewater or wastewater sludge, including any wastewater transmission lines, pumps, power, or other equipment associated with the ultimate disposal of wastewater or wastewater sludge.

"Distribution box" means a watertight chamber from which effluent from a treatment unit is distributed evenly to various portions of a disposal system.

"Drip irrigation" means application of water and wastewater, including recycled water, from emitters, either on the surface or subsurface, that are part of a piping system alongside the plants being irrigated and that discharges at a rate not to exceed two gallons per hour per emitter.

"Domestic sewage" is waste and wastewater from humans or household operations that is:

(1) Discharged to or otherwise enters a treatment works; or
(2) Of a type that is usually discharged to or otherwise enters a treatment works or an individual wastewater system.

"Domestic wastewater" has the same meaning as "domestic sewage".

"Dwelling" means any building which is wholly or partly used or intended to be used for living or sleeping by human occupants and includes, but is not limited to, apartment houses, single family houses, duplex houses, cluster houses, townhouses, and planned developments, but excludes hotels and lodging houses.

"Dwelling unit" means any habitable room or group of habitable rooms located within a dwelling and forming a single habitable unit with facilities which are used or intended to be used for living, sleeping, cooking, and eating.

"Engineer" means a professional engineer registered in the State of Hawaii.

"EPA" means the United States Environmental Protection Agency.

"EPA's methods for chemical analysis of water and wastes" means the 1979 edition of "Methods for Chemical Analysis of Water and Wastes" as published by the EPA.

"Evapotranspiration system" means a subsurface disposal system which relies on soil capillarity and plant uptake to dispose of treated effluent through surface evaporation and plant transpiration.

"Exceptional quality sludge" means wastewater sludge that has been treated to a level specified in this chapter in which it may be used with little or no restrictions for land application.

"Existing" means constructed under a valid county permit or with written approval from the director before the effective date of this rule.

"Filter fabric" means a woven or spun-bonded sheet material used to impede or prevent the movement of sand, silt and clay through the filter material. This material shall be non-biodegradable, resistant to acids and alkalies within a pH range of 4 to 10, and resistant to common solvents.

"Grab sample" means a single discrete sample of wastewater collected at a particular time and place which represents the composition of the source at that time and place.

"Graywater" shall have the same meaning as defined in HRS section 342D-1.

"Haul" means the transport of an item by vehicle or boat.

"Holding tank" means a nonportable, watertight closed vault used or designed to temporarily hold domestic wastewater.

"Household aerobic unit" means an individual wastewater system which receives domestic wastewater from dwellings or from other sources generating wastewater of a similar volume and strength, and retains solids, aerobically digests organic matter over a period of time, and allows the clarified effluent to discharge outside the tank into a disposal system.

"Individual permit" means a document issued under this rule to a specific person for a specific facility, or practice to generate, treat, use, dispose, or discharge of wastewater and wastewater sludge at a specific location.

"Individual wastewater systems" means facilities, such as septic systems, aerobic treatment units, and cesspools, that are not connected to a sewer and are used and designed to receive and dispose of:

(1) No more than one thousand gallons per day of domestic wastewater; or

(2) Greater than one thousand gallons per day of domestic wastewater from buildings with highly variable flows.

"Injection well" has the same meaning as defined in chapter 11-23.

"Land application" means the spraying or spreading of wastewater sludge onto the land surface, the injection of wastewater sludge below the land surface, or the incorporation of wastewater sludge into the soil such that the wastewater sludge can either condition the soil or fertilize crops or vegetation grown in the soil.

"Large capacity cesspool" means a cesspool that serves more than one residential dwelling or, for a non-residential cesspool, has the capacity to serve twenty or more persons per day.

"Living area" means the portion(s) of a dwelling unit including, but not limited to, the bedroom, kitchen, bathroom, living room, family room, covered lanai, den, and library, but excluding the garage, carport, open lanai, fence, and utility shed.

"Makai" means toward the sea or the area outside the Underground Injection Control (UIC) Line encircling the protected aquifer.

"Manual of Septic Tank Practice" means the United States Department of Health, Education and Welfare Publication No. (HSM) 72-10020, formerly known as "PHS Publication No. 526", revised in 1967.

"Modal time" means the amount of time elapsed between the time that a tracer, such as salt or dye, is injected into the influent at the entrance to a chamber and the time that the highest concentration of the tracer is observed in water where it is discharged from the chamber.

"Mound system" means a soil absorption system which is installed in or below an artificially created mound or earth.

"MPN" means most probable number.

"New" means constructed on or after the effective date of this chapter.

"Non-domestic wastewater" means all wastewater excluding domestic wastewater.

"Non-exceptional quality wastewater sludge" means wastewater sludge that is not exceptional quality wastewater sludge.

"Owner" means a person(s) who has legal title to a treatment works or individual wastewater system, or duly authorized representative of the owner.

"Pathogenic organisms" means disease-causing organisms. These include, but are not limited to, certain bacteria, protozoa, viruses, and viable helminth ova.

"Person" has the same meaning as defined in section 342D-1, HRS.

"Person who prepares wastewater sludge" means anyone who generates wastewater sludge during the treatment of wastewater in a wastewater treatment works, a person who derives a material from wastewater sludge, a person who provides treatment of wastewater sludge, or a person who changes the quality of wastewater sludge.

"pH" means the logarithm of the reciprocal of the hydrogen ion concentration measured at 25 degrees Celsius or measured at another temperature and then converted to an equivalent value at 25 degrees Celsius.

"Private" means not owned or operated by a federal, state, or county authority.

"Proposed" means put forward for consideration or suggested to the director. For the purposes of this chapter, "proposed" shall refer to the plans for a wastewater system or activity.

"Public" means, for issues of ownership, owned or operated by a federal, state, or county authority.

"Public water system" has the same meaning as defined in chapter 11-20.

"Qualified cesspool" shall have the same meaning as defined in Chapter 235, HRS.

"Qualified expenses" shall have the same meaning as defined in Chapter 235, HRS.

"R-1 water" means recycled water that has been oxidized, filtered, and disinfected to meet the corresponding standards set in this chapter.

"R-2 water" means recycled water that has been oxidized and disinfected to meet the corresponding standards set in this chapter.

"R-3 water" means recycled water that has been oxidized to meet secondary treatment standards as set forth by EPA.

"Recycled water" means treated wastewater that by design is intended or used for a beneficial purpose.

"Recycled water system" means a facility which conveys to users or uses recycled water. Recycled water systems are subdivided into distribution and use systems. Recycled water systems include all piping, storage, and repressurization facilities to deliver recycled water to users, but exclude treatment units.

"Residential large capacity cesspool" shall have the same meaning as defined in HRS section 342D-1.

"Reuse guidelines" means the "Guidelines for the treatment and use of reclaimed water", Hawaii State Department of Health, Wastewater Branch, November 23, 1993, revised January 2016.

"Seepage pit" means an excavation in the ground whose depth is greater than its widest surface dimension and which receives the discharge from treatment units and permits the effluent to exit through its bottom or sides for gradual seepage into the ground which does not result in contamination of water-bearing formations or surface water.

"Septage" means either a liquid or solid material removed from a septic tank, cesspool, portable toilet, Type III marine sanitation device, or similar treatment works that receives wastewater.

"Septic system" shall have the same meaning as defined in Chapter 235, HRS.

"Septic tank" means a watertight receptacle that receives the raw wastewater, retains after settling solid matter or sewage for treatment by bacteria, and discharges a partially treated effluent.

"Sewage sludge" means any solid, semi-solid, or liquid residue removed during the treatment of municipal wastewater or domestic sewage. Sewage sludge includes, but is not limited to, solids removed during primary, secondary, or advanced wastewater treatment, scum, septage, portable toilet pumping, Type III Marine Sanitation device pumpings (33 Code of

Federal Regulations Part 159), and sewage sludge products. Sewage sludge does not include grit, screenings, or ash generated during the incineration of sewage sludge.

"Sewer" means a pipe or conduit or any other appurtenances that carry wastewater from a building or buildings to a specific point for treatment and disposal.

"Sewer system" shall have the same meaning as defined in Chapter 235, HRS.

"Soil absorption" means a process which uses the soil to treat and dispose of effluent from a treatment unit.

"Spray irrigation" means application of water and wastewater, including recycled water, to the land to maintain vegetation or support the growth of vegetation by spraying the water and wastewater above ground from sprinklers, micro-sprinklers, or orifices in piping.

"SS" means suspended solids and indicates the characteristic state of solids in wastewater.

"Standard methods" means the 22^{nd} edition, 2014, of "Standard Methods for the Examination of Water and Wastewater" as published by the American Water Works Association, American Public Health Association and the Water Pollution Control Federation, unless another edition is specified by the director.

"State waters" shall have the same meaning as defined in section 342D-1, HRS.

"Subsurface disposal system" means a disposal system that allows the gradual seepage of effluent into the ground which does not result in contamination of water-bearing formations or surface water, such as a seepage pit, cesspool, soil absorption system, or other facility used in the disposal of wastewater, including any wastewater transmission lines, pumps, power, or other equipment associated with the disposal of wastewater.

"Subsurface drip irrigation" means the application of water and wastewater, including recycled water, to the land to maintain vegetation or to support the growth of vegetation by discharging or emitting the water and wastewater from orifices in piping below the surface or finished grade.

"Suitable soil" means a soil which acts as an effective filter in the removal of organisms and suspended solids before the effluent reaches any highly permeable earth formations, bedrock, or groundwater.

"Surface disposal" means the placing of wastewater sludge on the land for final disposal and includes storage on land for two or more years.

"Surface irrigation" means the application of water and wastewater, including recycled water, by means other than spraying.

"Ten States Standards" means the 1980 edition of the Recommended Standards for Individual Sewage Systems, a report by the committee of the Great Lakes-Upper Mississippi River Board of State Sanitary Engineers on the policies for review and approval of plans and specifications for individual wastewater systems.

"Theoretical detention time" means the value obtained by dividing the volume of a chamber, through which fluid flows, by the flow rate expressed in amount of fluid volume per unit of time.

"Treatment unit" means any plant, facility, or equipment used in the treatment of wastewater, including the necessary pumps, power equipment, blowers, motors, holding tanks, flow splitter, and other process equipment.

"Treatment works" means any treatment unit and its associated collection system and disposal system, excluding individual wastewater systems.

"Vector attraction" means the characteristic of wastewater sludge that attracts rodents, flies, mosquitoes, or other organisms capable of transporting infectious agents.

"Wastewater" means any liquid waste, whether treated or not, and whether animal, mineral, or vegetable, including agricultural, industrial, and thermal wastes.

"Wastewater sludge" has the same meaning as "sewage sludge".

"Wastewater sludge facility" means a facility which collects, handles, stores, treats, or disposes of wastewater sludge. Wastewater sludge facilities shall exclude individual wastewater systems.

"Wastewater system" means the category of all wastewater and wastewater sludge treatment, use, and disposal systems, including all wastewater treatment works, collection systems, wastewater sludge facilities, recycled water systems, and individual wastewater systems.

"Water pollution" has the same meaning as defined in section 342D-1, HRS.

"Watertight" means constructed so that no water can enter and discharge except through the inlet and outlet pipe respectively. [Eff 12/10/88; am 8/30/91; am and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 328(a), 342D-1, 342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-1, 342D-2, 342D-4, 342D-5, 342D-50, 342E-3; 40 CFR Parts 501, 503, 40 CFR §501.2)

§11-62-04 <u>County wastewater advisory committee.</u> (a) The mayor of each county may request that the director form a county wastewater advisory committee ("committee"), and the mayor may nominate its members, who may include representatives of the county water supply, public works, planning, and land utilization departments, labor, industry, environmental groups, and other interested people. The chief of the environmental management division on Oahu and the district environmental health program chiefs on the neighbor islands shall serve as ex officio members of their respective county committees. The department shall provide technical and support services for the committee.

(b) The primary role of the committee is to review and make recommendations to the director on the application of this chapter on matters which are unique to each county, on the establishment of critical wastewater disposal areas, on proposals which are not specifically addressed in these rules, and upon the director's request, for applications for variances. The committee's recommendations shall seek to advance the purposes of this chapter.

[Eff 12/10/88; am 8/30/91; am and comp 12/09/2004; am and comp MAR 21 2016] (Auth: HRS §§321-11,342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-50)

§11-62-05 Critical wastewater disposal areas (CWDA). (a) All areas of the State are critical wastewater disposal areas.

(b) The director may impose more stringent requirements than those specified in this chapter for wastewater systems located or proposed to be located within areas that require additional protection. Requirements that the director may impose include, but are not limited to, meeting higher effluent standards for wastewater systems, limiting the method of effluent disposal, and requiring flow restriction devices on water fixtures. [Eff 12/10/88; am 8/30/91; am and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11,342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-50)

§11-62-06 General requirements. Owners shall comply with these requirements: (a) All buildings used or occupied as a dwelling, all public buildings, and all buildings and places of assembly generating wastewater or with toilets, sinks, drains, or other plumbing fixtures capable of conveying wastewater, shall be connected to a wastewater system. In addition, any new building capable of generating wastewater shall be connected to a wastewater system which meets the requirements of this rule.

(b) All buildings and places of assembly generating wastewater or with toilets, sinks, drains, or other plumbing fixtures capable of conveying wastewater and located within or near an available public sewer system as determined by the director, shall connect to the public sewer.

(c) All wastewater systems shall be designed, constructed, operated, and maintained in accordance with this chapter.

(d) Operation and maintenance. All wastewater systems and parts thereof that are installed or used by persons to achieve compliance with this chapter and the conditions of any department approval for use issued under this rule shall at all times be properly operated and maintained. Proper operation and maintenance includes adequate laboratory controls and appropriate quality assurance procedures as specified by the director. Effluent testing for private wastewater systems shall be performed by an independent laboratory. Proper operation and maintenance also includes operation of any required back-up or auxiliary facilities or similar systems as specified by the director to be installed to achieve compliance with this chapter and the conditions of any department approval for use issued under this chapter.

(e) No holding tank, except for public facilities, and no privy shall be used. No portable toilets shall be used for any permanent structure unless approved by the director.

(f) No person or the owner shall cause or allow any wastewater system to create or contribute to any of the following:

(1) Human illness;
(2) Public health hazard;
(3) Nuisance;
(4) Unsanitary condition;
(5) Wastewater spill, overflow, or discharge into surface waters or the contamination or pollution of state waters, except in compliance with a permit or variance issued under chapter 11-55, or a water quality certification or waiver obtained under chapter 11-54;
(6) A wastewater spill, overflow, or discharge (spill) onto the ground, except for R-1 water from a recycled water system that is implementing BMPs approved by the director. The burden of proof is on the recycled water system's owner or operator to demonstrate that the spill qualifies for this exception;

(7) Harborage of vectors, including insects and rodents;
(8) Foul or noxious odors;
(9) Public safety hazard; or
(10) Contamination, pollution, or endangerment of drinking waters, except in compliance with a permit issued under chapter 11-23.

(g) Notice. If any of the conditions in subsection (f) exist, the owner or the person responsible for the wastewater system shall notify the director immediately, unless for subsection (f)(5) and (f)(6), the owner or person responsible demonstrates compliance with the protocol attached to this chapter as Appendix B, entitled Responses for Wastewater Spills, Overflows, and Discharges ("Spills") dated July 1, 2014.

(h) In case of a violation of this chapter, the director, at the director's discretion, shall initiate enforcement action against the owner(s) of the wastewater system and initiate enforcement action against other persons to have the offending condition abated, corrected, or removed. In addition, once a violation of this chapter occurs, the director shall order the owner to take immediate actions to protect public health and safety.

(i) Duty to mitigate. The owners of wastewater systems shall take steps to minimize or prevent the use and disposal of wastewater or wastewater sludge in violation of this chapter which has a reasonable likelihood of adversely affecting human health or the environment.

(j) Upon request by the director, proposed wastewater systems in critical wastewater disposal areas shall be approved in writing or by rule by the respective county board of water supply or department of water supply.

(k) If applicable, a wastewater system involving the subsurface disposal of wastewater shall be in compliance with chapter 11-23.

(l) Approvals to-construct the wastewater system shall be considered invalid if:

(1) A county does not issue a building permit for a private building within one year after

the director approves the wastewater system, or the construction of the wastewater system has not begun within one year of the approval; and

(2) A county revokes or rescinds a building permit and the building is to be served by a wastewater system that was approved in conjunction with the building permit application. Reapproval of any wastewater system for which the director's approval has been rescinded or determined invalid pursuant to this paragraph shall be based on the applicable rules in effect at the time the request for reapproval is made.

(m) The director, at the director's discretion, may require that a wastewater system be upgraded to meet the applicable requirements of this chapter whenever a building modification is proposed that may change the nature or quantity of the wastewater flowing to the wastewater system. The modifications may include but not be limited to adding additional bedrooms to a dwelling or adding a restaurant to a shopping complex. The director, at the director's discretion, may also require that a wastewater system be upgraded if any of the following conditions exists:

(1) The existing wastewater system has created or contributed to any of the conditions noted in subsection (f);
(2) The existing wastewater disposal system has within the last twelve months been pumped more than twice or has spilled wastewater more than once;
(3) The existing wastewater system disposes untreated wastewater directly into the groundwater table; or
(4) The owner of the existing wastewater system has not satisfactorily addressed all of the deficiencies noted by the director.

(n) Modifications to wastewater systems that may affect the quality or quantity of the wastewater and wastewater sludge shall meet the applicable provisions of this chapter.

(o) Actions taken by the director to evaluate and determine possible measures to achieve compliance with this chapter do not guarantee that an approved wastewater system will function satisfactorily for any period of time, or mean that department employees are liable for any damages, consequential or direct, that are or may be caused by a malfunction of the wastewater systems.

(p) Duty to comply. The owners of any wastewater system shall comply with all applicable provisions of this chapter. In addition, all owners shall comply with all conditions of any department approval for use issued under this chapter. Any noncompliance constitutes a violation and is grounds for: enforcement action; department approval for use termination, revocation and reissuance, or modification; or denial of a department approval for use renewal application.

(q) In cases where the director is required to conduct an inspection at a location outside the State, the owner of the wastewater system shall be required to cover all costs related to the inspection. [Eff 12/10/88; am 8/30/91; am and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 322-8(a), 342D-4, 342D-5, 342D-15, 342E-3) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-6, 342D-50, 342E-3; HRS chs. 340E; 33 U.S.C. §§1311, 1342, 1345; 40 CFR Parts 122, 123, 40 CFR §501.15(b)(6))

§11-62-07 REPEALED [R 8/30/91]

§11-62-07.1 <u>Requirements for non-domestic wastewater.</u> (a) <u>The director will review the</u> use and disposal of non-domestic wastewater on a case-by-case basis.

(b) Non-domestic wastewater includes, but is not limited to:

(1) Wastewater from agricultural, commercial, or industrial activities or operations;

(2) Solids, semi-solids, or liquids removed from the non-domestic wastewater;
(3) Wastewater that contains a mix of both domestic and non-domestic wastewater; or
(4) Solids, semi-solids, or liquids removed from wastewater that contains a mix of both domestic and non-domestic wastewater.

(c) Buildings and operations generating non-domestic wastewater, including farms, shall meet the specific requirements of this chapter as determined to be applicable by the director.

(1) Wherever applicable, the director shall use the requirements for non-domestic wastewater as set forth by the EPA, Chapter 11-23, the Department's Guidelines for the Treatment and Reuse of Recycled Water, and wherever applicable, Department's Guidelines for Livestock Waste Management. The Guidelines are available on-line at the Wastewater Branch section of the department's website. Construction plans and engineering reports for proposed non-domestic wastewater systems shall be sufficient in scope and depth for determining compliance with the provisions of this chapter.
(2) Any building or facility which is located within the state agricultural land use district, county agricultural zoned districts, or conservation districts may be exempt from the provisions of subchapters 2 and 3 for its non-domestic wastewater provided that the buildings or facilities are essential to the operation of an agricultural enterprise or consistent with the conservation district use intent. The owner shall submit for the director's approval plans or engineering reports, or both, for the wastewater systems proposed to accommodate the wastewater generated from any building or facility in this category. Information submitted shall be sufficient in scope and depth for determining the adequacy

of performance of the wastewater system in meeting the provisions of this chapter.

(d) In determining treatment requirements for the non-domestic wastewater, the director shall use requirements for non-domestic wastewater as set forth by EPA, Chapter 11-23, the Department's Guidelines for the Treatment and Reuse of Recycled Water and the Department's Guidelines for Livestock Waste Management. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 322-8(a), 342E-3) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342E-3)

§11-62-08 Other requirements for wastewater systems. (a) Purpose.

(1) It is the purpose of this section and subchapters 2, 3, and 4 to set forth minimum requirements for the following purposes:
   (A) To clarify responsibilities of owners, engineers, and the department;
   (B) To set minimum distance requirements so that nuisances are avoided;
   (C) To set minimum requirements to protect public health, safety, and welfare, and to protect the wastewater systems from malicious damage or unauthorized entry; and
   (D) To emphasize the need for proper design, installation, operation, and maintenance.

(2) This section and subchapters 2, 3, and 4 give the engineer designing the wastewater system flexibility and design responsibility. The design engineer is responsible for the choice of equipment, types of treatment processes used, structural integrity, electrical components, disposal system designs, adequate work space, accessibility for operation, maintenance and repair, redundancy of major equipment and processes, corrosion control,

and all other major aspects of wastewater system design.

(3) Nothing in this chapter shall be construed to prevent the engineer from exceeding the minimum requirements if the engineer determines that specific conditions warrant such additional measures.

(b) No person shall construct, modify the construction of, or modify the use of a wastewater system without the approval of the director. The following documents shall be submitted to the director prior to such approval:

(1) Construction plans prepared by or under the supervision of an engineer indicating the following:

(A) Acreage, address, and tax map key number(s) of the project site;

(B) Plot plan drawn to scale showing the location of the proposed and any existing wastewater system and its distances from existing and proposed buildings, structures, legal boundaries, property lines, adjacent surface bodies of water, drinking water sources, and existing public sewers within 2,000 feet of the nearest property line; and

(C) Sufficient details to show compliance with all applicable requirements of this chapter.

(2) Construction plans for an individual wastewater system prepared by the engineer showing sufficient details to enable the contractor to construct the individual wastewater system.

(3) Wastewater sludge use and disposal plan indicating how the wastewater sludge facility will comply with subchapter 4.

(c) Whenever applicable, the design flow of any development to be served by a wastewater system shall be based on Appendix D, Table I, dated July 1, 2014, except as provided by section 11-62-24(b).

(d) Measures to control public accessibility to all treatment units shall be provided to prevent accidents, drownings, vandalism, and interference with the treatment process. At a minimum, the provisions shall include:

(1) Fencing or other secured enclosures at least six feet in height with no more than three and a half inch clear openings or spaces for treatment units with exposed water surfaces or equipment; or

(2) Completely enclosed treatment units with unexposed water surfaces and equipment. Access openings to completely enclosed treatment unit(s) and equipment shall be secured and properly identified, and be large enough to allow removal of equipment from the facility.

(e) No person shall use the area adjacent to or directly above any wastewater system for purposes or activities which may hinder or interfere with the operation and maintenance, modification, or replacement of the wastewater system.

(f) No person shall operate a wastewater system unless that person or the owner of the wastewater system is authorized by the director in accordance with the applicable provisions of sections 11-62-23.1(e) and 11-62-31.1(f) and the applicable provisions of chapter 11-61. The director may inspect the wastewater system or its site at any time before authorizing the use of the system and may require advance notice of the engineer's inspection.

(g) All wastewater systems shall be constructed or modified by a person meeting the requirements of chapter 444, HRS, and any pertinent rules adopted by the department of commerce and consumer affairs, State of Hawaii. [Eff 8/30/91; am and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 342D-4, 342D-5, 342E-3) (Imp: §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-6, 342D-50, 342E-3)

§11-62-09 Public access to information. (a) The following information is available for public inspection:

(1) The name and address of any person seeking or obtaining registration, an individual permit, or department approval for use of an individual wastewater system; and

(2) Registration information and forms, registrations, individual permit applications and permits, department approval for use of an individual wastewater system, sludge and effluent data, and reports required to be submitted under this chapter. This includes information submitted on the forms themselves and any attachments used to supply information required by the forms.

(b) This section is not intended to limit chapter 92F, HRS, or any other law requiring the disclosure of information.

(c) Applications for request for public information regarding wastewater system shall be made in writing on forms furnished by the director. At a minimum, the application shall identify where the wastewater system is, including when possible the applicable street address to and tax map key of the lot, and a mailing address which the information is to be sent. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§91-2, 92-21, 342D-4, 342D-5, 342D-14) (Imp: HRS §§91-2, 92-21, 342D-2, 342D-4, 342D-5, 342D-6, 342D-14, 342D-55)

§11-62-10 Public hearings and informational meetings. (a) The director may hold a public hearing in the director's discretion, when such a hearing may help the director's decision on a matter regulated by this chapter or for another reason which the director considers to be in the public interest.

(b) The director may hold a public informational meeting when the director considers it to be in the public interest. [Eff and comp 12/09/04; comp

MAR 21 2016] (Auth: HRS §§342D-4, 342D-5, 342D-6) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-57; 40 CFR Part 501, §501.15(d)(7))

§11-62-11 Incorporation by reference. Appendices A through E, dated July 1, 2014, located at the end of this chapter, are made a part of this chapter. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: 342D-4, 342D-5) (Imp: 342D-4, 342D-5, 342D-6)

§11-62-12 Timely processing. (a) This section applies to applications for a permit, license, certificate, or any form of approval required under this chapter.

(b) The director shall approve, approve with conditions, or deny a complete application and notify the applicant accordingly within one hundred eighty days of the receipt of the complete application. Otherwise, the application is deemed automatically approved on the one hundred eighty-first day.

(c) The director shall determine and notify an applicant of the completeness or deficiency of an application covered by this section, including payment of required fees, within forty-five days of receipt of the application. Failure by the applicant to provide additional information, pay the fees, or correct a deficiency for completeness of the application is sufficient ground to suspend or terminate a review of the application. The director shall determine and notify an applicant of the completeness of a revised application covered by this section, including payment of required fees, within thirty days of receipt of the revised completed application.

(d) Notice to the applicant shall be complete upon mailing, facsimile transmission, or electronic mail transmission.

(e) The period for the director's action includes all calendar days, but if the period ends on a Saturday, Sunday, or state holiday, the period extends to the next working day.

(f) The one hundred eighty day period for the director's action under subsection (b) applies to the director's initial decision and notice. The initial decision and notice do not become untimely if later there is a request for hearing, an actual hearing, a lawsuit, or other challenges to the initial decision which prevents it from becoming final.

(g) The time for the director's action and notice to the applicant shall be extended when allowed by section 91-13.5, HRS.

(h) Any action taken and any wastewater system or sludge facility built, modified, or operated under an automatic approval shall comply with all applicable requirements of this chapter, and the automatic approval is effective for a period of one year. [Eff 10/21/00; comp 12/09/04; am and com MAR 21 2016] (Auth: HRS §§91-13.5, 322-11, 322-8(a), 342D-4, 342D-5) (Imp: HRS §91-13.5)

SUBCHAPTER 2

WASTEWATER TREATMENT WORKS

§11-62-21 REPEALED [R 8/30/91]

§11-62-22 REPEALED [R 8/30/91]

§11-62-23 REPEALED [R 8/30/91]

§11-62-23.1 Specific requirements for wastewater treatment works. (a) In addition to the requirements of section 11-62-08(b), the following documents shall be submitted to the director prior to approval to construct the treatment works:

(1) A written declaration signed and dated by the engineer that the proposed treatment works was designed to meet all applicable

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effluent requirements of sections 11-62-26 and 11-62-27; and

(2) Certification by the owner of a proposed treatment works that the treatment works shall be operated and maintained in accordance with all of the provisions of the operation and maintenance manual developed pursuant to subsection (d)(2). The owner shall certify that the operation and maintenance manual shall be available to the operator of the treatment works and shall further certify that, upon sale or transfer of ownership of the treatment works, the sale or transfer will include construction drawings, equipment manuals, operational data collected, and the appropriate transfer documents and provisions binding the new owner to the operation and maintenance manual.

(b) All treatment works shall be provided with a continuous effluent flow measuring device such that daily wastewater flow can be determined. For treatment works with design flows equal to or greater than 100,000 gallons per day, the continuous effluent flow measuring device shall include recording equipment to totalize or chart daily flows.

(c) Unless otherwise specified by the director, the following distance requirements apply to all treatment works:

(1) Treatment units, except as provided in paragraph (3), shall not be less than twenty-five feet from any property lines nor less than ten feet from any building and swimming pools;

(2) Disposal systems, excluding effluent irrigation systems, shall not be less than five feet from a property line nor less than five feet from any building; and

(3) Completely enclosed, locked, and ventilated equipment rooms used to house items such as blowers, motors, pumps, electrical controls, and chemical feeders shall not be less than

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five feet from property lines or less than ten feet from dwelling unit(s).

(d) No person shall operate a treatment works unless the following documents are provided:

(1) A written declaration signed and dated by the engineer responsible for the preparation of the operation and maintenance manual for the treatment works, that the operation and maintenance manual meets paragraph (2) and that if the treatment works is operated in accordance with the manual, all applicable effluent requirements will be met; and

(2) An operation and maintenance manual prepared by the engineer. The manual as a minimum, shall provide the details on the following:
   - (A) Operation and maintenance instructions for each pump station and treatment unit or process under normal and emergency conditions such as power outage and equipment malfunction;
   - (B) Operation and maintenance instructions for the disposal system including procedures for purging or chemical "shock loading" to prevent or eliminate biological growth in the subsurface disposal system;
   - (C) List of required sampling frequencies and analyses to be conducted by the operator;
   - (D) Troubleshooting, corrective, and preventive measures to be taken to maintain process control and treatment performance;
   - (E) Start-up procedures;
   - (F) Applicable state effluent requirements;
   - (G) Instructions on wasting and disposal of wastewater sludge;
   - (H) Manpower requirements needed to operate and maintain the treatment works;
   - (I) List of critical parts of the treatment works;
   - (J) "As-built" drawings of the treatment works;

(K) List of required daily activities, checks, and observations;
(L) Logs or report forms for all operation and maintenance activities performed;
(M) Flow schematic diagrams with details of piping and valving;
(N) Plot plan of the treatment works and Project site including all collection lines and equipment;
(O) Details on all safety equipment at the treatment works site, any applicable spare parts, maintenance, and operation instructions; and
(P) Details on all monitoring equipment including spare parts, maintenance, and operating instructions.

(e) No person shall operate a treatment works until it has been inspected to the director's satisfaction and the director has authorized in writing the use of the treatment works.

(1) The owner's engineer shall inspect the treatment works and submit to the director a final inspection report stating whether the wastewater treatment works has been constructed according to the submitted plans approved by the director and identifying any discrepancies and their resolutions. Any discrepancy between the constructed treatment works and the approved plans is sufficient reason to withhold approval to operate the treatment works.
(2) Before operation of the treatment works, the owner shall resolve all discrepancies.
(3) Any changes to the approved plan shall be resubmitted to the director for approval before the final inspection.
(4) The inspection shall not be considered final until the constructed treatment works conforms to the approved plans.

(f) After the first year of operation, the owner's engineer shall submit to the director a written statement based on results of actual sampling and professional judgment of whether or not the treatment works is meeting and at the design flow will meet the applicable effluent requirements of sections 11-62-26 and 11-62-27. If the treatment works is not meeting the applicable effluent requirements, the owner's engineer shall submit to the director a corrective action report containing:

(1) An analysis of the cause of the treatment works' failure to meet the effluent requirements and an estimate of the scope of the corrective action necessary to enable the treatment works to be in compliance;

(2) A schedule for undertaking the corrective actions; and

(3) A date by which the treatment works shall be in compliance with the applicable effluent requirements.

(g) Treatment works shall be designed with safety in mind and comply with appropriate provisions of the Occupational Safety and Health Standards of the State of Hawaii, Department of Labor and Industrial Relations.

(h) Upon abandoning, retiring, or permanently discontinuing use of a treatment works, the owner shall render it safe by removing it or filling it completely with earth, sand, gravel, or similar non-organic matter. All above ground portions of the treatment works shall be rendered safe and vector free. Electrical components shall be disconnected at the circuit breaker or source and all access openings sealed. Injection wells shall be abandoned in accordance with chapter 11-23.

(i) For public wastewater treatment works, a facility plan shall be initiated when the actual wastewater flow reaches 75 per cent of the design capacity of the wastewater treatment works. Implementation of the recommendation of the facility plan shall be initiated when the actual wastewater flow reaches 90 per cent of the design capacity of the wastewater treatment works.

(j) The owner or operator shall provide standby power for all lift stations to prevent unauthorized discharges of wastewater during a primary power outage.

(k) For all treatment works which produce recycled water, the director shall be guided by the requirements of subchapter 1, other applicable sections of this subchapter, and the Reuse Guidelines for all decisions on production of recycled water. [Eff 8/30/91; am and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-6, 342D-50)

§11-62-24 Treatment unit requirements. (a) For private wastewater treatment works of required design capacities of less than 100,000 gallons per day:

(1) For sludge digesters or aerated sludge holding tanks constructed after December 10, 1988, the sludge digesters or aerated sludge holding tanks shall treat and store at least the amount of sludge generated over a twenty day period;
(2) Except for subsurface disposal systems, continuous disinfection of the treated effluent shall be provided for treatment works unless otherwise approved or ordered by the director;
(3) For aeration tanks constructed after December 10, 1988, the aeration tank loading shall not exceed 12.5 pounds of BOD_5 per 1,000 cubic feet. For the sequencing batch reactor process, food to microorganism (F/M) ratios shall be between 0.05 and 0.10;
(4) For final settling tanks constructed after December 10, 1988, the detention time for final settling tanks shall not be less than four hours and the surface overflow rate shall not exceed 300 gallons per day per square foot based on the average daily flow;
(5) For treatment works constructed after December 10, 1988, flow equalization shall be provided unless the engineer submits written justification that changes in normal daily flow rate or seasonal occupancy rates

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shall not affect the treatment unit's ability to meet continuous compliance with the effluent requirements of sections 11-62-25, 11-62-26, and 11-62-27;

(6) For treatment works constructed after December 10, 1988, easy access shall be provided for operators to allow necessary operation, maintenance, and repair. Completely enclosed treatment units with unexposed water surfaces and equipment shall not be allowed unless the design engineer can satisfy the director that provisions have been included to eliminate confined space work areas and to allow accessibility for necessary operation, maintenance, and repair, and replacement; and

(7) For all treatment units utilizing gas chlorination for disinfection, the following equipment shall be provided: chlorine gas leak detector and alarm, self contained breathing apparatus, chlorine gas mask, warning signs, and an emergency eyewash and shower.

(b) New and proposed private wastewater treatment works of required design capacity greater than or equal to 100,000 gallons per day and new and proposed county wastewater treatment works shall comply with the design standards of their respective counties. If a county does not have wastewater treatment works design standards, then the design standards of the City and County of Honolulu shall be used.

(c) Private wastewater treatment works with design flows greater than or equal to 100,000 gallons shall have solids dewatering equipment included in the facility design. [Eff 12/10/88, am 8/30/91; am and comp 12/09/04; am and comp MAR 21 2016](Auth: HRS §§321-11, 342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-6, 342D-50)

§11-62-25 Wastewater effluent disposal systems.
(a) New and proposed effluent disposal systems.
(1) Effluent disposal systems shall at least consist of a primary disposal component and a separate 100 per cent back-up disposal component.
(2) The primary disposal component and the back-up disposal component shall each be designed to handle the peak flow. The peak flow shall be determined in accordance with the design standards of their respective county. If a county does not have design standards, the design standards of the City and County of Honolulu shall be used. Other means of determining the peak flow, as recommended by the design engineer, may be approved by the director.
(3) Each disposal component shall be tested to accommodate the wastewater flow as required in paragraph (2).

(b) For treatment works utilizing subsurface disposal systems, design data and other pertinent data shall be submitted to and approved by the director on a case-by-case basis. Decisions by the director shall be guided by subchapter 1 and other applicable sections of this subchapter.

(c) All wastewater effluent disposal systems shall include provisions to facilitate operation, maintenance, and inspection.

(d) All wastewater subsurface effluent disposal systems and injection wells shall include provisions for purging and chemical "shock loading". [Eff 12/10/88, am 8/30/91; am and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-6, 342D-50)

§11-62-26 Wastewater effluent requirements, recycled water quality, monitoring, and reporting requirements applicable to treatment works treating domestic wastewater. (a) All treatment works shall meet the applicable requirements of this section.

Nothing in this section shall be construed to prevent the engineer from applying more stringent requirements if the engineer determines that the particular design and circumstances for which the engineer is responsible warrants the more stringent requirements.

(b) Treatment works' effluent and other parameters shall be monitored as follows and shall not exceed the following limits:

(1) Biochemical oxygen demand (BOD_5).

(A) For wastewater treatment works excluding wastewater pond systems with average daily flows greater than or equal to 100,000 gallons per day, the owner or operator shall perform composite sampling at least weekly.

(B) For wastewater treatment works with average daily flows less than 100,000 gallons per day, the owner or operator shall perform grab sampling at least monthly.

(C) For wastewater pond systems with average daily flows greater than or equal to 100,000 gallons per day, the owner or operator shall perform grab sampling at least weekly.

(D) The BOD_5 in the effluent from a treatment works shall not exceed 30 milligrams per liter based on the monthly average of the results of the analyses of composite samples.

(E) The BOD_5 in the effluent from a treatment works shall not exceed 60 milligrams per liter based on a grab sample.

(2) Suspended solids.

(A) For wastewater treatment works, except for wastewater pond systems, with average daily flows greater than or equal to 100,000 gallons per day, the owner or operator shall perform composite sampling at least weekly.

(B) For wastewater treatment works with average daily flows less than 100,000 gallons per day, the owner or operator shall perform grab sampling at least monthly.
(C) For wastewater pond systems with average daily flows greater than or equal to 100,000 gallons per day, the owner or operator shall perform grab sampling at least weekly.
(D) The suspended solids in the effluent from a treatment works shall not exceed 30 milligrams per liter based on the monthly average of the results of the analyses of composite samples.
(E) The suspended solids in the effluent from a treatment works shall not exceed 60 milligrams per liter based on a grab sample.

(3) Owners or authorized agents shall submit suspended solids and BOD_5 lab data to the director no later than thirty days after the last day of June and December, unless the data is already being submitted to the Department under an NPDES permit by a public agency.
(4) The dissolved oxygen, pH, and 30 minutes settleability of the contents of the aeration tank shall be sampled and analyzed at least weekly.
(5) Effluent chlorine residual, if any, shall be sampled and analyzed at least weekly.
(6) Total daily flow shall be monitored at least weekly.
(7) The volume of wastewater sludge wasted, the solids concentration of wastewater sludge wasted, the name of the wastewater sludge pumping and hauling firm, and the dates of pumping and hauling, if applicable, shall be recorded.
(8) The operator shall maintain a log book or records which shall include but not be limited to: the date and time of operator

entry, operating conditions, process control testing performed, and any servicing or preventative maintenance done while at the wastewater treatment works.

(9) Alternative effluent limitations as permitted by EPA regulations, (40 CFR 125 and 40 CFR 133), relating to the definition of secondary treatment or other industrial categories, may be utilized by the director.

(10) For the purposes of this section, the arithmetic average of the results of the analyses of composite samples shall be based upon one or more analyses made within a 30 consecutive calendar day period. The arithmetic average shall be the sum of the results of all analyses divided by the number of analyses made during the 30 consecutive calendar day period.

(11) For the purposes of this section, composite samples shall consist of at least eight sample aliquots, collected at periodic intervals during the operating hours of the facility over a 24-hour period. The composite sample must be flow proportional; either the time interval between each aliquot or the volume of each aliquot must be proportional to either the stream flow at the time of sampling or the total stream flow since the collection of the previous aliquot. Aliquots may be collected manually or automatically.

(c) In addition to subsection (b), treatment works producing R-1 water or R-2 water for recycled water systems shall provide continuous disinfection of the effluent as specified below unless otherwise specified by the director.

(1) R-1 water disinfection requirements.

(A) For chlorine disinfection process. The disinfection process shall provide a CT (the product of total chlorine residual and modal contact time measured at the same point) value of not less than 450 milligrams-minutes per liter at all times with a modal contact time of at least ninety minutes based on peak dry weather design flow; or

(B) For non-chlorine disinfection processes. The disinfection process shall demonstrate to the director's satisfaction the inactivation and removal of 99.999 per cent of the plaque forming units of F-specific bacteriophage MS2 or polio virus in the wastewater.

(2) R-2 water disinfection requirements.

(A) For chlorine disinfection processes.

(i) A theoretical contact time of fifteen minutes or more and an actual modal time of ten minutes or more throughout which the chlorine residual is 0.5 milligrams per liter or greater; and

(ii) Automatic continuous measuring and recording of chlorine residual shall be provided. The chlorine facilities shall have adequate capacity to maintain a residual of 2 milligrams per liter.

(B) For non-chlorine disinfection processes.

(i) The disinfection process shall demonstrate to the director's satisfaction the ability to meet the requirements of subsection (d)(2); and

(ii) Automatic controls shall be provided to continuously measure and record disinfection dosage and residuals, if any.

(3) Monitoring shall be by grab samples that shall be taken at a point following disinfection.

(d) In addition to subsections (b) and (c), treatment works producing R-1 water or R-2 water for recycled water systems shall meet the following daily fecal coliform requirements unless other sampling frequencies are approved by the director. Monitoring shall be by grab samples that shall be taken at a point following disinfection.

(1) R-1 water.

(A) The median density measured in the disinfected effluent shall not exceed 2.2/100 milliliters using the bacteriological results of the last seven days for which analyses have been completed;

(B) The density shall not exceed 23/100 milliliters in more than one sample in any thirty day period; and

(C) The density in any one sample shall not exceed 200/100 milliliters.

(2) R-2 water.

(A) The median density as measured in the disinfected effluent shall not exceed 23/100 milliliters using the bacteriological results of the last seven days for which analyses have been completed; and

(B) The density of shall not exceed 200/100 milliliters in more than one sample in any thirty day period.

(e) In addition to subsections (b) through (d), treatment works producing R-1 water for recycled water systems shall provide continuous turbidity monitoring and recording prior to the filtration process and at a point after the filters and before application of the disinfectant. The R-1 water shall meet the following turbidity limits:

(1) For filtration systems utilizing sand or granular media, cloth, or other synthetic media, the turbidity shall not exceed any of the following:

(A) An average of two nephelometric turbidity units (NTU) within a twenty-four hour period;

(B) 5 NTU more than five percent of the time within a twenty-four hour period; and

(C) 10 NTU at any time.

(2) For filtration systems utilizing membrane filtration, the turbidity shall not exceed any of the following:

(A) 0.2 NTU more than five percent of the time within a twenty-four hour period; and

(B) 0.5 NTU at any time.

(f) When using media filtration for existing R-1 facilities the following performance criteria shall apply:

(1) The design UV dose shall be at least 100 mJ/cm^2 under maximum daily flow; and

(2) The filtered UV transmittance shall be 55 percent or greater at 254 nanometers (nm).

(g) When using membrane filtration for existing R-1 facilities, the following performance criteria shall apply:

(1) The design UV dose shall be at least 80 mJ/cm^2 under maximum daily flow; and

(2) The filtered effluent UV transmittance shall be 65 percent or greater at 254 nm.

(h) The minimum acceptable design requirements and commissioning of new UV disinfection systems shall comply with the Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse, Third Edition, 2003, published by the National Water Research Institute.

(g) The analysis, including the handling and preservation of samples, to determine compliance with effluent requirements shall be performed in accordance with Standard Methods or EPA's Methods for Chemical Analysis of Water and Wastes. The director may approve alternative methods for analyzing the effluent limits of this section. The alternative test methods, when approved, may be used by the director to determine compliance with effluent limits as stated in this rule. [Eff 12/10/88, am 8/30/91; am and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-6, 342D-50)

§11-62-27 Recycled water systems. (a) No recycled water system shall be constructed, used, or modified without written approval by the director.

(b) In reviewing recycled water systems and in addition to this chapter, the director shall be guided by the Reuse Guidelines.

(c) Before using recycled water, the owner of the recycled water system shall submit to the director the following information:

(1) Name, address, and phone number of the owner and party responsible for the application of recycled water at the site (if different from the owner);

(2) Clear identification of the people who will actually operate and maintain the system, if different from paragraph (1);

(3) Detailed site information on the water recycling application site and its surroundings, including site name, address, and tax map key number(s), a map indicating specific areas of use, areas of public access, surrounding land use, location of all wells within a one-fourth mile radius, description of nearest housing or public area, setbacks, general location of existing and proposed water and sewer lines, the direction of drainage with a description of how the drainage will flow, and the depth to groundwater underlying the irrigated area with a description of the ground water quality; and

(4) Information sufficient to show compliance with the requirements of subsection (h), and identification of best management practices.

(d) Before using recycled water, the owner of the recycled water system shall also submit to the director for approval an engineering report or recycled water application. The report or application form shall include the following information and shall clearly identify all best management practices to be implemented:

(1) An irrigation use plan that includes information on application rates, intended

uses, and schedules for recycled water use. The irrigation use plan shall also include information on types of vegetation, types and methods of irrigation, proposed irrigation schedules, vegetative consumption rates, water balance calculations, nutrient balance calculations, and the corresponding acreage to be used for irrigation;

(2) An overflow control plan that includes detailed best management practices to control or minimize runoff or ponding or recycled water;

(3) A management plan that includes establishment and delineation of the responsibilities of operation and maintenance of the recycled water system;

(4) A public information and access plan, to minimize public contact with the recycled water, that includes methods to adequately inform the public that recycled water is being used and that the recycled water is unfit for human consumption; and methods to control public access to the recycled water system and areas of recycled water use;

(5) A labeling plan to distinguish piping and appurtenances which carry or contain recycled water from those for potable water;

(6) An employee training plan that describes the training that the employees will receive to ensure compliance with this chapter and any other features specified by the director;

(7) A vector control plan (if applicable); and

(8) A groundwater monitoring plan (if applicable), including formulation of a strategy for the observation and surveillance of groundwater for possible sources of pollution.

(e) For existing users of recycled water, the owner of the recycled water system shall submit the information and plans required in subsections (c) and (d), except for the information contained in subsection (d)(1) regarding the vegetative consumption rates and water balance, and subsection (d)(8) regarding groundwater monitoring. For users of non R-1 recycled water spray irrigation systems, the owner shall also describe the methods and controls used to ensure that public contact with aerosols are minimized.

(f) For new users of recycled water obtaining access to an existing recycle water system, the user shall submit the information and plans required in subsections (c) and (d), except for the information contained in (d)(1) regarding vegetative consumption rates and water balance, and subsection (d)(8) regarding groundwater monitoring. For users of non R-1 recycled water spray irrigations systems, the owner shall also describe the methods and controls used to ensure that public contact with aerosols are minimized.

(g) For recycled distribution water systems, the owner of the recycled water distribution system shall submit an engineering report or recycled water application containing the following information:

(1) Name, address, and phone number of the owner and party responsible for the recycled water distribution system (if different from the owner);

(2) Information about the treatment works supplying the recycled water, including the name, address, tax map key number, and owner's name;

(3) Maps showing the location of the distribution system layout. The maps shall also include the location of all water and sewer lines;

(4) A labeling plan to distinguish piping and appurtenances which carry or contain recycled water from those for potable water; and

(5) A description of how the distribution system complies with this chapter and the Reuse Guidelines.

(h) The engineering report or application required in subsection (d), (e), (f), or (g) plus any other submittals shall contain sufficient information to assure the director that the degree of treatment and reliability is commensurate with the proposed use, that the distribution and use of the recycled water will not create a health hazard or nuisance, and that the director is able to make decisions in accordance with subsection (b).

(i) For recycled water systems that use recycled water, the owner of the recycled water system shall operate the system in accordance with the requirements of this chapter and to the maximum extent practicable shall:

(1) Irrigate at a rate not greater than the plants use it;
(2) Minimize recycled water runoff and ponding on the ground;
(3) Post signs or other devices warning the public not to drink, swim, or otherwise come into contact with the recycled water;
(4) Keep the public away from the areas being irrigated with recycled water;
(5) Clearly mark pipes, tanks, valves, and equipment used in recycled water use systems such that they are easily differentiated from potable water systems;
(6) Provide training to employees such that they are aware of this chapter and any conditions the director imposed on the recycled water use system;
(7) Provide control measures to minimize vector nuisances; and
(8) Monitor groundwater as required by the director.

(j) The owners of new, proposed, or modified recycled water systems, where applicable, shall provide adequate storage basin(s) or a backup disposal system to prevent any overflows or discharges from the system when the irrigation system is not in operation or when recycled water quantities exceed the irrigation requirements.

(k) Spills, overflows, and discharges ("spills") of recycled water shall be responded to as required by section 11-62-06(f) and (g) and Appendix B, entitled

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Responses for Wastewater Spills, Overflows, and Discharges ("Spills"), dated July 1, 2014.

(l) For recycled water systems, the owner or the owner's duly authorized agent, unless otherwise directed, shall report the following information to the director:

(1) The volume of recycled water used, the volume of recycled water stored, the volume and location of any recycled water spills, and details on the irrigated areas, including water budgets, precipitation, evaporation, application rates, and monitoring of best management practices; and

(2) Reported information shall be submitted by February 19 of each year and shall be in a monthly summary format for the preceding calendar year unless otherwise specified or agreed to by the director. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-6, 342D-50; 33 U.S.C. §§1311, 1342; 40 CFR Parts 122, 123)

Historical note: §11-62-27 is based substantially upon §11-62-25(b)(1), (b)(2), and (c). [Eff 12/10/88; am and comp 8/30/91]

§11-62-28 Additional monitoring, recordkeeping, and reporting. (a) The owners of treatment works or the owners' duly authorized agents shall maintain complete records of operation and maintenance, repairs, replacements, and improvements performed or installed at the treatment works.

(b) The monitoring results, reports, and all records required in sections 11-62-26 and 11-26-27, this section, and Appendix B, entitled Responses for Wastewater Spills, Overflows, and Discharges ("Spills"), dated July 1, 2014, located at the end of this chapter shall be kept on site and available for the director's inspection for at least two years and a copy made available to the director without charge upon the director's request. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-6, 342D-50)

§§11-62-29 (Reserved)

SUBCHAPTER 3

INDIVIDUAL WASTEWATER SYSTEMS

§11-62-31 REPEALED [R 8/30/91]

§11-62-31.1 General requirements for individual wastewater systems. (a) Individual wastewater systems may be used as a temporary on-site means of wastewater disposal in lieu of wastewater treatment works under the following conditions:

(1) Developments involving dwellings.
   (A) There shall be 10,000 square feet of land area for each individual wastewater system;
   (B) Total development of an area shall not exceed fifty single family residential lots or exceed fifty dwelling units except for developments consisting of one dwelling unit per acre or greater;
   (C) Area of the lot shall not be less than 10,000 square feet, except for lots created and recorded before August 30, 1991. For lots less than 10,000 square feet which were created and recorded before August 30, 1991, only one individual wastewater system shall be allowed.
   (D) The total wastewater flow into one individual wastewater system shall not exceed one thousand gallons, and one

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individual wastewater system shall not serve more than five bedrooms, whether they are in one dwelling unit or two.

(2) Developments involving buildings other than dwellings.

(A) There shall be 10,000 square feet of usable land area for each individual wastewater system. Usable land area shall not include the area under buildings;

(B) The total wastewater flow of the development shall not exceed 15,000 gallons per day;

(C) Area of the lot shall not be less than 10,000 square feet except for lots created and recorded before August 30, 1991. For lots less than 10,000 square feet which were created and recorded before August 30, 1991, only one individual wastewater system shall be allowed; and

(D) The total wastewater flow into each individual wastewater system shall not exceed one thousand gallons per day.

(b) Whenever an individual wastewater system is allowed under subsection (a), the following shall apply:

(1) The director may allow an individual wastewater system other than a cesspool to be used for two dwelling units which may or may not be located within the same building, provided that:

(A) Both of the dwelling units are located on the same single family residential lot; and

(B) The individual wastewater system used shall meet the current requirements of this chapter.

(2) A building may use more than one individual wastewater system where each individual wastewater system shall connect to a single dwelling unit.

(3) For buildings without any dwelling units:
 (A) More than one individual wastewater system may be used provided that the building is owned by one person; or
 (B) Upon the director's discretion, buildings may connect to one individual wastewater system other than a cesspool provided the buildings are located on the same lot and the buildings generate wastewater of similar strength and character.

(4) For buildings, other than dwellings with highly variable wastewater flow rates, such as but not limited to schools, parks, and churches, the individual wastewater system excluding cesspools may exceed a design flow rate of 1000 gallons per day; provided that the density does not exceed 1000 gallons per day per 10,000 square feet of useable land area and the development is owned by one person.

(c) The director may require the installation of dry sewers as a condition of approval of proposed individual wastewater systems where:

(1) Public sewers exist but are at capacity such that connection is prohibited but remedial actions have been initiated to increase the public sewer capacity;

(2) Public sewers exist, but the treatment and disposal system is not complete or operational;

(3) Design of the public sewers has been completed and construction of the public sewers is imminent; or

(4) Conditions warrant such requirements.

(d) No cesspool shall be used as the wastewater system by any new building. No new cesspools shall be constructed after the effective date of this rule unless they have been approved for construction before the effective date of this rule.

(e) Before the approval of the operation of an individual wastewater system excluding cesspools, the following requirements shall be satisfied:

(1) An operation and maintenance manual developed pursuant to section 11-62-23.1(d)(2) as applicable shall be submitted and approved by the director; and

(2) The owner of the individual wastewater system shall certify that the individual wastewater system shall be operated and maintained in accordance with all of the provisions of the operation and maintenance manual developed pursuant to paragraph (1). The certification shall include a statement that upon sale or transfer of ownership of the individual wastewater system, the sale or transfer will include the appropriate transfer documents and provisions binding the new owner to the operation and maintenance manual.

(f) No person shall use an individual wastewater system until authorized in writing by the director.

(1) Written approval to use an individual wastewater system shall be issued if:

(A) The owner resolves all discrepancies recorded as a result of any inspections conducted.

(B) The engineer furnishes a final inspection report to the director within thirty days after the completion of the construction which provides the following information:

(i) A certification that the individual wastewater system was constructed and installed in accordance with the approved plans and specifications or that changes made to the approved plans and specifications are accepted by the engineer; and

(ii) An "as-built" plan of the individual wastewater system; and

(2) The director may inspect the individual wastewater system or its site at any time before approving the system and may require advance notice of the engineer's inspection.

(g) A graywater system shall be designed in accordance with Chapter 3-183.

(h) Each individual wastewater system shall be an independent system and shall have all of its plumbing, treatment (if any), and disposal components separate from any other wastewater system.

(i) Wastewater into an individual wastewater system from buildings other than dwellings shall meet the pretreatment standards and local pollutant limits as set by the respective county. If the county does not have any local pollutant limits, the local limits as set forth by the City and County of Honolulu shall be used.

(j) Certification of a qualified cesspool. A taxpayer seeking a cesspool upgrade, conversion, or connection income tax credit must obtain a certification by the director indicating: that the cesspool location makes it eligible to be a qualified cesspool; that the cesspool upgrade has been completed consistent with this rule and plans prepared by a licensed engineer; and the total dollar amount the taxpayer paid for the cesspool upgrade. The director may issue such certification only where the director has received:

(1) A certification from a licensed contractor or licensed engineer that the cesspool is located within 200 feet of a shoreline, perennial stream, or wetland. Certifications are not required for properties that are located in their entirety within 200 feet of a shoreline, perennial stream, or wetland. The director shall certify as qualified all cesspools that are located within a source water assessment area (two year time of travel from a cesspool to a public drinking water source);

(2) Design plans prepared by a licensed engineer for a sewer connection or individual wastewater system that complies with this chapter;

(3) Certification by a licensed contractor of closure and filling of the cesspool and completion of

an upgrade, either sewer connection or installation of an individual wastewater system that complies with this chapter; and

(4) A licensed engineer's final construction inspection report with photos and as built plans and certifying that the system was constructed in accordance with design plans and this chapter. The director will review submitted documentation and provide certification to the taxpayer and the Department of Taxation of any qualified cesspool.

(k) Certification of qualified expenses. The director will determine all qualified expenses for the tax credit. The taxpayer seeking a tax credit shall submit to the director all receipts of payments made to engineers and installers for the design, completed installation and final construction inspection for the cesspool upgrade along with the appropriate form as directed by the Department of Taxation. The director will notify the taxpayer and the Department of Taxation of the amount of the tax credit allowed for the tax year by noting the same on the form and affixing the signature of the director or the director's designee thereto.

(l) If the annual amount of the certified credits reaches $5,000,000 in the aggregate, the director shall immediately discontinue certifying credits for that year and notify the Department of Taxation. Any taxpayer who is not eligible to claim the credit in a taxable year due to the $5,000,000 cap having been exceeded for that taxable year shall be eligible to claim the credit in the subsequent taxable year, except if the $5,000,000 cap was exceeded in 2020 and no additional credits are available. [Eff 8/30/91; am and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-6, 342D-50)

§11-62-31.2 <u>Site evaluation.</u> (a) The site evaluation shall be performed by the engineer.

(b) The site shall be evaluated for depth of permeable soil over seasonal high groundwater, bedrock, or other limiting layer, soil factors, land slope, flooding hazard, and amount of suitable area available.

(c) The minimum depth of the soil profile observation shall be at least five feet. If the engineer performs a preliminary observation at three feet, the engineer shall confirm the soil profile to five feet at the time of construction.

(d) The following factors shall be evaluated and reported for a depth of at least three feet below the proposed absorption system:

(1) Thickness of layers or horizons;
(2) Texture of soil layers;
(3) General color, and color variation (mottling);
(4) Depth to water, if observed;
(5) Depth to estimated seasonal high groundwater table;
(6) Depth to and type of bedrock, if observed; and
(7) Other prominent features such as structure, stoniness, and roots.

(e) Percolation tests.

(1) Soil percolation tests shall be conducted at a minimum depth of three feet. If at the time of construction, the soil profile at five feet is different than at three feet, another percolation test shall be performed at the depth of the bottom of the absorption system;
(2) Percolation tests shall follow the falling head test procedure in Appendix C, entitled Falling Head Test Procedure, dated July 1, 2014, located at the end of this chapter; and
(3) Additional percolation tests may be required to identify the existence of a limiting layer.

(f) The site evaluation information shall be reported on forms developed by the director.

(g) If, during construction the actual site conditions differ from the site conditions upon which the wastewater system was approved, the design engineer shall revise the wastewater plans to reflect the actual site conditions. The plans of the revised wastewater system shall be submitted to the director for approval pursuant to section 11-62-31.1(f). [Eff 8/30/91, am and comp 12/09/04; am and comp MAR 21 2016](Auth: HRS §§321-11, 342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-50)

§11-62-32 <u>Spacing of individual wastewater systems.</u> No individual wastewater system shall be located at any point having less than the minimum distances indicated in Table II attached to this chapter in Appendix D, entitled Tables, dated July 1, 2014, and located at the end of this chapter unless otherwise approved by the director. The minimum distances indicated in Table II shall be measured from the outer edge of each item. [Eff 12/10/88, am 8/30/91; am and comp 12/09/04; am and comp MAR 21 2016](Auth: HRS §§321-11, 342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-6, 342D-50)

§11-62-33.1 <u>Specific requirements for new and proposed treatment units.</u> (a) Septic tank.

(1) All wastewater shall discharge into the septic tank. Roof, footing, garage, surface water drainage, cooling water, and graywater disposed of in accordance with section 11-62-31.1(g)(4) shall be excluded.
(2) Septic tanks shall meet the International Association of Plumbing and Mechanical Officials (IAPMO) material and property standards for prefabricated septic tanks, IAPMO ANSI Z1000-2013. Septic tanks shall be approved and listed by IAPMO.
(3) Plans for cast-in-place septic tanks shall be submitted with the application for the individual wastewater system. The plans for the septic tank shall be designed and stamped by a licensed structural engineer

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and shall meet the IAPMO design specifications.

(4) The following schedule shall apply to septic tank sizing:

No. of Bedrooms	Minimum Capacity (Gallons)
4 or less	1000
5	1250

(5) For wastewater flows greater than 1,000 gallons per day or five bedrooms, the formula: Minimum capacity gallons = 1,000 + (Q-800)x 1.25, where Q=design flow, shall be used.

(6) Concrete septic tanks shall be coated to protect the tank from leakage and corrosion by acceptable means. The coating shall cover the entire tank interior.

(7) Manholes or removable covers to septic tanks shall be brought to grade. The cover shall be secured to prevent unauthorized entry or opening of the tank.

(8) When septic tanks are installed in ground water or in clay soils with an expansive nature, the engineer shall design or provide adequate protection to prevent the tank from floating, moving, or crushing.

(9) The excavation to receive the tank shall be large enough to permit the proper placement of the tank and backfill. Tanks shall be installed on a solid base that will not settle and shall be level. Where rock or other undesirable protruding obstructions are encountered, the bottom of the hole shall be excavated an additional six inches and backfilled with sand, crushed stone, or gravel to the proper grade. Backfill around and over the septic tank shall be placed in such a manner as to prevent undue strain or damage to the tank or connected pipes.

(10) When a septic tank is installed under a driveway, parking lot, in a heavy saturated

soil, or other areas subject to heavy loads, the tank shall be capable of withstanding an H-20 wheel load as defined by the American Association of State Highway Officials.

(11) Effluent from a septic tank shall be discharged into a soil absorption system, sand filter, subsurface irrigation system as approved by the director, or other treatment unit approved for use by the director.

(b) Household aerobic units.

(1) All wastewater shall discharge into the household aerobic unit. Roof, footing, garage, surface water drainage, and cooling water shall be excluded.

(2) Household aerobic units shall be approved by the director based upon the "Standard No. 40" for Class I units as set forth by the National Sanitation Foundation. The performance data shall have been obtained by an agency such as a university or an independent research laboratory acceptable to the director or from the National Sanitation Foundation (NSF) Testing Laboratory, Ann Arbor, Michigan.

(3) Owners of proposed and existing household aerobic units shall have an active service contract for the proper maintenance of the aerobic unit and its disposal system with a certified operator or factory certified representative, and a copy of an active service contract shall be submitted annually to the department. The contract shall also include pumping service to maintain the household aerobic unit. For proposed household aerobic units, a copy of an executed service contract shall be submitted prior to the final approval of the individual wastewater system.

(4) As a minimum, the aerobic treatment unit service contract shall include the term of contract period (start and end dates) and the following requirements:

(A) Inspect all aerobic treatment unit equipment to ensure its proper operation at least every six (6) months;
(B) Provide regular maintenance of equipment as required by the manufacturer;
(C) Verify the aerobic treatment unit is providing adequate mixing and aeration of the microbes;
(D) Measure the depth or volume of sludge in the aerobic treatment unit every six months, and assess whether sludge removal by pumping is necessary. Provide sludge pumping, as needed. If pumping is necessary, record the depth of sludge or percentage of sludge volume in the ATU prior to pumping; and
(E) Maintain a log of all service provided.

(5) Effluent from an aerobic unit shall be discharged into a soil absorption system, sand filter, subsurface irrigation system as approved by the director, or other treatment unit or disposal system approved for use by the director.

(6) In areas below (makai of) the Underground Injection Control Line established pursuant to chapter 11-23, where the vertical separation distance from the discharge to the seasonal high groundwater table is less than three feet, a new household aerobic unit may discharge its effluent into an elevated mound to achieve the vertical separation or drip irrigation system or, with a variance approved by the director and if the effluent is disinfected, to a seepage pit. Where water bearing formations are in danger of contamination, the director may require greater vertical separation.

(c) Subsurface and recirculating sand filters shall be reviewed on a case-by-case basis by the director. [Eff 8/30/91; am and comp

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12/09/04; am and comp MAR 21 2016]
(Auth: HRS §§321-11, 342D-4, 342D-5) (Imp:
HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2,
342D-4, 342D-5, 342D-50)

§11-62-34 <u>Specific requirements for new and proposed disposal systems.</u> (a) Absorption trenches.

(1) Location.
 (A) Absorption trenches shall be located in accordance with section 11-62-32.
 (B) Absorption trenches shall not be constructed in soils with a percolation rate slower than sixty minutes per inch or where rapid percolation may result in contamination of water-bearing formations or surface waters.
 (C) Absorption trenches shall be located on the property to maximize the vertical separation distance from the bottom of the absorption trench to the seasonal high groundwater level, bedrock, or other limiting layer, but under no circumstance shall the vertical separation be less than three feet. The director may require a greater vertical separation where water-bearing formations are in danger of contamination.
 (D) Absorption trenches shall not be constructed in unstabilized fill.

(2) Design.
 (A) The minimum absorption area for any absorption trench system shall be based upon a flow of 200 gallons per bedroom per day and in accordance with Table III located in Appendix D, entitled Tables, dated July 1, 2014, and located at the end of this chapter.
 (B) The absorption area shall be computed using the bottom area of the absorption trench.

(C) Each absorption trench system shall have a minimum of two trenches.
(D) Each distribution line shall be equal in length.
(E) The maximum length of any one trench shall be one hundred feet.
(F) Absorption trenches shall be at least eighteen inches wide but no more than thirty-six inches wide.
(G) The bottom of absorption trenches shall be at least eighteen inches below the finished grade.
(H) Gravity fed absorption lines and trenches shall have a slope at the rate of two to four inches per hundred feet.
(I) Absorption trenches shall not be installed on land with a slope gradient greater than twelve per cent.
(J) On rolling or sloping land, each absorption trench shall approximate the land surface contour.
(K) A distribution box or header shall be installed between the treatment unit and the absorption trenches.
(L) Each distribution line shall connect individually to the distribution box.
(M) If a header is used, there shall be an equal number of distribution lines on each side of the influent junction. An inspection port shall be provided on the header and shall be brought to grade and fitted with a screw type cap or cover.
(N) If a distribution box is used, a permanent inspection port with a minimum interior diameter of six inches shall be secured to the box cover, brought to the finished grade, and fitted with a screw type cap or cover.

(3) Materials.
(A) The engineer shall be responsible for the choice of materials used in the soil absorption system.

(B) Pipe used for distribution lines shall meet the appropriate ASTM standard or those of an equivalent testing laboratory. Fittings used in the absorption system shall be compatible with the materials used in the distribution lines.

(C) Gravel or crushed stone shall be washed and shall range in size from three-fourths to two and one-half inches.

(D) The material used to cover the top of the stone shall be a filter fabric material or equal.

(4) Construction.

(A) A distribution box or header shall be set level and arranged so that effluent is evenly distributed to each distribution line. Adequate provisions shall be taken to assure stability and provide access for inspection of the distribution lines.

(B) The pipe connecting the distribution box to the distribution line shall be of a tight joint construction laid on undisturbed earth or properly bedded throughout its length.

(C) If a header is used, it should be made of water-tight construction.

(D) When the trenches have been excavated, the sides and bottom shall be raked to scarify any smeared soil surfaces. Construction equipment and other materials not needed to construct the system should be kept off the area to be used for the absorption system to prevent undesirable compaction of the soils. Construction shall not be initiated when the soil moisture is high.

(E) At least six inches of gravel or crushed stone shall be placed in the bottom of the trench.

(F) The distribution line shall be carefully placed on the bedding at a uniform slope and covered with at least two inches of gravel or stone.

(G) The ends of the distribution lines shall be capped or plugged.

(b) Deep absorption trenches. Deep absorption trenches may be considered where the depth of suitable soil is insufficient to permit the installation of a conventional trench system due to the presence of a limiting layer more than two feet in depth which overlies suitable soils of sufficient thickness. Requirements for location, design, slope, material, construction, and dosing system design contained in subsection (a) shall apply to deep absorption trenches except for depth of construction. In addition, the following design considerations shall apply:

(1) The site evaluation procedure shall include soil profile observations of at least three soil observation pits constructed to a minimum depth of three feet below the proposed trench bottom. Monitoring to establish depth to seasonal soil saturation or high groundwater may be considered;

(2) Deep absorption trenches shall be constructed at least one foot into the suitable soil; and

(3) The distribution piping in deep absorption trenches shall be installed with the invert of the piping at a depth of not more than thirty inches. Gravel or crushed stone shall be placed from the bottom of the trench excavation to a point two inches above the top of the distribution piping.

(c) Absorption beds.

(1) Location.

(A) Absorption beds shall be located in accordance with section 11-62-32.

(B) Absorption beds shall not be constructed in soils with a percolation rate slower than sixty minutes per inch or where rapid percolation may result in contamination of water-bearing formations or surface waters.

(C) Absorption beds shall be located on the property to maximize the vertical separation distance from the bottom of the absorption bed to the seasonal high groundwater level, bedrock, or other Limiting layer, but under no circumstance shall the vertical separation be less than three feet. The director may require a greater vertical separation where water-bearing formations are in danger of contamination.

(D) Absorption beds shall not be constructed in unstabilized fill.

(2) Design.

(A) The minimum area for any absorption bed system shall be based upon a flow of 200 gallons per bedroom per day and in accordance with Appendix D, Table III dated July 1, 2014 and located at the end of this chapter.

(B) The absorption area shall be computed using the bottom area of the absorption bed.

(C) Each soil absorption bed system shall have a minimum of two distribution lines.

(D) If more than one absorption bed is designed, each absorption bed shall be equal in area.

(E) The maximum length of any distribution line shall be one hundred feet.

(F) Distribution lines within an absorption bed shall be uniformly spaced no more than six nor less than four feet apart.

(G) Distribution lines within an absorption bed shall be placed no more than three feet nor less than eighteen inches from the sidewall of the bed.

(H) The bottom of absorption beds shall be at least eighteen inches below the finished grade.
(I) Absorption beds shall not be installed on land with a slope gradient greater than eight per cent.
(J) A distribution box or header shall be installed between the treatment unit and the absorption bed.
(K) Each distribution line shall connect individually to the distribution box.
(L) If a header is used, there shall be an equal number of distribution lines on each side of the influent junction. An inspection port shall be provided on the header and shall be brought to grade and fitted with a screw type cap.
(M) If a distribution box is used, a permanent inspection port with a minimum interior diameter of six inches shall be secured to the box cover, brought to the finished grade, and fitted with a screw type cap or cover.

(3) Materials.
(A) The engineer shall be responsible for the choice of materials used in the soil absorption system.
(B) Pipe used for distribution lines shall meet the appropriate ASTM standard or those of an equivalent testing laboratory. Fittings used in the absorption system shall be compatible with the materials used in the distribution lines.
(C) Gravel or crushed stone shall be washed and shall range in size from three-fourths to two and one-half inches.
(D) The material used to cover the top of the stone shall be a filter fabric material or equal.

(4) Construction.
(A) The floor of the absorption bed shall be level.

(B) A distribution box or header shall be set level and arranged so that effluent is evenly distributed to each distribution line. Adequate provisions shall be taken to ensure stability and provide access for inspection of the distribution lines.

(C) The pipe connecting the distribution box to the distribution line shall be of a tight joint construction laid on undisturbed earth or properly bedded throughout its length.

(D) If a header is used, it should be made of watertight construction.

(E) When the beds have been excavated, the sides and bottom shall be raked to scarify any smeared soil surfaces. Construction equipment and other materials not needed to construct the system should be kept off the area to be used for the absorption system to prevent undesirable compaction of the soils. Construction shall not be initiated when the soil moisture is high.

(F) At least six inches of gravel or crushed stone shall be placed in the bottom of the bed.

(G) The distribution line shall be carefully placed on the bedding with no slope and covered with at least two inches of gravel or stone.

(H) The ends of the distribution lines shall be capped or plugged.

(d) Seepage pits.

(1) Location.

(A) Seepage pits shall be located in accordance with section 11-62-32.

(B) Seepage pits shall not be constructed in soils having a percolation rate slower than ten minutes per inch (weighted average) or where rapid percolation through such soils may result in contamination of water-bearing formations or surface water.

(C) The seepage pit shall be located on the lot to maximize the vertical separation distance from the bottom of the seepage pit to the seasonal high groundwater table, bedrock, or other limiting layer. The vertical separation shall not be less than three feet unless otherwise approved by the director and the requirements of section 11-62-33.1(b)(5) are met. Where water-bearing formations are in danger of contamination, greater vertical separation may be required.

(2) Design.

(A) Seepage pits shall be used only when one of the following are met:

(i) Slope of the finished elevation of the lot is greater than twelve per cent and the use of absorption beds or trenches is not feasible.

(ii) The presence of a limiting layer more than seven feet in depth which overlies suitable soils of sufficient thickness.

(iii) Insufficient land area exists to install absorption trenches or beds.

(B) The minimum area in any seepage pit shall be based upon a flow of 200 gallons per bedroom per day and in accordance with Appendix D, Table III dated July 1, 2014 and located at the end of this chapter.

(C) The surface dimension is measured as the mean distance of the clear opening below the inlet pipe.

(D) The minimum surface dimension is six feet.

(E) The effective depth of the seepage pit shall be measured from the bottom of the inlet pipe to the bottom of the pit, with the thickness of strata of soils having percolation rates slower than thirty minutes per inch deducted.

(F) The minimum effective depth is ten feet and shall be greater than its widest surface dimension.

(G) The effective area of the seepage pit shall be the vertical wall area of the areas corresponding to the effective depth of the pit excavation. No allowance shall be made for the bottom area.

(H) When more than one seepage pit is used, a distribution box shall be installed between the treatment unit and all seepage pits. Each seepage pit shall individually connect to the distribution box.

(I) When more than one seepage pit is used, each pit shall have an equal effective area.

(J) If a distribution box is used, a permanent inspection port with a minimum interior diameter of six inches shall be secured to the box cover, brought to the finished grade, and fitted with a screw type cap or cover.

(3) Construction.

(A) Seepage pits shall include a sidewall lining constructed of durable material that will permit free passage of wastewater without excessive plugging while still excluding the entry of surrounding soil.

(B) Seepage pits shall include a cover which extends at least twelve inches beyond the seepage pit excavation, unless a concrete ring is used.

(C) The lining and cover of any seepage pit shall be capable of supporting the normal loads imposed. The engineer shall submit written justification for the deletion of any sidewall lining.

(D) The distance between the outer diameter of the lining and the excavation diameter shall be at least six inches, but not more than twelve inches. The space between lining and the excavation diameter shall be filled with washed gravel or crushed stone ranging in size from three-fourths to two and one-half inches. The placement of the gravel or stone shall fill the annular space between the pit lining and excavation diameter. Gravel and stone shall not be placed within the seepage pit itself.

(E) The watertight cover shall be provided and at least one watertight manhole either round or square, tapered to a minimum of twelve inches in dimension shall be provided in the cover for inspection or for emptying the contents when required.

(F) The top of the seepage pit shall be within twelve inches of the final grade.

(G) If the cover of the seepage pit does not extend to the finished grade, a permanent inspection port with a minimum diameter of twelve inches expanding through and secured to the cover shall be brought to the finished grade and fitted with a screw type cap or cover.

(H) The distribution box shall be set level so that the effluent is evenly distributed to each seepage pit.

(I) The distribution box shall connect to each seepage pit with pipe of watertight construction at least six inches in diameter, and sloped at least one-eighth inch per foot.

(J) The material used to cover the top of the stone or gravel surrounding the lining shall be a filter fabric material or equal.

(e) Elevated mound system. Elevated mound systems shall be reviewed on a case-by-case basis.

(f) Other disposal systems.

(1) Soil replacement system.

(A) Soil replacement systems shall be used for sites with the following soils layers in the upper soil horizons:

(i) Soils with percolation rates less than one minute per inch;

(ii) Soils with percolation rates greater than sixty minutes per inch that occur within the upper five feet of the soil and underlain by more permeable soils. Installation guidelines shall comply with the requirements of very high permeability soils of subparagraph (B); or

(iii) Fractured lava.

(B) Trenches may be excavated up to thirty-six inches in width to depths not to exceed five feet below grade nor closer than three feet to seasonal high groundwater level, provided any groundwater mounding induced by wastewater does not rise closer than one foot from the bottom of the excavation and bedrock is at least three feet below the bottom of the excavation.

(C) Soil replacement absorption trenches and beds shall follow the applicable provisions of subsections (a), (b), and (c).

(2) Evapotranspiration systems shall be reviewed on a case-by-case basis by the director. The director shall use the provisions of section 7.3.2 of the October 1980 edition of

the EPA Design Manual on Onsite Wastewater Treatment and Disposal Systems as a guide for the review of evapotranspiration systems.

(3) Gravelless systems.

(A) Gravelless soil absorption systems may be used as an alternative to soil absorption systems as specified in subsections (a) and (b), except for sections 11-62-34(a)(3)(C), 11-62-34(a)(3)(D), 11-62-34(a)(4)(E), and 11-62-34(a)(4)(F), 11-62-34(c)(2)(F), 11-62-34(c)(2)(G), 11-62-34(c)(3)(C), 11-62-34(c)(3)(D), and 11-62-34(c)(4)(F).

(B) Design criteria, material specifications, and other pertinent data shall be submitted to the director.

(C) The total area of the soil absorption system for the gravelless system shall be the same as specified in subsections (a), (b), and (c), except for chambered system where the director may approve of a reduction factor as deemed appropriate.

(D) If chambered systems are used, the chamber units shall be placed up against the sidewall of the excavation. In absorption beds, the adjacent chambers shall abut one another.

(E) The use of filter fabric, unless specified by the director, shall follow the manufacturer's recommendation.

[Eff 8/30/91; am and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-50)

§11-62-35 <u>Other individual wastewater systems.</u> (a) The specific design requirements for composting toilets, incinerator toilets, natural systems, and

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other individual wastewater systems not specifically covered in this chapter shall be reviewed and approved by the director on a case-by-case basis. Solids generated from such products that are land applied must meet the requirements of subchapter 4. Such products, if sold in Hawaii, shall be approved by the director based on appropriate testing procedures and standards as set forth by the National Sanitation Foundation (NSF) Testing Laboratory, Ann Arbor, Michigan. The performance data shall be obtained by an agency such as a university or an independent research laboratory acceptable to the director or from the NSF.

(b) The director may approve an innovative wastewater system based on the following conditions:

(1) The innovative system provides or may provide a benefit to the people of the State;

(2) The owner of the innovative system shall agree that for a period of up to twelve months after the initiation of the operation of the innovative system, operational data shall be gathered and submitted to the director; and

(3) The owner shall submit a written agreement stating that should the director at any time find the operation of the innovative system unsatisfactory, the owner shall promptly repair or modify the system, or replace it with another acceptable system. [Eff 8/30/91; am and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-6, 342D-50)

§11-62-36 <u>Cesspools.</u> (a) No new cesspools shall be constructed after the effective date of this rule unless they have been approved for construction before the effective date of this rule.

(b) The director may require a cesspool card from an owner whose cesspool has no cesspool card on file with the department. An existing cesspool card shall be completed and signed by a licensed engineer, contractor, plumber, or architect. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 342D-4, 342D-5, 342E-3)(Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-6, 342D-50, 342E-3)

§11-62-37 Application for and review of building permits and individual wastewater systems. (a) The director shall review all individual wastewater systems before the director signs any related county building permit application.

(b) The application to construct a new individual wastewater system or to modify an existing individual wastewater system shall be made by the applicant on forms furnished by the director. The application at a minimum shall contain the following information:

(1) Name of the owner of the individual wastewater system;
(2) The location of the individual wastewater system, including a location map, plot plan, street address, and tax map key number;
(3) The type and size of treatment unit and disposal system;
(4) Certification by the engineer that the individual wastewater system has been designed in accordance with sections 11-62-31.1 through 11-62-41; and
(5) Certification by the engineer that a final inspection report will be submitted to the director in accordance with section 11-62-31.1(f)(1)(B).

(c) Every applicant for an individual wastewater system shall pay a filing fee in accordance with the schedule of this subsection. The filing fee shall be submitted with the individual wastewater system application and shall not be refunded nor applied to any subsequent individual wastewater system application. Fees shall be made payable to the State of Hawaii.

(1) New individual wastewater system, new treatment unit or new disposal system - $100; and

(2) Addition or modification to an approved or existing individual wastewater system or part thereof - $25. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5, 342D-6, 342D-13, 342D-50)

§§11-62-38 to 11-62-39 (Reserved)

SUBCHAPTER 4

WASTEWATER SLUDGE USE AND DISPOSAL

§11-62-41 General requirements and prohibition. (a) No person shall generate, treat, prepare, store, haul, apply, place, use, or dispose of wastewater sludge except:

(1) In compliance with:
 (A) A permit or department approval for use of an individual wastewater system obtained under this chapter;
 (B) A registration under this chapter; or
 (C) An exemption from permitting or registration provided by section 11-62-50.

(2) In a municipal solid waste landfill unit which is in compliance with the sludge related conditions in a permit issued under chapter 11-58.1:
 (A) Where that permit was issued following public participation procedures at least as open to the public as those specified in subchapter 5; and

(B) Incorporates the requirements of 40 CFR Part 258.

(3) By incineration in a facility in compliance with the requirements of 40 CFR Part 503, Subpart E, Incineration, and 40 CFR §503.8, Sampling and analysis, and §503.9, General definitions;

(4) In a facility in compliance with the sludge related conditions in a National Pollutant Discharge Elimination System (NPDES) permit issued under chapter 11-55 or issued by the U.S. EPA, where that permit includes or incorporates the requirements of 40 CFR Part 503, Subpart B, Land Application, Subpart D, Pathogens and Vector Attraction Reduction, and 40 CFR §503.8, Sampling and analysis, and §503.9, General definitions and any applicable requirements of this chapter;

(5) For hauling, by a county, state, or federal agency, or by a person or an operation registered under section 11-62-50(b)(4); or

(6) As otherwise authorized in writing by the director.

(b) Direct enforceability. No person shall generate, treat, prepare, store, haul, apply, place, use, or dispose of wastewater sludge except in compliance with the requirements of this chapter and all applicable federal rules, whether or not a permit has been issued or registration has been made.

(c) Exclusion. This chapter does not apply to operations and facilities involved with the collection, handling, storage, treatment, use, disposal, or transportation of the following:

(1) Wastewater sludge co-fired in an incinerator with other wastes or incinerators in which the wastewater sludge and other wastes are co-fired;

(2) Wastewater sludge generated at an industrial facility during the treatment of industrial wastewater, including wastewater sludge generated during the treatment of industrial

wastewater combined with domestic wastewater;
(3) Wastewater sludge determined to be hazardous under state rule or federal regulation;
(4) Wastewater sludge containing polychlorinated biphenyls (PCBs) equal to or greater than 50 milligrams per kilogram of total solids (dry weight basis);
(5) Incinerator ash generated during the firing of wastewater sludge in a wastewater sludge incinerator;
(6) Grit and screenings;
(7) Drinking water treatment sludge; and
(8) Commercial and industrial septage that contains no domestic wastewater. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-50; 40 CFR Parts 258, 501, 503, 40 CFR 503 Subparts B, C, D, E, 40 CFR §§501.15, 503.1(b), 503.3, 503.4, 503.6, 503.7, 503.8, 503.9)

§11-62-41.1 Relation to federal law. (a) This chapter shall be interpreted and applied so that it is at least as stringent as 40 CFR Part 503 and so that the department's sludge management program complies with 40 CFR Part 501.

(b) No wastewater sludge generation, treatment, preparation, storage, hauling, application, placement, use, or disposal shall be conducted unless allowed by this chapter, even if allowed under 40 CFR Part 503.

(c) References to the Code of Federal Regulations (CFR) are to the July 1, 1999 version, and references to specific sections or subparts of the CFR incorporate those regulations and make them part of this chapter, whether or not the word incorporate is specifically used, unless otherwise specifically stated.

(d) Special definitions. For the purposes of this chapter, when used in 40 CFR Part 503:

"Municipal solid waste landfill unit" has the same meaning as defined in 40 CFR Part 258.

"Permitting authority" means the director.
"Sewage" means wastewater.
(e) No permit shall be issued when the United States Environmental Protection Agency Administrator for Region IX has objected in writing under 40 CFR §123.44. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-50; 40 CFR Parts 258, 501, 503, 40 CFR §§123.41, 123.42, 123.44, 501.2, 501.18, 501.19, 501.20, 503.1(b), 503.5, 503.21, 503.32)

§11-62-42 Land application of exceptional quality wastewater sludge. (a) Exceptional quality wastewater sludge shall meet the following criteria at a minimum:

(1) Pollutant limits. No pollutant concentration shall exceed the ceiling limits in Appendix D, Table IV.
(2) Pathogens. The Class A pathogen requirements in section 11-62-46(a) shall be met.
(3) Vectors. One of the vector attraction reduction requirements in 40 CFR §503.33(b)(1) through (8) shall be met.

(b) Monitoring. Exceptional quality wastewater sludge shall be monitored by the preparer at least as often as required by 40 CFR § 503.16(a). References in §503.16(a) to federal pollutant limit tables are replaced with Appendix D, Table IV dated July 1, 2014 and located at the end of this chapter. To determine compliance with section 11-62-42(a)(2), wastewater sludge shall be monitored not more than sixty days before land application or being bagged for distribution unless otherwise specified by the director. The director may also specify more monitoring, to better protect human health or the environment.

(c) Recordkeeping.

(1) The preparer of exceptional quality wastewater sludge that is applied to the land shall meet the requirements of 40 CFR

§503.17(a)(1), except the certification requirement there;

(2) The preparer shall sign complete certification form, form A, entitled Certification Form - Land Application, dated July 1, 2014, and located at the end of this chapter, in Appendix E, items 1, 2.a, and 3.a, and retain the form for five years; and

(3) The preparer shall develop and retain information for five years on the volume of wastewater sludge bagged, distributed, or land applied.

(d) Reporting. The test results and records required in subsections (b) and (c) shall be kept on site and unless otherwise specified, copies shall be submitted to the director on February 19 of each year.

(e) The exceptional quality sludge shall be applied to the land at a rate that is less than ten dry tons per acre and equal to or less than the agronomic rate.

(1) The preparer shall provide to each land applier a fact sheet which contains the nitrogen, phosphorus, and potassium concentrations of the wastewater sludge; and

(2) When the wastewater sludge is applied in bulk to agricultural land, forest, a public contact site, or a reclamation site, the director may require a nutrient balance to be submitted prior to the application to the land. [Eff and comp 12/09/04; comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-50; 40 CFR §§503.1, 503.5, 503.10, 503.13, 503.15(a), 503.16(a), 503.17(a), 503.18, 503.32, 503.33(b))

§11-62-43 <u>Land application of other than exceptional quality wastewater sludge, to agricultural land, forest, public contact site, or reclamation site.</u> (a) No person shall apply non-exceptional quality wastewater sludge to land unless the land is agricultural land, forest, a public contact site, or a reclamation site, and all the requirements of this section are met.

(b) Pollutant limits. Non-exceptional quality wastewater sludge shall not be land applied if the concentration of any pollutant in the wastewater sludge exceeds the ceiling limits in Appendix D, Table IV dated July 1, 2014, and located at the end of this chapter.

(c) Pathogens. The Class A pathogen requirements in section 11-62-46(a) or the Class B pathogen requirements in 40 CFR §503.32(b) shall be met for non-exceptional quality wastewater sludge.

(d) Vectors. One of the vector attraction reduction requirements in 40 CFR §503.33(b)(1) through (10) shall be met for non-exceptional quality wastewater sludge.

(1) The preparer shall meet one of the requirements of 40 CFR §503.33(b)(1) through (8); or

(2) The applier shall meet one of the requirements of 40 CFR §503.33(b)(9) or (10).

(e) Notice. The preparer of the non-exceptional quality wastewater sludge shall inform in writing to the land applier and the owner of the land application site of:

(1) The vector attraction reduction requirements of 40 CFR §503.33(b)(9) and (10), if the preparer did not use or meet any of the requirements of 40 CFR §503.33(b)(1) through (8);

(2) The spacing and site restrictions in subsection (g);

(3) The management requirements of subsection (h); and

(4) The concentration of total nitrogen (as N on a dry weight basis).

(f) Monitoring. Non-exceptional quality wastewater sludge shall be monitored at least as often as required by 40 CFR § 503.16(a). References in §503.16(a) to federal pollutant limit tables are replaced with Appendix D, Table IV dated July 1, 2014, and located at the end of this chapter. To determine compliance with section 11-62-43(c), wastewater sludge shall be monitored not more than sixty days before land application unless otherwise specified by the director. The director may also specify more monitoring, to better protect human health or the environment.

(g) Spacing and site restrictions for non-exceptional quality sludge.

(1) Horizontal distances. The land application of wastewater sludge shall meet the minimum horizontal limits in Appendix D, Table VI.

(2) Vertical separation. The land application of wastewater sludge shall be at least five feet above the seasonal high groundwater table.

(3) If the class B pathogen requirements are met, the site restrictions in 40 CFR §503.32(b)(5) shall be met.

(h) Management practices. The management practices required by 40 CFR §503.14(a), (b), (d), (e)(1), and (e)(2) shall be met, and wastewater sludge shall not be applied to the land so that either the sludge or any pollutant from the sludge enters state waters.

(i) Recordkeeping, preparers of non-exceptional quality wastewater sludge.

(1) The preparer of the wastewater sludge which meets the Class A pathogen requirements in section 11-62-48(a) shall develop and retain for five years information on:

(A) The concentration of pollutants listed in Appendix D, Table IV dated July 1, 2014, and located at the end of this chapter; and

(B) A description of how the pathogen requirements in section 11-62-48(a) are met.

(2) The preparer of wastewater sludge which meets the class B pathogen requirements in 40 CFR §503.32(b) shall develop and retain for five years information on:

(A) The concentration of pollutants listed in Appendix D, Table IV dated July 1, 2014, and located at the end of this chapter;
(B) A description of how the pathogen requirements in 40 CFR §503.32(b) are met; and
(C) A description of how one of the vector attraction reduction requirements of 40 CFR §503.33(b)(1) through (8) is met, when one is met.

(3) The preparer shall sign and complete certification form, form A entitled Certification Form - Land Application dated July 1, 2014, and located at the end of this chapter, in Appendix E, items 1, 2, and 3, and retain the form for five years; and

(4) The preparer shall develop and retain for five years information on the volume of wastewater sludge prepared for land application, names of persons taking wastewater sludge from the facility, the date and time the wastewater sludge was taken, and the amount taken.

(j) Recordkeeping, appliers of non-exceptional quality wastewater sludge to the land.

(1) The applier shall meet the information requirements of 40 CFR §503.17(a)(3)(ii)(B) and (C); or §503.17(a)(4)(ii)(B), (C), (D), and (E);

(2) The applier shall sign and complete the certification form, form A entitled Certification Form - Land Application, July 1, 2014, and located at the end of this chapter, in Appendix E, items 4, 5, and 6, and retain the form for five years; and

(3) The applier shall develop and retain for five years the following information:
(A) The location, including street address and tax map key number, of the site on which wastewater sludge is applied;
(B) The number of acres in each site on which wastewater sludge is applied;

(C) The date and time the wastewater sludge is applied to each site;
(D) The amount of wastewater sludge applied to each site; and
(E) A nutrient balance.

(k) Reporting. The test results and records required in subsections (f), (i), and (j) shall be kept on site and unless otherwise specified copies shall be submitted to the director on February 19 of each year.

(l) Notification to other states. Any person who prepares wastewater sludge that is land applied in another state shall provide written notice, prior to the initial land application, to the permitting authority for the state in which the bulk in which the wastewater sludge is to be applied to the land in accordance with 40 CFR §503.12(i). [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-50; 40 CFR §§503.12, 503.13(b), 503.14, 503.15(a), (c), 503.16(a), 503.17, 503.18, 503.32, 503.33(b))

§11-62-44 <u>Land application of domestic septage to agricultural land, forest, or reclamation site.</u> (a) No person shall apply domestic septage to land unless the land is agricultural land, forest, or a reclamation site if the annual application rate (AAR) exceeds 1/0.0026 the amount of nitrogen (N) in pounds per acre per 365 day period needed by the crop or vegetation growth on the land.

$$AAR = \frac{N}{0.0026} \qquad \text{Equation (1)}$$

(b) Pathogens. The pathogen requirements of
(1) 40 CFR §503.32(c)(1); or

(2) 40 CFR §503.32(c)(2), including the site restrictions of 40 CFR §503.32(b)(5)(i) through (iv), shall be met for domestic septage.

(c) Vectors. One of the vector attraction reduction requirements in 40 CFR §503.33(b)(9), (10), or (12) shall be met for domestic septage.

(d) Monitoring. If either the pathogen requirement in subsection (b)(2) or vector attraction reduction requirement in 40 CFR §503.33(b)(12) applies, each container of domestic septage shall be monitored for compliance with those requirements. The director may specify more monitoring, to better protect human health or the environment.

(e) Recordkeeping.

(1) The applier shall meet the information requirements of 40 CFR §503.17(b)(2),(3), (4),(5),(7), and (8);

(2) The applier shall develop and retain for five years the location, including street address and tax map key number, of the site on which septage is applied; and

(3) The applier shall sign and complete the certification form, form A entitled Certification Form - Land Application dated July 1, 2014, and located at the end of this chapter, in Appendix E, items 7, 8, 9, and 10, and retain the form for five years.

(f) Reporting. The test results and records required in subsection (e) shall be kept on site and unless otherwise specified copies shall be submitted to the director on February 19 of each year.

(g) Spacing and site restrictions.

(1) Horizontal distances. The land application of domestic septage shall meet the minimum horizontal limits in Appendix D, Table VI dated July 1, 2014, and located at the end of this chapter.

(2) Vertical separation. The land application of domestic septage shall be at least five feet above the seasonal high groundwater table.

(3) The site restrictions in:
(A) 40 CFR §503.32(b)(5); or
(B) The pathogen requirement of 40 CFR §503.32(c)(2) and the site restrictions of 40 CFR §503.32(b)(5)(i) through (iv) shall be met for domestic septage.

(h) Management practices. The management practices required by 40 CFR §503.14(a), (b), (d), (e)(1), and (e)(2)for wastewater sludge shall be met for domestic septage, and domestic septage shall not be applied to the land so that the septage or any pollutant from septage enters state waters. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-50; 40 CFR §§503.12(c), 503.13(c), 503.14, 503.15(b), (d), 503.16(b), 503.17, 503.18, 503.32, 503.33)

§11-62-45 REPEALED [R MAR 21 2016]

§11-62-46 Pathogens. (a) Wastewater sludge - class A. (1) The requirements of this subsection shall be met for a wastewater sludge to be classified exceptional quality sludge or class A with respect to pathogens.

(2) One of the class A requirements in paragraphs (3), (4), (6) or (7) shall be met, or with the prior approval of the director paragraph (5) shall met. The requirements in paragraphs (3) through (7) shall be met before or at the same time that the vector attraction reduction requirements in 40 CFR §503.33 are met, unless one of the vector attraction reduction requirements in 40 CFR §503.33(b)(6) through (8) is met.

(3) Class A - alternative 1. The requirements of 40 CFR §503.32(a)(3) apply, except that the requirements of §503.32(a)(3)(i) are replaced with those of paragraph (8).

(4) Class A - alternative 2. The requirements

of 40 CFR §503.32(a)(4) apply, except that the requirements of §503.32(a)(4)(i) are replaced with those of paragraph (8).

(5) Class A - alternative 3. The requirements of 40 CFR §503.32(a)(6) apply, except that the requirements of §503.32(a)(6)(i) are replaced with those of paragraph (8).

(6) Class A - alternative 4. The requirements of paragraph (8), and subsection (d), Process to Further Reduce Pathogens (PFRP), apply.

(7) Class A - alternative 5. The requirements of paragraph (8) apply and, as determined by the director, a process equivalent to one in subsection (d), Process to Further Reduce Pathogens (PFRP), shall be used.

(8) Pathogen density at the time the wastewater sludge is used, disposed, or prepared for sale or give away in a bag or other container for land application, shall meet the following:

(i) Unless otherwise specified by the director, seven samples shall be analyzed; and

(ii) For each sample the fecal coliform shall be less than 1000 MPN per gram of total solids (dry weight basis) or for each sample the Salmonella sp. bacteria shall be less than three MPN per four grams of total solids (dry weight basis).

(b) Wastewater sludge - class B. The requirements of 40 CFR §503.32(b) shall be met for a wastewater sludge to be classified class B with respect to pathogens.

(c) Domestic septage. The requirements of 40 CFR §503.32(c) apply.

(d) Processes to further reduce pathogens (PFRP). The requirements of 40 CFR Part 503, appendix B, Pathogen Treatment Processes, section B, Processes to Further Reduce Pathogens, apply, except for section B.1 which is replaced by paragraph (1).

(1) Composting.

(A) Windrow. The temperature of the wastewater sludge is maintained at 55 degrees Celsius or higher for at least fifteen consecutive days during the composting period. In addition, during the high temperature period, the windrow must be turned at least five times and turned at least once every three days.

(B) Static aerated pile. The wastewater sludge must be maintained at operating temperatures of 55 degrees Celsius or greater for three consecutive days.

(C) Within vessel method. The wastewater sludge must be maintained at operating temperatures of 55 degrees Celsius or greater for three consecutive days.

(2) Heat Drying. See Part 503, appendix B, section B.2.

(3) Heat Treatment. See Part 503, appendix B, section B.3.

(4) Thermophilic Aerobic Digestion. See Part 503, appendix B, section B.4.

(5) Beta ray irradiation. See Part 503, appendix B, section B.5.

(6) Gamma ray irradiation. See Part 503, appendix B, section B.6.

(7) Pasteurization. See Part 503, appendix B, section B.7.

(e) Processes to significantly reduce pathogens (PSRP). The requirements of 40 CFR Part 503, appendix B, Pathogen Treatment Processes, section A, Processes to Significantly Reduce Pathogens, apply.

(1) Aerobic Digestion. See Part 503, appendix B, section A.1.

(2) Air Drying. See Part 503, appendix B, section A.2.

(3) Anaerobic Digestion. See Part 503, appendix B, section A.3.

(4) Composting. See Part 503, appendix B, section A.4.

(5) Lime Stabilization. See Part 503, appendix

B, section A.5. [Eff and comp 12/09/04; comp MAR 2 1 2016] (Auth: HRS §342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-50; 40 CFR Part 503, Subpart D, Appendix B, 40 CFR §503.32)

§11-62-47 Vector attraction reduction. (a) Requirements for land application.

(1) One of the vector attraction reduction requirements in 40 CFR §503.33(b)(1) through (8) shall be met before exceptional quality wastewater sludge is land applied.

(2) The requirements of 40 CFR §503.33(a)(1), (4), and (5) apply.

(b) Vector attraction reduction requirements. The requirements of 40 CFR §503.33(b) apply. [Eff and comp 12/09/04; comp MAR 2 1 2016] (Auth: HRS §342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5,342D-6, 342D-50; 40 CFR Part 503, Subpart D, 40 CFR §503.33)

§11-62-48 Sampling method. Samples of wastewater sludge that is applied to the land, [placed on a surface disposal site,] fired in a wastewater sludge incinerator, or disposed into a solid waste landfill or any other wastewater system shall be collected and analyzed using the methods specified in 40 CFR §503.8. [Eff and comp 12/09/04; comp MAR 2 1 2016] (Auth: HRS §342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-50; 40 CFR §503.8)

SUBCHAPTER 5

WASTEWATER MANAGEMENT PERMITS AND REGISTRATION

§11-62-50 Registration and permits. (a) Owners and operators are not required under this subchapter to register or obtain any permit coverage for their:

(1) Individual wastewater systems (e.g., cesspools, septic tanks, and household aerobic units);
(2) Land on which exceptional quality wastewater sludge is applied;
(3) Land application or land placement operations involving only exceptional quality wastewater sludge;
(4) Operations, such as businesses, that haul only exceptional quality wastewater sludge; or
(5) Non-domestic wastewater treatment works, unless deemed necessary by the director.

(b) Owners or operators or both of the following shall register with the department:
(1) Land on which non-exceptional quality sludge is applied or placed, with or without the landowner's permission;
(2) Land on which non-exceptional quality sludge is stored for less than two years, if the land is different from the treatment works which generated the sludge;
(3) Land application or land placement operations for non-exceptional quality wastewater sludge, whether or not the wastewater sludge is applied or placed on land with the landowner's permission;
(4) Operations, such as businesses, that haul wastewater or wastewater sludge, or both, including grease haulers and cesspool pumpers, except those operations that only haul exceptional quality sludge; and
(5) Other facilities, operations, or land, if directed by the director.

(c) Owners or operators or both shall obtain an individual permit for their:
(1) Treatment works that generate wastewater sludge that is directly land applied;
(2) If different from the generator, facilities or operations that treat or prepare wastewater sludge that is land applied or surface disposed;
(3) Treatment works not located in the State but

generate wastewater sludge that is directly land applied in the State;

(4) Facilities or operations not located in the State that treat or prepare wastewater sludge that is land applied or surface disposed in the State; and

(5) Other facilities, operations, or land, if directed by the director.

(d) The department may accept and issue consolidated registrations and individual permits (collectively "authorizations"), and for the consolidated authorizations the department may charge the fee for only the most expensive authorization. The department may also charge the fees for all or some of the authorizations. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5, 342D-6) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-13, 342D-50; 40 CFR §§501.15, 503.3(a))

§11-62-51 Fees. (a) Registration. Every registrant shall pay a filing fee according to this subsection. The filing fee shall be submitted with the registration and shall not be refunded nor applied to any later registration after filing or denial of a registration. Fees shall be made payable to the State of Hawaii.

(1) For a new operation, facility, or land, the fee is $30;

(2) For major changes in the registration of an operation, facility, or land, the fee is $30;

(3) For renewal, the fee is $10;

(4) To change only ownership shown in a registration, the fee is $5; and

(5) To make other changes in a registration, the fee is $10;

(b) Individual permits. Every person applying for an individual permit, its modification, or renewal shall pay a filing fee according to this subsection. This filing fee shall be submitted with the application for the permit or permit modification and shall not be refunded nor applied to any subsequent individual after final issuance or denial. Fees shall be made payable to the State of Hawaii.

(1) To apply for an individual permit for a new or existing operation or facility, the fee is $1000;
(2) To apply to modify an individual permit to cover a substantial alteration or addition to an operation, facility, or land, the fee is $1000;
(3) To renew an individual permit for an existing operation or facility, the fee is $1000;
(4) To transfer ownership or to modify an individual permit to show only a change in ownership, the fee is $25; and
(5) To apply to modify an individual permit to cover a change other than those covered above, the fee is $100.

(c) Late fees. Every person who fails to submit complete forms for a new or renewed registration or a complete application for a new or renewed individual permit when required by this chapter, shall pay a late fee. Fees shall be payable to the State of Hawaii. Late submission of required fees and registration forms, notice of intent, or individual permit application does not excuse a person from liabilities for any violations due to the lack of a required registration or individual permit.

(1) The fee for submitting a registration form late is $5;
(2) The fee for submitting an application for an individual permit late is $250.

(d) Relation to other fees. The foregoing fees are subject to section 11-62-50(e) and do not include any public participation costs (for notices, hearings, etc.) that the would-be registrant or permittee may be required to pay under other sections. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-13, 342D-50)

§11-62-52 Signatories and certification requirements. (a) Unless otherwise specified, each registration, notice of intent, permit application, and any information required to be submitted to the director shall be signed and certified as required by 40 CFR §122.22.

(b) Each person who knowingly makes any false statement, representation, or certification in any application, record, report, plan, or other documentation submitted or required to be maintained under this chapter or who knowingly falsifies, tampers with, or renders inaccurate any monitoring device or method required to be maintained under this chapter is subject to the penalties and remedies in section 11-62-72. [Eff and comp 12/09/04; comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5, 342D-6) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6; 40 CFR Parts 122, 501, 40 CFR §§122.22, §501.15(a)(4), (b)(11))

§11-62-53 Wastewater management registration. (a) Timing. Completed registrations forms required under section 11-62-50 shall be submitted as follows.

(1) For existing lands, facilities, and operations, not later than ninety days after the effective date of this rule; and

(2) For new lands, facilities, and operations, no later than one hundred eighty days before such lands, facilities, or operations are used or begin activity.

(b) Registration information and forms. Registrants shall complete and submit one original and one copy of the form(s) furnished by the director. Registrants shall provide at least the following information:

(1) Activities conducted by the applicant which require registration;
(2) Name, mailing address, and location of the wastewater or wastewater sludge collection, handling, storage, treatment, use, disposal, or transportation facility, operation, or land;
(3) Owner's name, mailing address, telephone

number, ownership status, and status as federal, state, private, public, or other entity; and

(4) Operator's name and certification number under chapter 11-61, if applicable.

(c) The director may require the submission of additional information after registration forms have been submitted.

(d) Records. Registrants shall keep records of all data used to complete registrations and any supplemental information submitted under this section for at least five years from the date the registrant submits the registration form, unless otherwise specified by the director.

(e) Fees. Each registrant shall pay the filing fee specified in section 11-62-51 for each facility, operation, or land registered, except as the director may provide under section 11-62-50(e).

(f) Term. Registrations expire on November 15 of each even-numbered year.

(g) Renewals. Renewal registration forms shall be submitted by November 15. If a renewal registration form is not submitted on time, it may be submitted after payment of the current annual fee and a late payment fee. If a renewal registration form is submitted more than ninety days after it is due, then the registrant shall supply all the information required for a new registration regardless of whether there have been any changes to report.

(h) Automatic filing. Registrations shall be deemed filed automatically sixty days after submission, or on the next working day after sixty days expire, unless the director suspends registration.

(i) Filing suspension. If the director considers a registration form incomplete, lacking payment of all or part of the fee, otherwise deficient, or considers more information necessary, the director shall order that the land, operation, or facility shall not be registered until the registrant has supplied the missing information or otherwise corrected the deficiency. [Eff and comp 12/09/04; comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5, 342D-6) (Imp: HRS §§342D-2, 342D-4, 342D-6, 342D-13)

§11-62-54.01 Wastewater management individual permits. (a) Timing. Applications for individual permits required under section 11-62-50 shall be submitted as follows:

(1) For existing lands, facilities, operations, and lands, not later than one year after the effective date of this section; and
(2) New facilities, operations, and lands, not later than one hundred eighty days before the facilities, operations, or lands are used or begin activity. The director may waive this one hundred eighty day requirement by issuing the permit before the one hundred eighty days expire.

(b) Information and forms. Applicants for individual permits shall complete and submit one original and one copy of the form(s)furnished by the director. Applicants shall provide at least the type of information required by 40 CFR Part 501 and the following information:

(1) The type of activities conducted by the applicant which requires a permit to be obtained;
(2) The name, mailing address, and location of the wastewater or wastewater sludge collection, handling, storage, treatment, use, disposal, or transportation facility, operation, or land;
(3) The owner's name, address, telephone number, ownership status, and status as federal, state, private, public, or other entity;
(4) The operator's name, address, telephone number, ownership status, status as federal, state, private, public or other entity, and operator's certification number under chapter 11-61, if applicable;
(5) A listing of all environmental permits received or applied, including all federal, state, or local permits;
(6) A topographical map or other map if a

topographical map is unavailable extending one mile beyond the property boundaries of the sludge management facility, depicting the treatment and disposal sites, the location of all water bodies, and the locations of potable water wells within one-quarter mile of the property boundaries;

(7) Any sludge monitoring data and for land application, any available groundwater monitoring data, with a description of the well locations and approximate depth to the groundwater;

(8) A description of the applicant's sludge use and disposal practices, including where applicable, the location of any sites where the applicant transfers wastewater sludge for treatment, disposal, or both, as well as the name of the applier who applies the wastewater sludge to the land if different from the applicant, and the name of any distributors when the sludge will be distributed, if different from the applicant;

(9) For each land application site the applicant will use during the life of the permit, the applicant will supply information necessary to determine if the site is appropriate for land application and a description of how the site is, or will be managed. Applicants intending to apply wastewater sludge to land application sites not identified at the time of application must submit a land application plan which at a minimum:

(A) Describes the geographical area covered by the plan;

(B) Identifies the site selection criteria;

(C) Describes how the site will be managed;

(D) Provides for advanced notice to the director of specific land application sites; and

(E) Provides for advance public notice and notice to landowners and occupants adjacent to or abutting the proposed land application site;

(10) Annual sludge production volumes; and

(11) Any information required to determine the appropriate standards for permitting under 40 CFR Part 503.

(c) The director may require the submission of additional information after an individual permit application has been submitted.

(d) Records. Applicants shall keep records of all data used to complete permit applications and any supplemental information submitted under this section for a period of at least five years from the date the application is submitted, unless otherwise specified by the director.

(e) Fees. Every applicant for an individual permit shall pay the filing fee specified in section 11-62-51 for each facility, operation, or land to be permitted, except as the director may provide under section 11-62-50(e).

(f) Processing suspension. If the director considers permit application incomplete, lacking payment of the fee, otherwise deficient, or considers more information necessary, the director shall order that the permit application shall not be processed or a permit issued until the applicant supplies the missing information or otherwise corrects the deficiency. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5, 342D-6) (Imp: HRS §§342D-2, 342D-4, 342D-6, 342D-13, 342D-50; 40 CFR Part 501, 40 CFR §501.15(a),(d))

§11-62-54.02 Draft individual permits. After an application for a new, modified, or renewed permit is complete, the director shall tentatively decide to prepare a draft individual permit or deny the application. If the director tentatively proposes to revoke and reissue a permit, the director shall prepare a draft individual permit. A draft permit shall contain the necessary conditions to implement the requirements of this chapter, 33 U.S.C. §1345, and the incorporated sections of 40 CFR Parts 501 and 503.

[Eff and comp 12/09/04; comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5, 342D-6) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6; 40 CFR Part 501, 40 CFR §501.15(d)(3))

§11-62-54.03 Fact sheets. (a) The director shall prepare a fact sheet for every draft individual permit for a major facility, operation, or activity, and when required by 40 CFR §501.15(d)(4).

(b) The director shall send the fact sheet to the applicant and, upon request, to any other person.

(c) Fact sheets shall include at least the information required by 40 CFR §501.15(d)(4)(i). [Eff and comp 12/09/04; comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5, 342D-6) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6; 40 CFR Part 501, 40 CFR §501.15(d)(4))

§11-62-54.04 Public notices of draft individual permits; public comments and hearing requests. (a) The director shall notify the public that a draft individual permit has been prepared and that the public has thirty days to comment on it. The comment period may be extended at the discretion of the director. The director may require the permit applicant to have the notice published.

(b) Methods. The director shall notify the public by at least the methods specified in 40 CFR §501.15(d)(5)(ii).

(c) Content. The public notice shall include at least the information required by 40 CFR 501.15(d)(5)(iii)(A).

(d) Costs. All publication and mailing costs associated with notifying the public of a draft permit shall be paid by the permit applicant(s) to the appropriate publishing agency or agencies determined by the director. Failure to provide and pay for public notice as required by the director is a basis to deny issuance of a permit.

(e) Public comments and hearing requests. During the public comment period, any person may submit comments in writing and may ask in writing for a public hearing. A request for hearing shall state the nature of the issues that the hearing should cover. [Eff and comp 12/09/04; comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5, 342D-6, 342D-13) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6; 40 CFR Part 501, 40 CFR §501.15(d)(5),(6))

§11-62-54.05 Public meetings or hearings on individual permits. (a) The director shall hold a public meeting or hearing if the director determines that there is a significant degree of public interest in a draft individual permit, based on hearing requests.

(b) The director may hold a meeting or hearing at the director's discretion, when such a meeting or hearing may help the director's decision on an individual permit application or for another reason which the director considers to be in the public interest. [Eff and comp 12/09/04; comp MAR 21 2016] (Auth: 342D-4, 342D-5, 342D-6) (Imp: 342D-2, 342D-4, 342D-5, 342D-6, 342D-57; 40 CFR Part 501, 40 CFR §501.15(d)(7))

§11-62-54.06 Public notice of public meetings or hearings on individual permits. (a) The director shall notify the public that a meeting or hearing on an individual permit matter has been scheduled. The notice shall be given at least thirty days before the hearing. The director may require the permit applicant to have the notice published.

(b) Methods. The director shall notify [to] the public by at least the methods specified in 40 CFR §501.15(d)(5)(ii).

(c) Content. The public notice shall include at least the information required by 40 CFR §501.15(d)(5)(iii).

(d) Costs. All publication and mailing costs associated with notifying the public of a public meeting or hearing shall be paid by the permit applicant(s) to the appropriate publishing agency or agencies determined by the director. Failure to provide and pay for public notice as required by the director is a basis to deny issuance of a permit. [Eff and comp 12/09/04; comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5, 342D-6, 342D-13) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6; 40 CFR Part 501, 40 CFR §501.15(d)(5))

§11-62-54.07 Response to comments. When a final individual permit is issued, the director shall issue a written response to written comments as required by 40 CFR §501.15(d)(8). [Eff and comp 12/09/04; comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5, 342D-6) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6; 40 CFR Part 501, 40 CFR §501.15(d)(8))

§11-62-54.08 Issuance of individual permits; duration, conditions. (a) Duration. The director may issue an individual permit for any period not exceeding five years, may renew such permit for any additional periods not exceeding five years each, and shall not modify an individual permit to extend its maximum period.

(b) Each individual permit shall contain conditions and requirements at least as stringent as:

(1) Those conditions contained in 40 CFR §501.15(b);
(2) The wastewater sludge standards in subchapter 4;
(3) The treatment requirements in subchapter 2;
(4) The application rates in sections 11-62-27;
(5) The standard permit conditions stated in Appendix A entitled Wastewater Management Individual Permit Standard Conditions dated July 1, 2014, and located at the end of this chapter; and
(6) Other requirements deemed necessary by the director. [Eff and comp 12/09/04; comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5, 342D-6) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-50; 40 CFR Parts 501, 503, 40 CFR §§501.15(a)(5),(b),

503.3(a), 503.10(b),(c), 503.13, 503.32, 503.33)

§11-62-54.09 Schedules of compliance. Individual permits may contain schedules of compliance that are at least as stringent as those allowed by 40 CFR §501.15(a). [Eff and comp 12/09/04; comp MAR 21 2016](Auth: HRS §§342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-50; 40 CFR Part 501, 40 CFR §501.15(a)(6))

§11-62-55.01 REPEALED [R MAR 21 2016]

§11-62-55.02 REPEALED [R MAR 21 2016]

§11-62-55.03 Requiring an individual permit. Cases where an individual permit may be required include, but are not limited to the following:

(1) The wastewater system generates wastewater sludge that is land applied; and
(2) Other relevant factors. [Eff and comp 12/09/04; am and comp] (Auth: HRS §§342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-50; 40 CFR Part 122, 40 CFR §122.28(b)(3)(i))

§11-62-55.04 REPEALED [R MAR 21 2016]

§11-62-55.05 REPEALED [R MAR 21 2016]

§11-62-55.06 REPEALED [R MAR 21 2016]

§11-62-55.07 REPEALED [R MAR 21 2016]

§11-62-55.08 REPEALED [R MAR 21 2016]

§11-62-56 Standard permit conditions. Standard permit conditions for individual permits are contained in Appendix A entitled Wastewater Management Individual Permit Standard Conditions dated July 1, 2014, and located at the end of this chapter. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-50; 40 CFR Part 501, 40 CFR §501.15(b))

§11-62-57.01 Transfer of permits. An individual permit coverage may be transferred for the reasons and under the procedures specified in 40 CFR §501.15(c)(1), which allows for transfers by modification or automatically. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6; 40 CFR Part 501, §501.15(c)(1))

§11-62-57.02 Modification or revocation and reissuance of permits. (a) Each permit coverage shall be subject to modification or revocation and reissuance by the director after notice and opportunity for a contested case hearing, except for minor modifications.

(b) Individual permits may be modified, or revoked and reissued, for the reasons specified in 40 CFR §501.15(c)(2) and section 342D-6(e), HRS, and the director shall follow the procedures in 40 CFR §501.15(c)(2) and (d)(2) and section 342D-6(e), HRS, except for minor modifications, which shall follow the procedures specified in Appendix A.

(c) All applications under section 342D-7, HRS, for a variance from the requirements of subchapter 4 shall be treated as an application for a modification under this section. Any variances, if granted, shall be for a period not to exceed five years and may be renewed upon application. [Eff and comp 12/09/04; am and comp MAR 2 1 2016] (Auth: HRS §§342D-4, 342D-5, 342D-6, 342D-7) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-7, 342D-50; 40 CFR Part 501, §501.15(c)(2),(d)(2))

§11-62-57.03 <u>Termination of permits.</u> (a) On the expiration date specified in the individual permit, the permit shall automatically terminate and the permittee shall be divested of all rights therein.

(b) Each individual permit coverage shall be subject to termination by the director after notice and opportunity for a contested case hearing.

(c) Individual permits may be terminated or denied for any of the reasons specified in 40 CFR §501.15(c)(3) and section 342D-6(e), HRS, and under the procedures specified in 40 CFR §501.15(d)(2) and section 342D-6(e), HRS. [Eff and comp 12/09/04; am and am and comp MAR 2 1 2016] (Auth: HRS §§342D-4, 342D-5, 342D-6) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-50; 40 CFR Part 501, 40 CFR §§501.15(c)(3), (d)(2))

§11-62-57.04 <u>Renewal of permits.</u> (a) Permittees seeking individual permit renewal shall submit a renewal application at least one hundred eighty days before the individual permit expires.

(b) An application for individual permit renewal is subject to all of the requirements for an application for a new permit, including a draft permit and fact sheet, public notice, and a possible public hearing, but excepting deadlines and fees specific to new permits.

(c) The director may administratively extend the existing permit pending the renewal of a wastewater management permit.

(d) Individual permits may be renewed for the reasons and under the procedures specified in section 342D-6(c), HRS, and renewal may be denied for noncompliance with the permit. [Eff and comp 12/09/04; am and comp MAR 2 1 2016] (Auth: HRS

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§§342D-4, 342D-5, 342D-6) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-50; 40 CFR Part 501, 40 CFR §501.15(b)(14))

§11-62-58 Conflict of interest. (a) Any board or body who reviews or approves applications for new, modified, or renewed individual permits shall not include as a member any person who receives, or has during the previous two years received, a significant portion of that person's income directly or indirectly from permit holders or applicants for a permit.

(b) For this section the definitions of 40 CFR §501.15(f)(1) shall apply. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§342D-3, 342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-3, 342D-4, 342D-5; 40 CFR Part 501, 40 CFR §501.15(f))

SUBCHAPTER 6

WASTEWATER AND WASTEWATER SLUDGE PUMPERS AND HAULERS

§11-62-60 Applicability. This subchapter applies to all persons who own or conduct operations that haul or pump wastewater or wastewater sludge, including septage and grease, and including cesspool pumping firms (collectively "pumpers"). [Eff and comp 12/09/04; comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-50)

§11-62-61 Registration requirements. In addition to meeting the registration requirements of sections 11-62-50(b)(4) and 11-62-53, each pumper shall submit with its registration:

(1) A statement signed by the owner of the wastewater and wastewater sludge pumping and hauling firm attesting that:

(A) The owner has read, understands, and

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shall follow all applicable rules regarding the collection, disposal, monitoring, recordkeeping, and reporting of pumping and hauling wastewater and wastewater sludge, including septage from individual wastewater systems and other wastewater systems; and

(B) The owner has and will continue to provide employees of the pumping and hauling firm with adequate training in the proper pumping, collection, hauling, and disposal of wastewater and wastewater sludge;

(2) Copies of authorization to dispose of wastewater and wastewater sludge into any state, county, federal, or private facility or site; and

(3) A statement signed by the owner of the wastewater and wastewater sludge pumping and hauling firm describing the firm's prior and current involvement in the activity of cesspool pumping. [Eff and comp 12/09/04; comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-50)

§11-62-62 Recordkeeping and reporting. In addition to meeting the requirements of section 11-62-53(c) and (d), each pumper shall maintain the following types of records and information. Such information shall be made available upon request to any state, county, or federal wastewater agency regulating or managing wastewater:

(1) Number of wastewater systems, including individual wastewater systems and grease traps pumped;

(2) Names of the owner of each wastewater system and grease trap pumped;

(3) Location (street address or tax map key or both) of each wastewater system and grease trap pumped;

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(4) Date of pumping;
(5) Type of wastewater or wastewater sludge pumped;
(6) Volume of wastewater or wastewater sludge pumped;
(7) Results of any test analyses performed on the wastewater or wastewater sludge;
(8) Disposal site of the pumped wastewater or wastewater sludge; and
(9) Date of such disposal. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-6, 342D-50, 342D-55)

SUBCHAPTER 7

VARIANCES, PENALTIES, AND SEVERABILITY

§11-62-71 Variances. (a) Variances and variance applications shall comply with section 342D-7, HRS.

(b) Variance application forms shall be provided by the department. All applications for variances shall be submitted with a filing fee of $300 for each application. Additionally, the applicant shall pay all fees assessed for publishing the legal notice(s) for each variance application. If a public hearing is required, the applicant shall pay all fees assessed for publishing the public hearing notice(s).

(c) Applications for renewal of variances shall be submitted one hundred eighty days before the expiration of the variance on forms provided by the department. A filing fee of $150 shall be submitted with each application for renewal. Additionally, the applicant shall pay all fees assessed for publishing the legal notice(s) and public hearing notice(s). Failure to renew a variance within the specified time will result in the termination of the variance and require the applicant to apply for a new variance. [Eff 12/10/88, am 8/30/91; §11-62-41; ren, am and comp 12/09/04; comp MAR 21 2016] (Auth: HRS §§321-11, 342D-4, 342D-5, 342D-7, 342D-13) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-5,342D-7, 342D-50)

§11-62-72 Penalties and remedies. Any person who violates any provision of this chapter shall be subject to the penalties and remedies for violations provided for in chapters 321, 322-part I, 342D, and 342H, HRS. [Eff 12/10/88; §11-62-42; ren, am and comp 12/09/04; comp MAR 21 2016] (Auth: HRS §§321-11, 322-8(a), 342D-1, 342D-4, 342D-5, 342D-9, 342D-11, 342D-30, 342D-31, 342D-50) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 322-9, 342D-2, 342D-4, 342D-5, 342D-9, 342D-11, 342D-18, 342D-30, 342D-31, 342D-50, 603-23)

§11-62-73 Severability. If any provision of this chapter or its application to any person or circumstance is held invalid, the application of such provision to other persons or circumstances, and the remainder of this chapter, shall not be affected thereby. [Eff 12/10/88; §11-62-43; ren and comp 12/09/04; comp MAR 21 2016] (Auth: HRS §§321-11, 342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 322-4, 322-8, 342D-2, 342D-4, 342D-19, 342D-50)

§11-62-74 Public participation in enforcement. The department shall provide for public participation in enforcement relating to violations of subchapters 4 and 5 at least to the extent specified in 40 CFR §501.17(d)(2). [Eff and comp 12/09/04; comp MAR 21 2016] (Auth: HRS §§342D-4, 342D-5) (Imp: HRS §§342D-2, 342D-4, 342D-5, 342D-50; 40 CFR Part 501, 40 CFR §501.17(d)(2))

SUBCHAPTER 8

FIELD CITATIONS

§11-62-81 Purpose. This subchapter authorizes field citations to effectively and quickly settle easily verifiable violations of chapters 322 and 342D, HRS, and this chapter. Settlements under this section are an additional remedy and do not supplant the director's authority to issue orders under section 342D-9, HRS. [Eff and comp 12/09/04; comp MAR 21 2016] (Auth: HRS §§321-11, 322-8(a), 342D-1, 342D-4, 342D-5, and 342D-31) (Imp: HRS §§321-11, 322-1 to 4, 322-8, 342D-2, 342D-4, 342D-5, 342D-9, 342D-18, 342D-31, 342D-50)

§11-62-82 Offer to settle; settlement amounts. (a) A field citation is an offer to settle an administrative case against a specific violation on a specific day. Instead of issuing a formal notice and finding of violation and order, the director, in the director's sole discretion, through any authorized employee, may issue a field citation by personal service or certified mail to:

(1) Any person or owner who causes or allows a wastewater system to create or contribute to a wastewater spill, overflow, or discharge onto the ground or into surface waters, in violation of section 11-62-06(f)(5) or (6);
(2) Any person or owner who uses or occupies a building not connected to a wastewater system in violation of section 11-62-06(a);
(3) Any person or owner who constructs, modifies, or uses any individual wastewater system without approval by the director or a county authorized by the director to approve and regulate individual wastewater systems, in violation of section 11-62-08(b) or 11-62-31.1(f); or

(4) Any person or owner who does not respond within thirty days to an operation and maintenance inspection report issued by the Department.

(b) A field citation shall indicate the following settlement amounts:

(1) $200 for a first violation, and $500 for a subsequent violation for:
   (A) Violating sections 11-62-06(a),(f)(1)-(4) and (f)(6)-(9), 11-62-08(b) or 11-62-31.1(f);
   (B) Failing properly to operate or maintain an aerobic treatment unit;
   (C) Failing to provide an effective contract for an aerobic treatment unit;
   (D) Failing to respond to department inspection reports, if the report states a response is required;
   (E) Having a cesspool without a concrete cover;
   (F) Not having a secured manhole cover for the cesspool; or
   (G) A collapsed cesspool.

(2) $500 for a first violation, and $2,000 for a subsequent violation for violating section 11-62-06(f)(5) or (10); and

(3) $1,000 for a first violation, and $2,500 for a subsequent violation for constructing an individual wastewater system without department approval to construct. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 322-8(a), 342D-1, 342D-4, 342D-5, 342D-9, 342D-11, 342D-30, 342D-31, 342D-50) (Imp: HRS §§321-11, 322-1 to 4, 322-8, 342D-2, 342D-4, 342D-5, 342D-9, 342D-11, 342D-18, 342D-30, 342D-31, 342D-50)

§11-62-83 Resolution of field citation. (a) A person issued a field citation may accept the citation by:

(1) Signing the field citation;

(2) Paying the full amount indicated by the field citation. Payment shall be made payable to the "State of Hawaii" by check, cashier's check, money order or as otherwise specified by the director;

(3) Mailing or delivering the signed citation and full payment to the wastewater branch in Honolulu, or the district health office for the county where the violation occurred. The department must receive the signed filed citation and full payment within twenty days after the person receives the field citation; and

(4) Correction within seven days or unless otherwise specified on the field citation any violation of section 11-62-06(f)(6).

(b) By signing the field citation, the person to whom it was issued agrees to:

(1) Give up the person's right to a contested case hearing under chapter 91 or 342D, HRS, or otherwise challenge the field citation;

(2) Pay the amount indicated; and

(3) Correct the violation.

(c) If the field citation is not accepted in compliance with subsection (a), the director may seek for that cited violation any remedies available under this chapter, chapters 321, 322, 342D, HRS, or any other applicable law. For all other violations the director retains authority to seek any available remedies. [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 322-8(a), 342D-1, 342D-4, 342D-5, 342D-9, 342D-11, 342D-30, 342D-31, 342D-50) (Imp: HRS §§321-11, 322-1 to 4, 322-8, 322-9, 342D-2, 342D-4, 342D-5, 342D-9, 342D-11, 342D-18, 342D-30, 342D-31, 342D-50, 603-23)

§11-62-84 <u>Form of citation.</u> The department shall prescribe a field citation form." [Eff and comp 12/09/04; am and comp MAR 21 2016] (Auth: HRS §§321-11, 322-8(a), 342D-1, 342D-4, 342D-5) (Imp: HRS §§321-11, 322-1 to 4, 322-8, 342D-2, 342D-4, 342D-5, 342D-9, 342D-18, 342D-31, 342D-50)

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Amendments and compilation of chapter 62, title 11, Hawaii Administrative Rules, on the Summary Page dated MAR 21 2016 were adopted on MAR 21 2016 following public hearings held on December 11, 14, 15, 17, 18 and 21, 2015, after public notice was given in the Honolulu Star-Advertiser, Hawaii Tribune-Herald, West Hawaii Today, The Maui News, and The Garden Isle on November 23, 2015.

The adoption of chapter 11-62 shall take effect ten days after filing with the Office of the Lieutenant Governor.

Virginia Pressler
VIRGINA PRESSLER, M.D.
Director of Health

David Y Ige
DAVID Y. IGE
Governor
State of Hawaii

LIEUTENANT GOVERNOR'S OFFICE
'16 MAR 11 A11 :01

Dated: 2-1-2016

Filed

APPROVED AS TO FORM:

Edward G. Bohlen
EDWARD G. BOHLEN
Deputy Attorney General

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CHAPTER 11-62 APPENDIX A

INDIVIDUAL PERMIT
STANDARD CONDITIONS

July 1, 2014

Appendix A, Individual standard conditions

1. Duty to comply
2. Compliance with sludge standards
3. Compliance with wastewater effluent standards
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5. Clean Water Act (CWA) penalties
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11. Permit actions
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13. Duty to provide information
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21. Minor modification of permits
22. Modification or revocation and reissuance of permits
23. Termination of permits
24. Availability of reports
25. Civil and criminal liability
26. State law
27. Severability

The following conditions apply to individual permits unless otherwise specified. "Permittee" refers to a person to whom an individual permit has been issued.

1. **Duty to comply.** Permittees shall comply with and are subject to §11-62-06(q).

2. **Compliance with sludge standards.** Permittees shall comply with HAR chapter 11-62, subchapter 4.

3. **Compliance with wastewater effluent standards.** Permittees treating wastewater shall comply with §11-62-26 and, if applicable, §11-26-27.

4. **Compliance with water quality standards.** Permittees shall not cause or contribute to any violation of applicable sections of HAR chapter 11-54.

5. **Clean Water Act (CWA) penalties.** The monetary fines and imprisonment terms referred to in 40 CFR §§501.15(b)(3), on CWA §309; 501.15(b)(11)(ii), on false statement, representation, or certification; and §501.15(b)(10), on falsification, tampering with, or rendering inaccurate any monitoring device or method; all apply, in addition to any state penalties.

6. **Signatory and certification requirements.** Each permit application, report, notice, and any information submitted to the director shall be signed and certified as required by §11-62-52.

7. **Duty to reapply.** Permittees shall comply with §11-62-57.04.

8. **Need to halt or reduce activity not a defense.** It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

9. **Duty to mitigate.** Permittees shall comply with §11-62-06(j).

10. **Proper operation and maintenance.** Permittees shall comply with §11-62-06(e).

11. **Permit actions.** This permit may be modified, revoked and reissued, or terminated for cause. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance does not stay any permit condition.

12. **Property rights.** This permit does not convey any property rights of any sort, or any exclusive privilege.

13. **Duty to provide information.** The permittee shall furnish to the director, within a reasonable time, any information which the director may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. The permittee shall also furnish to the director, upon request, copies of records required to be kept by this permit.

14. **Inspection and entry.** The permittee shall allow the director, or an authorized representative, upon the presentation of credentials and other documents as may be required by law, to:

    a. Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;

    b. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;

c. Inspect at reasonable times any facility, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and

d. Sample or monitor at reasonable times, for the purposes of assuring permit compliance or as otherwise authorized by the Clean Water Act, any substances, parameters, or practices at any location.

15. Sampling requirements.

a. Sampling points. All samples shall be taken at the monitoring points specified in this permit and, unless otherwise specified, before final use, disposal, or discharge. Monitoring points shall not be changed without notification to and the approval of the director. No use, disposal, or discharge is authorized which does not totally pass through the final monitoring point.

b. Calibration. The permittee shall periodically calibrate and perform maintenance on all monitoring and analytical equipment used to monitor the pollutants, sludge, and other items specified by the director under this permit, at intervals which will ensure the accuracy of measurements, but no less than the manufacturer's recommended intervals or one year intervals (whichever comes first). [Records of calibration shall be kept pursuant to section 13(b) of this general permit.]

16. Monitoring and recordkeeping.

a. Monitoring results shall be reported at a frequency specified here or elsewhere in the permit, whichever is greater. The frequency of sampling shall be dependent on the size of the wastewater system, nature and effect of the wastewater, reclaimed water, and wastewater sludge use and disposal practices. At a minimum, the frequency shall be as required by §§11-62-26(a), 11-62-26(c), 11-62-28(a), and subchapter 4.

b. Representative sampling. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activities listed in §§11-62-26(a), 11-62-26(c), 11-62-28(a), and subchapter 4.

As used in this section, a representative sample means that the content of the sample shall (1) be identical to the content of the substance sampled at the time of the sampling; (2) accurately represent the monitored item (for example, sampling to monitor final effluent quality shall accurately represent that quality, even though the sampling is done upstream of the discharge point); and (3) accurately represent the monitored item for the monitored time period (for example, sampling to represent monthly average effluent flows shall be taken at times and on days that cover significant variations). Representative sampling may mean including weekends and storms and may mean taking more samples than the minimum number specified elsewhere in the permit. The burden of proving that sampling or monitoring is representative shall be on the permittee.

c. Record retention. The permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least five (5) years from the date of the sample, measurement, report or application. This period may be extended by request of the director of health at any time.

d. Records' content. Records of monitoring information shall include:
   (1) The date, exact place, and time of sampling or measurements;
   (2) The name of individual(s) who performed the sampling or measurements;
   (3) The date(s) analyses were performed;
   (4) The name of individual(s) who performed the analyses;
   (5) The analytical techniques or methods used and if available, references and written procedures for these techniques or methods; and
   (6) The results of such analyses, including bench sheets, instrument readouts, etc., used to determine these results.

e. Monitoring procedures. Unless other procedures have been specified in this permit, monitoring shall be conducted according to test procedures approved under 40 CFR Part 136 or, in the case of sludge use or disposal, approved under 40 CFR Part 503.

17. Notice requirements.

a. Planned changes. The permittee shall give notice to the director as soon as possible of any planned physical alterations or additions to the permitted facility, or significant changes planned in the permittee's sludge use or disposal practice, where such alterations, additions, or changes may justify the application of permit conditions that are different from or absent in the existing permit, including notification of additional disposal sites not reported during the permit application process or not reported pursuant to an approved land application plan.

b. Anticipated noncompliance. The permittee shall give advance notice to the director of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.

c. Transfers. This permit is not transferable to any person except after notice to the director. The director may require modification or revocation and reissuance of the permit to change the name of the permittee and incorporate such other requirements as may be necessary under the CWA.

d. Other noncompliance reporting. The permittee shall report all instances of noncompliance. Reports of noncompliance shall if applicable follow the spill protocol of appendix C otherwise shall be submitted with the permittee's next self monitoring report or earlier if requested by the director or if required by an applicable standard for wastewater sludge use or disposal or condition of this permit.

e. Other information. Where the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the director, it shall promptly submit such facts or information.

18. Reopener clause.

a. If the standards for wastewater and wastewater sludge applicable to the permittee's use, disposal, or discharge method are promulgated under the Clean Water Act, the Hawaii Revised Statutes, or the Hawaii Administrative Rules before the expiration date of this permit, and those standards are more stringent than the wastewater or wastewater sludge pollutant limits or acceptable management practices authorized in this permit, or controls a pollutant or practice not limited in this permit, this permit may be promptly modified or revoked and reissued to conform to the standards for wastewater or wastewater sludge use, disposal, or discharge by no later than the compliance deadline specified in the regulations establishing those standards, whether or not this permit has been modified or revoked and reissued.

b. This permit shall be modified or revoked and reissued at any time if, on the basis of any new data, the director determines that continued wastewater or wastewater sludge use, disposal, or discharge may cause unreasonable degradation of the environment.

c. The permittee shall comply with new standards for wastewater sludge use or disposal adopted in 40 CFR 503 during the term of the permit, if they are more stringent than the terms of the permit and chapter 11-62, even if this permit has not yet been modified to incorporate the standards.

19. **Transfers by modification.** Except as provided in condition 20 of these standard conditions, a permit may be transferred by the permittee to a new owner or operator only if the permit has been modified or revoked and reissued to identify the new permittee and incorporate such other requirements as may be necessary to assure compliance with the CWA.

20. **Automatic transfers.** As an alternative to transfers under condition 19 of these standard conditions, the director may authorize automatic transfer of any permit issued under this rule to a new permittee if:

    a. The current permittee notifies the director at least 30 days in advance of the proposed transfer date in condition 20.c. of these standard conditions;

    b. The notice includes a written agreement between the existing and new permittee containing a specific date for transfer of permit responsibility, coverage, and liability between them; and

    c. The director does not notify the existing permittee and the proposed new permittee of the director's intent to modify or revoke and reissue the permit. If this notice is not received, the transfer is effective on the date specified in the agreement of condition 20.b of these standard conditions.

21. **Minor modification of permits.** Upon the consent of the permittee, the director may modify a permit to make the corrections or allowances for changes in the permitted activity listed in this section without following the procedures of §11-62-57.02. Any permit modification not processed as a minor modification under this section must be made for cause and with draft permit and

public notice as required. Minor modifications may only:

a. Correct typographical errors;

b. Require more frequent monitoring or reporting by the permittee;

c. Change an interim compliance date in a schedule of compliance, provided the new date is not more than 120 days after the date specified in the existing permit and does not interfere with attainment of the final compliance date requirement; and

d. Allow for a change in ownership or operational control of a facility where the director determines that no other change in the permit is necessary, provided that a written agreement containing a specific date for transfer of permit responsibility, coverage, and liability between the current and new permittee has been submitted to the director.

22. **Modification or revocation and reissuance of permits.** Permittees shall comply with and are subject to §11-62-57.02, except for minor modifications.

23. **Termination of permits.** Permittees are subject to §11-62-57.03 and general permittees are also subject to §11-62-55.03.

24. **Availability of reports.** Except for data determined to be confidential under HRS §342D-14, all reports prepared in accordance with the terms of this permit shall be available for public inspection at the offices of the director. As required by this rule, permit applications, permits, and effluent and wastewater sludge data shall not be considered confidential.

25. **Civil and criminal liability.** Nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance.

26. **State law.** Nothing in this permit shall be constructed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable state law or regulation.

27. **Severability.** The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, if held invalid, the application of such provision to other circumstances, and remainder of this permit, shall not be affected thereby.

CHAPTER 11-62 APPENDIX B

RESPONSES FOR WASTEWATER SPILLS, OVERFLOWS, AND DISCHARGES ("SPILLS")

July 1, 2014

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CHAPTER 11-62 APPENDIX B

1. Points of contact

Agency	Phone	Fax
Clean Water Branch (CWB)	586-4309	586-4352
Wastewater Branch (WWB)	586-4294	586-4352
Environmental Health Programs (EHP)		
Hawaii District Health Office	933-4371	933-4669
Kauai District Health Office	241-3323	241-3480
Maui District Health Office	984-8234	984-8237
State Hospital Operator (SHO)	247-2191	
Communications Office		586-4444

2. Spills from any facility into state waters, excluding R-1 water from recycled water systems

a. Applicability. Any wastewater spill which enters into state waters from a public or private wastewater system.
   (1) "State waters" has the meaning defined in HRS section 341-D, and includes drainage ditches, whether or not water is always flowing in them.
   (2) Exclusion. Spill of R-1 water covered by Appendix J to HAR chapter 11-5, "NPDES General Permit Authorizing Discharges of R-1 Water from Recycled Water Systems". That general permit does not cover spills from treatment works.

b. Immediate notice to DOH. If a spill occurs during working hours:
   (1) The wastewater system owner or its agent (owner/agent) shall immediately notify the CWB of any spill into state waters; and
   (2) If a spill occurs on the neighbor islands, the owner/agent shall also immediately notify their respective

district environmental health program chief.

If a spill occurs during non-working hours:
(1) Contact the state hospital operator; and
(2) The next working day notify the CWB and the respective district EHP chief with a follow-up call.

c. Press Release. The owner/agent shall immediately send out a press release for spills of a thousand gallons or more and for lesser spills if they present a substantial threat to public health. A press release shall comply with section 7. A press release is not required if the owner/agent demonstrates that the spill was of R-1 water and that BMPs as approved by the director were implemented.

d. Disinfection. The owner/agent shall disinfect wastewater which is continuously being spilled into nearshore waters if sufficient disinfection contact time is available. Best judgment should be used in determining the amount of chlorine added to the discharge if chlorine is used as a disinfectant. Disinfection is not required if the owner/agent demonstrates that the spill was either R-1 or R-2 water and that BMPs as approved by the director were implemented.

e. Warning signs. The owner/agent shall immediately post warning signs in the area(s) likely to be affected by the spill and where public access is possible. Posting of warning signs is not required if the owner/agent demonstrates that the spill was of R-1 water and that BMPs as approved by the director were implemented.

The director shall also assure that a sufficient number of warning signs have been posted and the locations are adequate. Authorization to remove the signs shall also come from the director.

f. Monitoring. The owner/agent shall conduct bacterial monitoring for any spill greater than 100 gallons or when public health may be threatened in accordance with section 8. Monitoring is not required if the owner/agent demonstrates that the spill was R-1 water and that BMPs as approved by the director were implemented.

g. Reporting. The owner/agent shall report to the CWB under section 9.a.

3. **Spills into state waters of R-1 water from recycled water systems**

a. Applicability. Any spills of R-1 water covered by Appendix J to HAR chapter 11-55, "NPDES General Permit Authorizing Discharges of R-1 Water from Recycled Water Systems."
(1) "State waters" has the same meaning defined in HRS section 342D-1, and includes drainage ditches, whether or not water is always flowing in them.
(2) Exclusion. The general permit does not cover spills from treatment works.

b. Requirements. Among other things, the general permit requires filing a Notice of Intent before any discharge, compliance with standard conditions in appendix A of chapter 11-55, implementation of best management practices (BMPs), monitoring of discharges, avoiding violations of water quality criteria, and specified reporting. The full statement of requirements appears in the general permit.

4. Spills to ground only - with public access

a. Applicability. Any wastewater spill from a wastewater system onto the ground and that does not enter state waters but is in an area which is or may be accessible to the public.

(1) In this appendix, the public includes hotel, apartment, and condominium residents and guests, or condominium apartment owners at their own condominium, and management personnel and building or facility staff, unless the person is specifically an operator of the wastewater system or a manager of the property.

(2) In this appendix, areas inaccessible to the public include areas:

(a) Confined within a fenced or walled (six foot high with locked gate or door) area; and

(b) Contact with the spill is limited to wastewater system operating personnel and management personnel for the property owner or lessee.

(3) Exclusion. Spills of R-1 water provided the owner/agent demonstrates that the spill was of R-1 water and that BMPs as approved by the director were implemented.

b. Immediate notice to DOH. If a spill of a thousand gallons or more occurs during working hours:

(1) On Oahu, the wastewater system owner/agent shall immediately notify the WWB; or
(2) On the neighbor islands, the owner/agent shall immediately notify their respective district EHP chief.

If a spill of a thousand gallons or more occurs during non-working hours:
(1) Contact the state hospital operator; and
(2) The next working day notify the WWB or on the neighbor islands, the respective district EHP chief with a follow-up call.

c. Press release. The owner/agent shall immediately send out a press release for spills of a thousand gallons or more, and for lesser spills if they present a substantial threat to public health. A press release shall comply with section 7.

d. Disinfection. The owner/agent shall disinfect the wastewater that is spilled onto the ground if the wastewater remains ponded on the ground for any sufficient length of time or if the discharge continues for any significant duration. Disinfection is not required if the owner/agent demonstrates that the spill was R-2 water and that BMPs as approved by the director were implemented.

e. Warning signs. The owner/agent shall immediately post warning signs in the vicinity of the spill area.

f. Clean up. All spill sites shall be cleared of all debris and standing wastewater, and disinfected pursuant to section 4.d.

In areas containing standing wastewater which cannot be removed, the owner/agent shall limit public access by having barricades or other means.

g. Reporting. The owner/agent of a public or private wastewater system shall report to the WWB as follows:
   (1) For spills of a thousand gallons or more, the owner/agent shall report to the WWB under section 9.a.
   (2) For spills less than a thousand gallons, immediate notice and reporting are not required. A tabulated summary of all spills less than a thousand gallons each shall be submitted to the WWB on a quarterly basis in accordance with section 9.b.
   (3) Exfiltration. Reporting of leaks or breaks in pipelines discovered during inflow/infiltration repair work is not required. These situations are considered exfiltration.

5. Spills to ground only - with no public access

a. Applicability. All wastewater spills from any public or private wastewater system that does not enter state waters and are in areas inaccessible to the public.
   (1) The public and inaccessibility are described in section 4.a.
   (2) Exclusion. Spills of R-1 water provided the owner/agent demonstrates the spill was of R-1 water and that BMPs as approved by the director were implemented.

b. Immediate notice to DOH. If a spill of a thousand gallons or more, and for spills over 50 gallons occurring more than twice within a 12 month, from the same cause and/or location, period within the confines or fence line of a wastewater system, the owner/agent shall notify the WWB within 24 hours.

c. Reporting. For spills of a thousand gallons or more, and for spills over 50 gallons occurring more than twice within a 12 month period, from the same cause and/or location, within the confines or fence line of a wastewater system, the owner/agent shall report to the WWB under section 9.a.

d. Recording. The owner/agent shall record and tabulate the date and time of the spill, the amount released, the cause(s) for the spill, clean up efforts, and remedial actions taken to prevent future spills for all spills greater than 50 gallons as they happen. The owner/agent shall keep the records and tabulations on site and make the records and tabulation available to the director for inspection and copying.

6. Spills to ground only - R-1 and RO water only

a. Applicability. Spills of R-1 or RO water provided the owner/agent demonstrates the spill was of R-1 or RO water and that BMPs as approved by the director were implemented.

b. Notice to DOH.

(1) For spills of a thousand gallons or more occurs, the wastewater system owner/agent shall notify the WWB at least by phone by the end of the next working day. The notice shall provide the information required by section 6.d(1), below.

(2) For spills of less than a thousand gallons, but more than fifty gallons, next day notice is not required, but the wastewater system owner/agent shall record the information and report as required by section 6.d.

c. Warning signs. For spills greater than fifty gallons, the owner/agent shall immediately post warning signs in the vicinity of the spill area.

d. Reporting. The owner/agent of a wastewater system shall report in writing to the WWB as follows:

(1) Information of each spill shall include at least the spill's date, time, location, quantity, the reason for the spill, and any corrective action.

(2) For spills more than fifty gallons, a tabulated summary shall be submitted to the WWB each year with the summary report required by section 11-62-28.

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7. Press release

The press release shall describe the location of the spill, the amount of wastewater released, what caused the spill, and what is being done to correct the situation. Also, include a contact person and telephone number (including an after hours/weekend contact). At a minimum, the press release shall be faxed, emailed or telephoned to the following:

a. Associated Press (for radio dissemination);
b. Major statewide and island newspapers;
c. Major television news stations;
d. Department of Health, Communications Office, Oahu
e. CWB if into state waters, otherwise WWB; and
f. For neighbor island spills, also include faxing the press release to the respective island DHOs.

8. Monitoring of state waters

Monitoring shall begin as soon as possible and be conducted in the receiving water area affected by the spill. Bacterial monitoring is not required if the owner/agent demonstrates that the spill was of R-1 water and that BMPs as approved by the director were implemented.

For spills entering fresh or brackish waters, the bacterial monitoring shall consist of sampling for the following indicator organisms:

a. Enterococci; and
b. Clostridium perfringens.

For spills entering marine waters, the bacterial monitoring shall consist of sampling for the following indicator organisms:

a. Enterococci; and
b. Clostridium perfringens.

Results of the bacterial monitoring shall be submitted to the director in care of the CWB immediately. Monitoring shall continue until notification to stop is received from the director. With the approval of the director, on a case by case situation, some protocol requirements such as sampling or sign posting may be waived.

The director shall also be informed of the sampling stations and may modify the number of stations and site selection.

The director may require additional bacterial monitoring by the owner/agent to supplement their existing monitoring program, as may be necessary or appropriate.

9. Reporting

a. When required above, the owner/agent shall submit a written report of the details of the spill within five (5) working days of the incident to the director in care of the CWB or WWB as applicable. The director may waive the five day written reporting requirement on a case by case basis provided that the director receives a request for waiver prior to the due date of the report.

The report shall include the date and time of the spill, the amount released, the cause(s) of the spill, location where the spill entered state waters (storm drains, ditches, streams, etc.), clean up efforts, remedial actions to prevent future spills, a summary of the monitoring data, a map of the sampling locations and public notification procedures if applicable.

b. For spills not reported under section 9.a. and when required above, the owner/agent shall tabulate the following information: the date and time of the spill, the amount released, the cause(s) for the spill, clean up efforts, and remedial actions taken to prevent future spills. The owner/agent shall submit each quarter's tabulation to the WWB within 30 days after the quarter.

10. Modifications by the director

With the approval or under the direction of the director, response requirements may be increased, changed, reduced, or eliminated. For example, the director may require the owner/agent to post additional Warning Signs as needed or may assist in the removal of warning signs.

CHAPTER 11-62 APPENDIX C

FALLING HEAD TEST PROCEDURE

July 1, 2014

A. Preparing Percolation Test Hole(s)
   1. Dig or bore a hole, four to twelve inches in diameter with vertical walls to the approximate depth of the soil absorption system (bottom of trench or bed).
   2. Scratch the side wall and bottom to remove any smeared soil and remove loose material.
   3. Place one inch of coarse sand or gravel on bottom to protect bottom from scouring action when the water is added.

B. Determine Percolation Rate
   1. If soil is mostly clay, go to step D.
   2. Place twelve inches of water in hole and determine time to seep away. Record this time on the site evaluation form.
   3. Repeat step B.2. above. Also record this time on the site evaluation form.
   4. If the time of the second test is less than ten minutes go to step C, if not skip to step D.

C. Sandy (granular) Soils
   1. Establish a fixed reference point, add water to six inches above gravel and measure water level drops every ten minutes for 1 hour.
   2. Use a shorter time interval if first six inches seeps away in ten minutes or less.
   3. After each measurement, the water level is readjusted to the six inch level. At no time during the test is the water level allowed to rise more than the six inches above the gravel.
   4. Record time intervals and water drops on site evaluation form.
   5. Use final water level drop interval to calculate percolation rate. (step F)

D. Other soils (non-granular, e.g. silt, loams and clays)
   1. Maintain at least twelve inches of water in the hole for at least four hours to presoak soil.
   2. Do not remove water remaining after four hours.
   3. Permit soil to swell at least twelve hours. (Dry clayey soils should be soaked and permitted to swell for longer periods to obtain stabilized percolation rates).
   4. After swelling, remove loose material on top of gravel.
   5. Use fixed reference point, adjust water level to six inches above gravel and measure water level drop.
   6. If the first six inches of water seeps away in less than thirty minutes, measure water level drops every ten-minutes and run for one hour.
   7. If the first six inches of water takes longer than thirty minutes to seeps away, use thirty minute time intervals for four hours or until two successive drops do not vary by more than one-sixteenth inch (stabilized rate).
   8. After each measurement, the water level is readjusted to the six inch level. At no time during the test is the water level allowed to rise more than the six inches above the gravel.
   9. Record time intervals and water drops on site evaluation form.
   10. Use final water level drop interval to calculate percolation rate. (step F)

F. Use final drop interval to calculate percolation rate and record on site evaluation form:

$$\frac{\text{Time Interval}}{\text{Water Level Drop}} = \text{Perc rate}$$

CHAPTER 11-62 APPENDIX D - TABLES

TABLE I
July 1, 2014

Type of Establishment	Gallons Per Person Per Day (Unless Otherwise Noted)
Airports (per passenger)	5
Camps:	
Campground with central comfort stations	32
With flush toilets, no showers	25
Construction camps (semi-permanent)	50
Day camps (no meals served)	15
Resort camps (night and day) with limited plumbing	50
Luxury camps	100
Church	
With kitchen	10
Without kitchen	5
Cottages and small dwellings with seasonal occupancy (2 persons per bedroom minimum)	100
Country clubs (per resident member)	100
Country clubs (per non-resident member present)	25
Dentist per chair	200
Doctor per patient	5
Dwelling (2 persons per bedroom minimum)	100
Factories (gallons per person, per shift, exclusive of industrial waste)	35
Hair salons and barber shops,	
Barber shops (per chair)	50
Beauty salons (per chair)	125
Hospitals (per bed space)	250
Hotels with private baths (2 person per bedroom minimum)	100
Institutions other than hospitals (per bed space)	125
Laundries, self-service (per machine)	300
Mobile home parks (per space)	250
Motels with bath, toilet, and kitchen waste (per bed space)	60
Picnic parks (toilets wastes only) (per picnicker)	5
Picnic parks with bathhouses, showers, and flush toilets	50
Restaurants	
Per day per seat	50
Per meal without public restrooms	5
Per meal served with toilets	10
Additional kitchen wastes per take out meals	3
Additional for bars and cocktail lounges, per seat	15
Schools:	
Boarding	100
Day, without gyms, cafeteria, or showers	15
Day, with gyms, cafeteria, and showers	25
Day, with cafeteria, but without gyms or showers	20
Service station (per vehicle served)	10
Swimming pools and bathhouses	10
Theaters:	
Movie (per auditorium seat)	5
Drive-in (per car space)	5
Workers (in addition to above):	
Construction (at semi-permanent camps)	50
Day, at schools and offices (per shift)	20
Employee (per shift)	20

TABLE II

July 1, 2014

Minimum Horizontal Distance From	Cesspool (ft)	Treatment Unit (ft)	Seepage Pit (ft)	Soil Absorption System (ft)
Wall line of any structure or building	5	5	5	5
Property line	9	5	9	5
Stream, the ocean at the shoreline certification, pond, lake, or other surface water body	50	50	50	50
Large trees	10	5	10	10
Treatment unit	5	5	5	5
Seepage pit	18	5	12	5
Cesspool	18	5	18	5
Soil absorption system	5	5	5	5
Potable water sources serving public water systems	1000	500	1000	1000

TABLE III
July 1, 2014

Percolation Rate (min/inch) Less than or equal to	Required Absorption Area (ft2/bedroom or 200 gallons)	Percolation Rate (min/inch) Less than or equal to	Required Absorption Area (ft2/bedroom or 200 gallons)
1	70	31	253
2	85	32	257
3	100	33	260
4	115	34	263
5	125	35	267
6	133	36	270
7	141	37	273
8	149	38	277
9	157	39	280
10	165	40	283
11	170	41	287
12	175	42	290
13	180	43	293
14	185	44	297
15	190	45	300
16	194	46	302
17	198	47	304
18	202	48	306
19	206	49	308
20	210	50	310
21	214	51	312
22	218	52	314
23	222	53	316
24	226	54	318
25	230	55	320
26	234	56	322
27	238	57	324
28	242	58	326
29	246	59	328
30	250	60	330

TABLE IV
July 1, 2014

Pollutant	Pollutant Ceiling Concentration Limit (dry weight basis, mg/kg)
Arsenic	20
Cadmium	15
Chromium	200
Copper	1500
Lead	300
Mercury	10
Molybdenum	25
Nickel	420
Selenium	25
Zinc	2000

TABLE V
July 1, 2014

Amount of Wastewater Sludge (Metric Ton per 365 day period, dry weight basis)	Frequency
Greater than zero but less than 290	Once per year
Equal to or greater than 290 but less than 1500	Once per quarter
Equal to or greater than 1500 but less than 15,000	Once per 60 days
Equal to or greater than 15,000	Once per month
Amount of Wastewater Sludge (English Ton per 365 day period, dry weight basis)	Frequency
Greater than zero but less than 320	Once per year
Equal to or greater than 320 but less than 1650	Once per quarter
Equal to or greater than 1650 but less than 16,500	Once per 60 days
Equal to or greater than 16,500	Once per month

TABLE VI
July 1, 2014

Horizontal Distance From	Feet
Waters of the United States, state waters, the ocean at the vegetation line, or any other surface water body	50
Property line	50
Occupied building or dwelling	500
Potable water source serving public water systems	1000

TABLE VII
July 1, 2014

Pollutant	Pollutant Ceiling Concentration Limit (dry weight basis, mg/kg)
Arsenic	20
Chromium	200
Nickel	420

CHAPTER 11-62 APPENDIX E

CHAPTER 11-62 FORM A
CERTIFICATION FORM - LAND APPLICATION
July 1, 2014

Instructions:

1. Each form must be signed and dated to be valid.
2. The certifier shall print or type his name below the signature line and print or type the certifier's title, if any, where indicated.
3. When the certifier checks a box or fills in a line other than the signature or date lines, the certifier shall initial below the check or the line, unless the certifier uses preprinted versions of the form which delete the boxes and lines which must be initialed.

[ ] For preparers only, I certify, under penalty of law, that:

[ ] 1. The pollutant concentration ceiling limits in Table IV of chapter 11-62, HAR have been met.

[ ] 2. The following pathogen requirements have been met:

[ ] a. The Class A pathogen requirements of §11-62-46(a), HAR, specifically §11-62-46(a) (_____); or

[ ] b. The Class B pathogen requirements of 40 CFR §503.32 (b),specifically §503.32(b) (_______) and notification each land owner and land applier of wastewater sludge which I have prepared, of the spacing and site restrictions in §11-62-43(g), HAR; and the

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management requirements in §11-62-43(h), HAR.

[ ] 3. Vector attraction reduction:

[ ] a. One of the vector attraction reduction requirements in 40 CFR §503.33(b) (1) through (8), has been met, specifically §503.33(b) (____); or

[ ] b. I have not met the one of the requirements of 40 CFR §503.33(b) (1) through (b) (8), and I informed the land applier and the owner of the land application site that one of the vector attraction reduction requirements in 40 CFR §503.33(b) (9) or (b) (10) must be met;

[ ] For appliers of wastewater sludge only, I certify, under penalty of law, that:

[ ] 4. One of the vector attraction reduction requirements in 40 CFR §503.33(b) (9) or (b) (10) has been met, specifically §503.33(b) (____);

[ ] 5. The spacing and site restrictions in §11-62-43(g) have been met; and

[ ] 6. The management requirements in §11-62-43(h), HAR have been met.

[ ] For appliers of septage only, I certify, under penalty of law, that:

[ ] 7. One of the pathogen requirements in 40 CFR §503.32(c) (1) or (c) (2) has been met, specifically §503.32(c) (____);

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[ ] 8. One of the vector attraction reduction requirements in 40 CFR §503.33(b) (9), (b) (10), or (b) (12) has been met, specifically §503.33(b) (____);

[ ] 9. The spacing and site restrictions in §11-62-44(g), HAR have been met; and

[ ] 10. The management requirements in §11-62-44(h), HAR have been met.

I certify, under penalty of law, that the information that will be used to determine compliance with the foregoing requirements was prepared under my direction and supervision in accordance with the system designed to ensure that qualified personnel properly gather and evaluate this information. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment.

______________________ ______________________

Date Name

Title:______________________

Hawaiʻi State Department of Health
Cesspool Conversion Technology Research

Technical Memorandum 4
EVALUATION OF DECENTRALIZED CLUSTER WASTEWATER SYSTEMS

FINAL | November 2020

carollo
in association with
College of Engineering
University of Hawaiʻi at Mānoa

Hawaiʻi State Department of Health
Cesspool Conversion Technology Research

Technical Memorandum 4
EVALUATION OF DECENTRALIZED CLUSTER WASTEWATER SYSTEMS

FINAL | November 2020

CARI K. ISHIDA
LICENSED PROFESSIONAL ENGINEER
No. 14977
HAWAII U.S.A.
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.
SIGNATURE 04/30/2022
EXPIRATION DATE OF THE LICENSE

ROGER W. BABCOCK, JR.
LICENSED PROFESSIONAL ENGINEER
No. 12133-C
HAWAII, U.S.A.
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION
SIGNATURE 04/30/2022
EXPIRATION DATE OF THE LICENSE

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Appendices

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Abbreviations

ABS	absorption trench/bed
BOD	biochemical oxygen demand
Carollo	Carollo Engineers, Inc.
CAS	conventional activated sludge
CCTV	closed circuit television
CCWG	Cesspool Conversion Working Group
CW	constructed wetland
DO	dissolved oxygen
DOH	Department of Health
DRIP	high-pressure drip irrigation
EAAS	extended aeration activated sludge
EPA or US EPA	US Environmental Protection Agency
ET	evapotranspiration
ETI	evapotranspiration-infiltration
FOG	fats, oils, and grease
fps	feet per second
ft	feet
GP	grinder pumps
gpd	gallons per day
GS	gravity sewers
H	high maintenance
HAR	Hawaiʻi Administrative Rules
HRT	hydraulic retention time
L	low maintenance
LPP	low-pressure pipe
LPS	low-pressure sewers
M	moderate maintenance
MBBR	moving bed biofilm reactor
MBR	membrane bioreactor
MG	million gallons
mgd	million gallons per day
mg/L	milligrams per liter
mL	milliliter
MLSS	mixed liquor suspended solids
N	no maintenance
NTU	Nephelometric Turbidity Units

O&M	Operations and Maintenance
OSWT	onsite wastewater treatment and disposal system
RAS	return activated sludge
SAT	soil aquifer treatment
sf	square foot (feet)
STEP	septic tank effluent pumping
TDS	total dissolved solids
TM04	Technical Memorandum 4
TSS	total suspended solids
TXF	textile filter
UIC	underground injection control
UV	ultraviolet light
WERF	Water Environment Research Foundation
WSSC	Washington Suburban Sanitary Commission
WWB	Wastewater Branch
WWTP	wastewater treatment plant

Technical Memorandum 4

EVALUATION OF DECENTRALIZED CLUSTER WASTEWATER SYSTEMS

4.1 Executive Summary

Hawaiʻi's Act 125 requires the upgrade of all 88,000 existing residential cesspools by the year 2050. As a result, it is expected that cesspools will be replaced either by onsite wastewater treatment (OSWT) and disposal systems located on individual properties or connection to sewers and offsite wastewater treatment facilities. Connections to centralized sewers are feasible for some, but not all cesspools. Most cesspools are not located within a reasonable distance of an existing sewer system and expanding the centralized sewer system can be infeasible and cost prohibitive.

In some cases where several cesspools are in proximity, it may be feasible to construct small-scale, decentralized cluster wastewater systems for a number of homes on a neighborhood level. These systems will require wastewater collection, treatment, and disposal. The purpose of this technical memorandum (TM04) is to summarize the evaluation and comparison of the technologies available for decentralized or cluster systems in Hawaiʻi. The cluster systems evaluated were limited to those that can collect and treat domestic wastewater from 10 to 100 homes or capacities of approximately 5,000 to 50,000 gallons per day (gpd).

This evaluation of decentralized cluster system components includes collection, treatment, and disposal technologies. Table ES.1 summarizes the technologies evaluated. Data and information for were gathered from previous studies, technical literature, vendor websites, and other publicly available resources. This study was limited to common and accepted technologies available in the wastewater industry, with a focus on those treatment technologies that are available in "package plant" configurations. Package wastewater treatment plants typically use proven technologies, are easily transported and installed, and generally have a small footprint. Collection and disposal systems are not configured as pre-engineered package units and must be customized to each site.

The cluster system technologies were evaluated by several criteria that can be grouped into the following categories:

- Benefits and challenges involved with implementation.
- Operation and maintenance (O&M) requirements.
- Land requirements for treatment and disposal systems.
- Construction, O&M, and 60-year life-cycle costs.

Costs were adapted from a 2010 study conducted by Water Environment Research Foundation (WERF) (see Appendix C). These costs should only be used for relative comparison purposes. Similar to OSWT and disposal systems, a more detailed, site-specific engineering evaluation is necessary to gain a better grasp of potential conversion costs for decentralized cluster systems. A comparison of conversions to individual OSWT versus decentralized cluster system conversions can facilitate homeowner's decision processes.

Decentralized cluster wastewater systems may make sense to convert several cesspools that have a high density, are within high priority areas, and where there is community support for this kind of a solution. The benefits of implementing cluster systems, where feasible include:

- **Potential for rapid conversions.** The use of cluster systems may allow the conversion of a greater number of cesspools at a single point in time. This could help to mitigate the public health and environmental risks in high priority areas in the near term.
- **Reducing the administrative oversight and enforcement burden on state/county agencies.** For the county/state, having all systems converted on an individual basis is a much larger task than having decentralized cluster systems. Just in terms of sheer numbers of permitted units, it could reduce the number by orders of magnitude (e.g. instead of 88,000 individual units; 880 to 8,800 cluster systems).
- **Reduce the burden on individual homeowners to hire engineers and contractors independently to design and construct onsite systems.** A coordinated, organized effort to evaluate a cluster system for a neighborhood would relieve the burden on individual homeowners to understand and determine their cesspool upgrade needs.
- **Ensure proper operations and ongoing maintenance of the systems by requiring a licensed wastewater operator.** Cluster systems are regulated and inspected by the State of Hawaiʻi Department of Health (DOH) Wastewater Branch (WWB) the same manner as existing wastewater treatment plants (WWTPs). The rules and procedures are already in place, including the requirement that state-licensed WWTP operators oversee the cluster systems. This is more likely to ensure that systems are inspected, operated, maintained, repaired, and function as required to meet the treatment and disposal regulations.
- **Potentially broaden the range of funding opportunities.** One of the hurdles in funding cesspool conversions is that many existing funding options require a conduit agency or intermediate party to manage and administer available grant or low interest loan funds to individual homeowners for cesspool conversions. Given that decentralized systems will need to be managed and operated by a third party, this also opens the door for more funding options. In addition, if water reuse is a disposal option for the decentralized system, there are additional funding opportunities that may apply. Water reuse is not allowed for onsite systems; thus, those funding opportunities would not be available.

The challenges to implementing cluster systems for cesspool conversions in Hawaiʻi include:

- **Need for neighborhood-level coordination.** One of the greatest hurdles to implementing decentralized solutions for cesspool conversions is that a group of homeowners would need to take the initiative to form an association or district to collect fees and procure various professional and construction-related services. To truly evaluate the feasibility of decentralized systems for certain neighborhoods, a licensed engineer needs to perform a site-specific analysis and develop costs for a recommended system. Legislative measures may be necessary to facilitate neighborhood-level coordination especially if participation will be required of homeowners.
- **Cost.** Decentralized cluster systems require higher up-front planning and design fees and have higher construction costs than OSWT and disposal systems. A site-specific analysis is necessary to evaluate the feasibility and best overall system options for a neighborhood. The engineering evaluation could be quite expensive – easily 5 to 10 times the cost of an onsite design for a single homeowner. In addition, the construction would be more extensive than onsite systems, and construction costs would accordingly be higher on a per lot basis.

- **Need for skilled operators.** Licensed wastewater operations professionals would be required to operate and maintain the cluster system components in perpetuity.
- **Land/space requirement.** Decentralized systems would likely need to be constructed on newly acquired land and may require easements. These cluster systems would only be a viable option if the required land is available.

A countywide or statewide study of potential neighborhoods/sites for cluster systems with an initial focus on priority areas, including planning level cost estimates could facilitate this process. Such a study could help the state to evaluate and upgrade those cesspools deemed to pose the greatest risks to public health and the environment more rapidly. The information provided within this TM can help to facilitate future studies and evaluations of decentralized cluster wastewater systems by licensed engineers.

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Table ES.1 Summary of Benefits, Challenges, and Operation and Maintenance Requirements for Decentralized Cluster Systems

Technology[1]	Benefits	Challenges	Technology Status	Replace Interval (year)	O&M Effort[2]	O&M Requirements[3]
Collection System Options						
Gravity Sewers (GSs)	• Can handle grit and other solids, as well as large volumes of flow. • Does not require onsite treatment or storage of the household wastewater before it is discharged. • Little impact to homeowners and their properties. • Presents a viable option if there is an appropriate difference in elevation. • No electricity for pumping and no pump maintenance.	• Flat or large variations in terrain can increase costs • Larger pipes compared to other collection system options. • Prone to clogging. • Manholes associated with gravity sewers are a potential source of inflow and infiltration. • Higher capital costs.	Most common, highly developed	60	L	• Inspect on a regular schedule, this can be accomplished via surface inspections of manholes, lowering hand-held camera or robotic CCTV. • Proactively flush accumulated debris and fats, oils, and grease (FOG). • Remove blockages and tree roots as required.
Liquid-Only Pressure Sewers	• Independent from land topography restrictions. • The septic tank retains most of the FOG and solids reducing clogging problems. • Septic tanks have storage capacity to operate during power outages. • Smaller pipes compared to conventional gravity sewers. • Can be installed at a shallow depth and do not require a minimum flow velocity or slope to function.	• Requires an onsite septic tank and pump on each property. • Grease and sludge must be pumped from each individual septic tank. • Anaerobic septic tanks can generate odors and methane gas. • Leaks pose a risk of wastewater exfiltration. • Pumps and filters must be maintained.	Highly developed	Pump - 20 Septic tank - 60 Piping - 60	M	• Provide/maintain electricity to each unit. • Inspect and clean filter on pump monthly. • Periodically remove accumulated sludge and scum from septic tank. • Remove any blockages in the pressure pipe network.
Low-Pressure Sewers	• Small diameter piping, shallow, easily installed. • Independent from land topography restrictions. • No manholes required and no storm water infiltration. • Less clogging and subsequent O&M cleaning or flushing.	• Requires pump/vault installation on each property. • Requires an energy source for the grinder pumps. • Pumps must be maintained on each property.	Highly developed	Pump - 20 Piping - 60	M	• Provide/maintain electricity to each unit. • Inspect pump and chamber on a regular basis, remove any accumulated materials. • Inspect and maintain backflow preventers. • Remove any blockages in the pressure pipe network.
Vacuum Sewers	• Small diameter piping, shallow, easily installed. • No manholes required and no storm water infiltration. • Closed system with no exfiltration or odors. • Flexible installations regardless of topography and water availability.	• Requires construction of vacuum equipment at each home. Requires land for central vacuum stations • Economic feasibility depends on the number of homes served by the system (the more the better). • Requires energy to create the permanent vacuum. • Vacuum stations require regular O&M checks, typically higher O&M than gravity collection systems.	Uncommon, Highly developed	Pumps - 20 Equipment - 20 Piping - 60	H	• Provide/maintain electricity to each unit and vacuum station. • Regular pressure/vacuum testing. • Vacuum stations require regular O&M checks • Remove any blockages in the pressure pipe network.

Technology[1]	Benefits	Challenges	Technology Status	Replace Interval (year)	O&M Effort[2]	O&M Requirements[3]
Treatment System Options						
Conventional Activated Sludge	• High BOD and nitrogen removal, high effluent quality, self-sustaining system. • Small land area requirement. • Free from fly and odor nuisance. • Can be modified to meet specific discharge limits.	• High electricity consumption and costly mechanical parts. • Requires skilled operation and maintenance. • Requires expert design and construction. • Bulking and biological surface foaming.	Most common, highly developed	30	M	• Monitoring of DO, pH, and MLSS. • Influent and effluent must be monitored, changing the parameters accordingly. • Regular cleaning of influent screens. • Regular sludge wasting and disposal. • Control of concentrations of sludge and oxygen levels in the aeration tanks. • Maintenance includes inspecting the aeration system and following manufacturer recommendations for maintenance of all equipment.
Extended Aeration Activated Sludge	• Systems consistently provide high quality effluent in terms of TSS, BOD, and ammonia levels. • Long HRT and complete mixing, minimal impact of a shock load or hydraulic surge. • Produces less sludge due to extended retention of biological solids in the aeration tank.	• Higher energy uses due to longer aeration time. • Larger footprint than CAS. • Less flexibility than CAS should regulations for effluent requirements change.	Most common, highly developed	30	M	• Monitoring of DO, pH, and MLSS. • Influent and effluent must be monitored, changing the parameters accordingly. • Regular cleaning of influent screens. • Regular sludge wasting and disposal. • Control of concentrations of sludge and oxygen levels in the aeration tanks. • Maintenance includes inspecting the aeration system and following manufacturer recommendations for maintenance of all equipment.
Membrane Bioreactor Activated Sludge	• Secondary clarifiers and tertiary filtration processes are eliminated, thereby reducing plant footprint. • High quality effluent.	• Membrane complexity and fouling. • Higher capital, operation, and energy costs. • Hydraulic flow peak capacity is limited to 1.8 times average flows and only for short periods.	Highly developed	30	M	• Maintenance includes chemical cleaning of membranes. • Monitoring of DO, pH, and MLSS. • Influent and effluent must be monitored, changing the parameters accordingly. • Regular cleaning of influent screens. • Regular sludge wasting and disposal. • Control of concentrations of sludge and oxygen levels in the aeration tanks. • Maintenance includes inspecting the aeration system and following manufacturer recommendations for maintenance of all equipment.
Textile Filter (Attached Growth Systems)	• Can operate at a range of organic and hydraulic loads. • Lower energy input than CAS. • Low sludge production.	• Requires expert design, construction, operation and maintenance. • Some variations have larger footprints. • Risk of clogging, depending on pre and primary treatment.	Highly developed	30	L	• Monitoring of influent and effluent. • Maintenance of all equipment following manufacturer's recommendations. • Optimum dosing rates and flushing frequency are determined from the field operation. • The packing should also be kept moist which can be problematic at night or during power failures. • Regular cleaning of influent screens. • Regular sludge wasting and disposal. • The sludge that accumulates on the filter must be periodically washed away to prevent clogging and to keep the biofilm thin and aerobic.

Technology[(1)]	Benefits	Challenges	Technology Status	Replace Interval (year)	O&M Effort[(2)]	O&M Requirements[(3)]
Moving Bed Biofilm Reactor	• Efficient treatment, low HRT, flexibility to adapt to fluctuating hydraulic and organic loads. • Low Maintenance. • Very compact, due to the maximized surface area the media provide for biofilm growth.	• High-tech system. • Higher capital and operating costs. • Carriers can wash out of the system, necessitating supplemental additions.	Uncommon, Highly developed	30	H	• Monitoring of influent and effluent. • Maintenance of all equipment following manufacturer's recommendations. • Observation of media color and adjustment of air. • Monitoring and adjustment of dissolved air flotation units. • Regular cleaning of influent screens. • Regular sludge wasting and disposal. • Operators must take samples periodically and analyze them to ensure the bacteria on the carriers are still thriving.
Constructed Wetland	• Simple, easily operated natural system. • Inexpensive compared to other treatment options. • Requires little energy when the system operates with gravity flow.	• Large land requirement. • Not available as a package facility. • Vector and odor nuisances.	Uncommon, Highly developed	30	L	• Vector control to prevent population growth of insects and odor control. • Occasional maintenance of the vegetation promotes growth of desired vegetation and maintains hydraulic capacity. • Monitoring of influent and effluent.
Effluent Disposal Options						
Absorption Trench/Bed	• Common type of disposal system so there are many products available and experience with installation. • When deployed downstream from an aerobic treatment system, it provides some treatment for BOD, TSS, and fecal coliform. • No power is required, and maintenance is generally not necessary. • Graveless dome systems require less gravel backfill and provide significant additional water storage volume.	• Cannot be used in terrain where natural slope is > 12 percent. • Cannot be used if groundwater is too close to the surface, minimum vertical separation of three feet from the bottom of the trench/bed. • Large land requirement. • Overloading, rainfall, or unsuitable soils may cause contaminants to spill out into the surroundings.	Most common, highly developed	60	N	• Normally none. • Some systems use a dosing pump - if present, it must be checked and cleaned. • Observation ports can be installed within the disposal area to check whether the water is percolating into the ground as expected.
High-Pressure Drip	• Reliable alternative for areas with low permeability, seasonal high-water tables, or severe slopes. • Ability to control dose/rest cycles allows for even spacing or dosing of effluent and facilitates wastewater infiltration by spreading it spatially and temporally. • Significant evapotranspiration is expected.	• Large dose tank is needed to accommodate timed dose delivery to the drip absorption area. • Power is required to run pumps, sensors, and controls. Some minimal regular maintenance is required. • Clogging of emitters can occur.	Highly developed	30	L	• Provide continuous electricity to small dosing pumps. • Typical inspections may include observing and reporting of the general condition of the system, water level in tanks, ponding around the system, clogging at pumps and filters, pump cycles, and readings of any meters. • Regular monitoring and maintenance of pump, filter and piping shall be performed.
Low Pressure Pipe	• Reliable alternative for areas with low permeability, seasonal high-water tables, and/or severe slopes. • Shallow and narrow trenches reduce site disturbance and land area requirement. • Ability to control dose/rest cycles allows for even spacing or dosing of effluent and facilitates wastewater infiltration by spreading it spatially and temporally.	• Limited storage capacity around laterals. • Possibility of wastewater accumulation in the trenches. • Potential for clogging and infiltration problems.	Highly developed	60	L	• Monitoring ponding at the bottom of trenches, readjusting operating pressure, and reducing flow to overloaded trenches. • Flushing manifold and lateral lines periodically.

Technology(1)	Benefits	Challenges	Technology Status	Replace Interval (year)	O&M Effort(2)	O&M Requirements(3)
Seepage Pit	• Simplest and most compact method to percolate water into the ground. • Viable options when land is insufficient for absorption beds or trenches, or the terrain is steep.	• Cannot provide additional treatment or evapotranspiration. • Must have adequate separation from groundwater (at least 3 ft).	Uncommon, unlikely to be approved	60	N	• Inspection and pumping every 2 to 4 years.
Water Reuse	• Helps reduce overall demand on potable water supply. • Utilized in landscaping, agricultural irrigation, and even toilet flushing.	• Often more expensive treatment is required to reach water quality requirements. • Strict rules and regulations to prevent potential environmental or health consequences.	Highly developed	60	H	• Extensive monitoring at the treatment facility is required; for R-1 water: continuous for NTU and fecal coliforms. • A water reuse plan is required for the reuse site, with monitoring and reporting. Signage is required at the site.
Evapotranspiration	• If an impermeable liner is included for a "zero-discharge" system, then 100 percent nitrogen removal is achieved. • Low cost, simple disposal system.	• Large surface areas are needed for year-round disposal. The size is controlled by a water balance based on rainfall and pan evaporation rates. • More effective in arid climates where evaporation rates are much higher than precipitation.	Uncommon, highly developed	60	L	• Provide continuous electricity to small dosing pumps. • Inspection of observation wells. • Trim vegetated area of ET system, replace plants as needed.
Injection Well	• Very simple system. • Little to no maintenance required.	• Limited applicable locations/siting. • Very difficult to obtain a permit.	Uncommon, unlikely to be approved	60	M	• Sampling and reporting.
Surface Water Discharge	• Simple system. • Effectively recycles water back into the environment. • Can augment stream flow.	• Potential negative impacts on natural bodies of water or drinking water. • NPDES permit required. Expensive monitoring and reporting required. • Very limited applicable locations/siting.	Uncommon, unlikely to be approved	60	M	• Sampling and reporting.

Notes:
(1) CAS = conventional activated sludge, LPP = low pressure pipe, ET = evapotranspiration.
(2) O&M = operations and maintenance, N = no maintenance, L = low maintenance, M = moderate maintenance, H = high maintenance.
(3) CCTV = closed circuit television, DO = dissolved oxygen, MLSS = mixed liquor suspended solids, BOD = biochemical oxygen demand, TSS = total suspended solids, HRT = hydraulic retention time, mg/L = milligrams per liter, mL = milliliter, NTU = Nephelometric Turbidity Units.

4.2 Introduction and Background

According to the United States Environmental Protection Agency (US EPA), cesspools are underground excavations that receive sanitary wastewater from bathrooms, kitchens, and washers. Figure 4.1 is a schematic diagram of a typical cesspool. The structure usually has an open bottom and perforated walls (unlined, except for geotextile fabric on the outside). Domestic wastewater flows into the structure and the solid waste collects at the bottom of the cesspool and the liquid waste flows out of the perforations. Cesspools are not designed to treat wastewater, but rather to separate solids from sanitary waste and allow liquid wastes to percolate into the soil strata and underlying groundwater aquifer as well as any hydraulically connected surface waters.

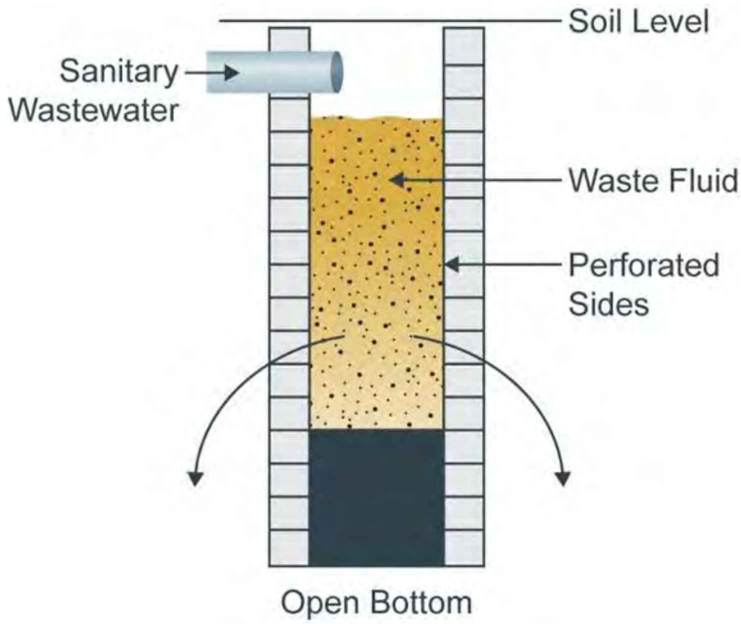

Figure 4.1 Cesspool Schematic

Throughout Hawaiʻi there are approximately 88,000 cesspools that release an estimated 53 million gallons per day (mgd) of wastewater into the environment. Most of these existing cesspools provide wastewater disposal for single-family residences, versus large-capacity systems that service multiple residences or commercial areas. Given that over 90 percent of the state's drinking water supplies are from groundwater sources, it was recognized that cesspools pose an environmental and public health risk.

In 2017, the Hawaiʻi State Legislature passed Act 125, which states that by January 1, 2050 all cesspools in the state of Hawaiʻi, unless granted exemption, shall upgrade or convert to a septic or aerobic treatment unit, or connect to a sewer system (ACT 125, 2017). Act 132 was then passed in 2018 to establish the Cesspool Conversion Working Group (CCWG) to develop a long-range, comprehensive plan and commission a statewide study of sewage contamination in nearshore marine areas (ACT 132, 2018). The CCWG retained Carollo Engineers, Inc., (Carollo) to provide expertise related to OSWT technologies, decentralized sewer systems, and cesspool conversion funding and finance options. There are generally three options for cesspool conversions including:

- New OSWT and disposal systems.
- New decentralized cluster sewer systems.
- Connection to existing or new centralized sewer systems.

The purpose of TM04 is limited to the evaluation of decentralized cluster sewer systems as a cesspool conversion option. Evaluations of OSWT and disposal systems are covered in TM03. Evaluation of centralized sewer systems is not included in the scope of this project.

4.2.1 Decentralized Cluster Wastewater Systems and Key Assumptions

For the purposes of this evaluation, decentralized cluster systems are defined as small systems treating wastewater flows from as few as 10 homes up to approximately 100 homes, or roughly 5,000 to 50,000 gpd. These systems consist of three major components: wastewater collection, treatment, and disposal. A decentralized system must be jointly owned by the homeowners it serves, a homeowner's association, private entity, or a public agency.

State rules require the use of a licensed wastewater treatment plant operator for any system with a flow of 1,000 gpd or more and for all multi-owner systems. The operator is required to visit the facility at least weekly to manage ongoing O&M including monitoring, cleaning, maintaining back-up power, reporting to DOH, hauling away and properly disposing of residual sludges, etc. The homeowners would generally have to form some sort of sewer district or other legal entity and have the decentralized system recorded on their property deeds to ensure timely payments to fund the system. Monthly fees would also need to be collected; this could be accomplished by a private wastewater operation firm or by a homeowner's association, district board, etc.

These systems will generally require infrastructure located off-site from the homeowner member properties. This could include sewer systems below ground in public or private rights-of-way requiring easements, as well as treatment and disposal facilities located on land that would have to be procured, leased, or possibly on common area property belonging to a homeowner's association.

This TM04 investigates the different options for:

- Small collection systems applicable to decentralized cluster systems.
- Treatment systems (in particular, package plants).
- Disposal systems.

All systems described herein must be designed to meet all applicable state and county regulations and rules including design criteria and regulated contaminants such as total suspended solids (TSS), biochemical oxygen demand (BOD), nitrogen, phosphorus, and fecal coliform. For each technology, a description is provided followed by analysis of constraints, benefits/challenges, and estimated costs.

Estimated costs for most of the systems evaluated were adapted from a previous report entitled *Performance and Cost of Decentralized Unit Processes* (WERF, 2010). Several of the systems evaluated were not included in the WERF study and thus new cost estimates were developed. The WERF report provided costs in 2009 dollars for mainland USA. Those costs were adapted and estimated for Hawaiʻi in 2020 dollars. Costs exclude engineering, permitting, land acquisition, and contingencies related to challenging site conditions (i.e. occurrence of rock, high groundwater, steep slopes, etc.). It should also be noted that collection system costs are highly dependent on the proximity of the parcels served and the distance to the treatment and disposal site.

4.2.2 Factors Related to the Comparison of Decentralized Versus Onsite Systems for Cesspool Replacements

There are approximately 150 privately owned wastewater treatment facilities in the state of Hawaii (versus approximately 49 publicly owned treatment works). Figure 4.2 shows the locations of the public and privately-owned wastewater treatment plants in the state[1].

Most of the privately-owned facilities serve resorts, condominiums/apartments, industries, and/or commercial buildings, and are generally constructed when new development or significant redevelopment occurs. There have not been many decentralized systems constructed to service existing residential areas of single-family homes, and it is not known if this option has been considered or evaluated for specific areas.

There may be instances and locations where decentralized systems are a better option for cesspool conversions in Hawaiʻi compared to individual, onsite solutions, or connections to centralized sewers. Factors to consider include:

- **The number of systems in the cluster and the separation distance between them.** There may be an ideal density of cesspools within a neighborhood that would allow for a cost-effective solution. This would need to be evaluated on a site-specific basis by a licensed engineer.
- **Terrain.** Depending upon the local soils, slopes, and other site-specific features, the terrain may limit the options and potential application of a decentralized system. Onsite systems need only consider the terrain of individual properties.
- **Availability of land.** Decentralized systems will likely need to be constructed on newly acquired land and may require easements. These cluster systems would only be a viable option if the required land is available.
- **Public support for a decentralized system, including shared funding for a utility service providing O&M.** For an onsite system, the homeowner is the only party involved and is responsible for the financing of the system, its O&M, any permits, and fines due to non-compliance or spills, etc. This is very simple for the owner in the sense that they do not rely on any other homeowners, a sewer district board, or potential future capital assessments for other people's problems. At the same time, the owner of an onsite system must be the responsible party and plan to have the O&M completed. While cost can be a powerful motivator, some homeowners may see value and convenience in having a separate service operate and maintain a decentralized system over an onsite system. Utility systems have stable, regular monthly bills rather than less frequent larger bills for pumping/servicing/repair of an onsite system. Failures and surprise costs due to lack of care are much less likely for continuously operated cluster systems than onsite systems which are frequently neglected because they are "out-of-site, and out-of-mind".

[1] https://geoportal.hawaii.gov/datasets/wastewater-treatment-plants/data?geometry=-178.050%2C16.796%2C-136.236%2C23.998

Figure 4.2 Publicly and Privately-Owned Wastewater Treatment Plants in Hawaii

- **Number of wastewater systems to oversee and manage.** For the county/state, having all systems converted on an individual is a much larger task than having decentralized cluster systems. Just in terms of sheer numbers of permitted units, it could reduce the number by orders of magnitude (e.g. instead of 88,000 individual units; 880 to 8,800 cluster systems). In addition, cluster systems are regulated and inspected by the Hawaii DOH WWB the same manner as existing WWTPs. The rules and procedures are already in place, including the requirement that state-licensed WWTP operators oversee the cluster systems. This is more likely to ensure that systems are inspected, operated, maintained, repaired, and function as required to meet the treatment and disposal regulations. A similar regulatory and enforcement system for individual onsite system management does not currently exist at the county/state level in Hawaiʻi and it will need to be developed, implemented, funded, and appropriately staffed[2].
- **Potential for funding opportunities.** Decentralized systems may have a broader range of funding opportunities than onsite systems. One of the hurdles in funding cesspool conversions is that many existing funding options require a conduit agency or intermediate party to manage and administer available grant or low interest loans to individual homeowners for cesspool conversions. Given that decentralized systems will need to be managed and operated by a third party, this also opens the door for more funding options. In addition, if water reuse is a disposal option for the decentralized system, there are additional funding opportunities that may apply. Water reuse is not allowed for onsite systems; thus, those funding opportunities would not be available.

4.2.3 Potential Application of Decentralized Cluster Systems for Cesspool Conversions in High Priority Areas

The 2018 DOH Report to the Hawaii State Legislature prioritized existing cesspools into four categories:

- **Priority 1:** Significant risk of human health impacts, drinking water impacts, or draining to sensitive waters.
- **Priority 2:** Potential to Impact Drinking Water.
- **Priority 3:** Potential Impacts on Sensitive Waters.
- **Priority 4:** Impacts Not Identified.

The highest risk areas (Priority 1) should be addressed as soon as possible due to high public health and environmental risks.

The following risk factors were considered in formulating the priority categories:

- Density of cesspools in an area.
- Soil characteristics.
- Proximity to drinking water sources, streams, and shorelines.
- Other groundwater inputs including agriculture and injected wastewater.
- Physical characteristics of coastal waters that may compound the impacts of wastewater in bays and inlets.

Table 4.1 shows that Priority 1 areas include 8,140 cesspools which comprise approximately 9 percent of the 88,000 cesspools in Hawaiʻi. These priority categories and assignments were presented by the DOH WWB and the US EPA to the 2018 Hawaiʻi Legislature and they are subject to evaluation and possible revision through the activities of the CCWG. It is recommended that cesspools located in Priority 1 areas are upgraded with technologies that remove nitrogen and may also require disinfection (if near surface water).

[2] TM01 included a discussion of staffing requirements by other agencies.

The costs for each OSWT and disposal system in the Priority 1 areas will likely be higher than other areas since a higher level of treatment is required.

Decentralized cluster systems may be a good option for Priority 1 areas to provide:

- Rapid, near-term conversions within areas deemed to have the greatest environmental risks.
- Reliable and appropriate level of treatment of wastewater prior to disposal.

Table 4.1 Initial Priority Upgrade Areas Established by DOH WWB (DOH, 2018)

Geographic Area	Priority Level Assigned	Number of Cesspools	Estimated Effluent Discharge (mgd)
Upcountry area of Maui	1	7,400	4.4
Kahaluʻu area of Oʻahu	1	740	0.44
Keaʻau area of Hawaiʻi Island	2	9,300	4.9
Kapaʻa/Wailua area of Kauaʻi	2	2,900	2.2
Poipu/Kōloa area of Kauaʻi	2	3,600	2.6
Hilo Bay area of Hawaiʻi Island	3	8,700	5.6
Coastal Kailua/Kona area of Hawaiʻi Island	3	6,500	3.9
Puako area of Hawaiʻi Island	3	150	0.60
Kapoho area of Hawaiʻi Island	3	220	0.12
Hanalei Bay area of Kauaʻi	3	270	0.13
Diamond Head area of Oʻahu	3	240	0.17
ʻEwa area of Oʻahu	3	1,100	0.71
Waialua area of Oʻahu	3	1,080	0.75
Waimanalo area of Oʻahu	3	530	0.35
	Total Assigned	**42,730**	**26.87**
Hawaiʻi Island Un-Assigned	NA	24,430	12.18
Kauaʻi Un-Assigned	NA	6,930	4.57
Maui Un-Assigned	NA	4,800	3.5
Oahu Un-Assigned	NA	7,610	5.08
Molokaʻi Un-Assigned	NA	1,400	0.80
	Total Un-Assigned	**45,170**	**26.13**
	Overall Totals	**87,900**	**53.0**

4.2.4 Regulation of Decentralized Cluster Wastewater Systems in Hawaiʻi

Collection, treatment, and disposal systems are all regulated separately in Hawaiʻi. Decentralized collection systems are regulated at the county level similar to centralized systems. These regulations include design standards, such as minimum slopes and diameters, materials, and depths[3].

Decentralized treatment systems are considered "treatment works" and thus, are regulated the same as centralized systems, such as those owned and operated by each of the counties, military facilities, and

[3] Honolulu County's rules are contained here: http://www.honolulu.gov/rep/site/env/wwm_docs/DESIGN_STANDARDS_-_CHAPT_1_FINAL.pdf, http://www.honolulu.gov/rep/site/env/wwm_docs/DESIGN_STANDARDS_-_CHAPT_2_FINAL.pdf

private sewer systems or districts. These regulations can be found in Hawaiʻi Administrative Rules (HAR) HAR 11-62 [4]. In addition, the City and County of Honolulu also has their own rules for treatment plant design[5].

HAR 11-62 also covers disposal via absorption and discharge to state waters. DOH has additional rules for water reuse[7] and for underground injection[8].

4.3 Description of Collection System Technologies

The collection system conveys wastewater from each home to a treatment and disposal facility and consists of a network of pipes and related equipment such as pumps, valves, manholes, etc. located on private and public property. The following options for collection systems are described in the following sections:

- Gravity Sewers (GS).
- Liquid-Only Pressure Sewers.
- Low-Pressure Sewers.
- Vacuum Sewers.

4.3.1 Gravity Sewers

Gravity sewers are a network of underground pipes that convey wastewater (greywater plus blackwater[5]) from individual households to a treatment facility (Figure 4.3). Gravity sewers are the standard, conventional type of system for centralized wastewater systems that connect numerous homes, businesses, and industries to a regional treatment plant. The sewers utilize gravitational energy resulting from a difference in elevation to cause flow.

Table 4.2 summarizes the benefits and challenges of this type of wastewater collection system. Where appropriate differences in elevation exist, gravity sewers are a feasible collection system option that has little unwanted effects on homeowners and their properties. Conventional gravity sewers do not require storage of household wastewater before it is discharged into the collection system pipes, and they can handle grit and other solids, as well as large volumes of flow. However, these sewers must be designed to maintain a self-cleansing velocity, generally 2 feet per second (fps), at a minimum, during most flow conditions.

[4] https://health.hawaii.gov/opppd/files/2015/06/11-62-Wastewater-Systems.pdf

[5] Wastewater can be separated into graywater and blackwater. Blackwater includes wastewater from toilets and kitchen sinks (includes foodwaste). Graywater excludes blackwater sources and is generally limited to bathroom sinks, showers/tubs, and laundry.

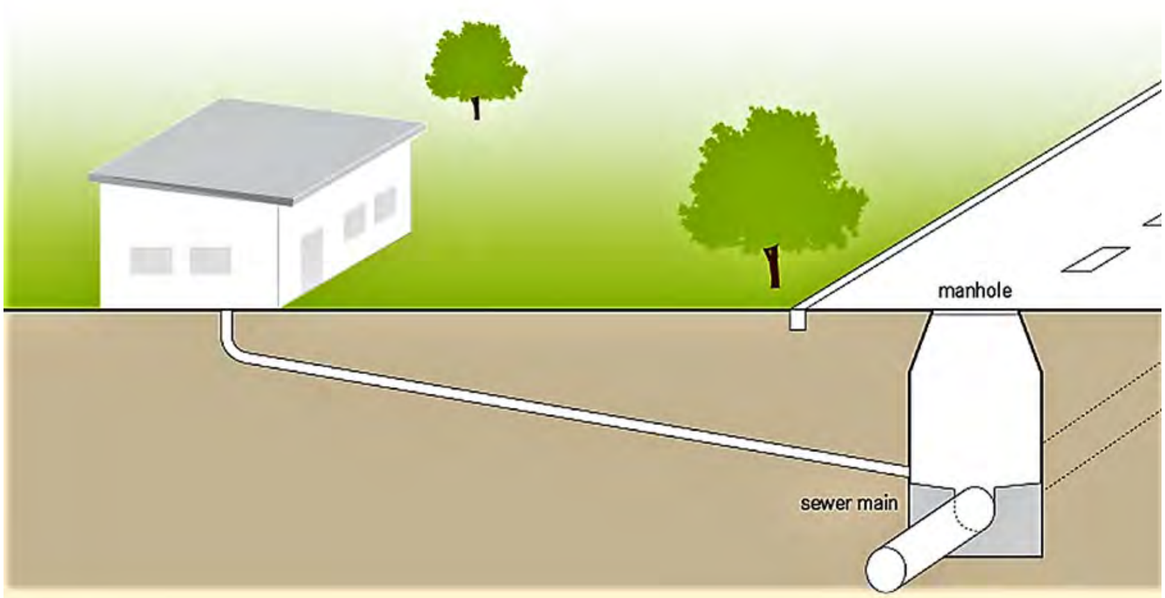

Figure 4.3 Typical Gravity Sewer System (Tilley et al, 2014)

Table 4.2 Benefits and Challenges for Decentralized Conventional Gravity Sewers

Benefits	Challenges
• Can handle grit and other solids, as well as large volumes of flow. • Does not require onsite treatment or storage of the household wastewater before it is discharged. • Little impact to homeowners and their properties. • Presents a viable option if there is an appropriate difference in elevation. • No electricity for pumping and no pump maintenance.	• Flat or large variations in terrain can increase costs • Larger pipes compared to other collection system options. • Prone to clogging. • Manholes associated with gravity sewers are a potential source of inflow and infiltration. • Higher capital costs.

4.3.2 Liquid-Only Pressure Sewers

A liquid-only sewer system is a network of pipes that convey pre-treated wastewater pumped under pressure to the treatment facility. A precondition for these sewers is that efficient preliminary treatment is available at the household level, typically achieved using a septic tank (see Figure 4.4). This system is also known as a septic tank effluent pumping (STEP) sewer system and is practical in areas with a limited number of homes and relatively short distances to the neighborhood treatment facility.

Some of the benefits and challenges of liquid-only pressure sewers are summarized in Table 4.3. Liquid-only sewer systems are most feasible in communities that have existing septic tanks at individual homes. Thus, for Hawaiʻi's cesspool conversions, septic tanks would be required in addition to a STEP collection system, followed by treatment and disposal systems. The septic tanks retain most of the fats, oils, and grease (FOG), thereby greatly reducing or eliminating clogging problems, and have storage capacity to hold its contents during power outages.

Compared to conventional gravity sewers, liquid-only pressure sewers can have lower capital costs depending upon terrain, local site conditions, and if there is an existing septic tank at each homesite. They also do not have to be installed on a uniform gradient with a straight alignment between inspection points; the alignment may curve vertically (go under or over) and horizontally (go around) to avoid obstacles, allowing for greater construction flexibility.

Figure 4.4 Typical Liquid-Only Pressure Sewer System (Orenco Systems, Inc.)

Table 4.3 Benefits and Challenges for Decentralized Liquid Only Pressure (STEP) Sewers

Benefits	Challenges
• Independent from land topography restrictions. • The septic tank retains most of the FOG and solids reducing clogging problems. • Septic tanks have storage capacity to operate during power outages. • Smaller pipes compared to conventional gravity sewers. • Can be installed at a shallow depth and do not require a minimum flow velocity or slope to function.	• Requires an onsite septic tank and pump on each property. • Grease and sludge must be pumped from each individual septic tank. • Anaerobic septic tanks can generate odors and methane gas. • Leaks pose a risk of wastewater exfiltration. • Pumps and filters must be maintained.

4.3.3 Low Pressure Sewers

Low pressure sewers (LPS) utilize grinder pumps (GPs) located in a small receiving station/vault on each property to transport finely ground raw wastewater from the home through a network of pressurized sewer pipes to the treatment facility (see Figure 4.5). Table 4.4 summarizes the benefits and challenges of low-pressure systems. Raw wastewater from the home enters an onsite tank that is much smaller than a septic tank which houses the GP where the sewage is shredded by cutting blades in the pump intake. Pumps at each home contribute flow to the pressurized network which conveys the chopped raw sewage to the treatment facility. Compared to conventional gravity sewers, low-pressure sewers can have lower capital costs depending upon terrain and local site conditions.

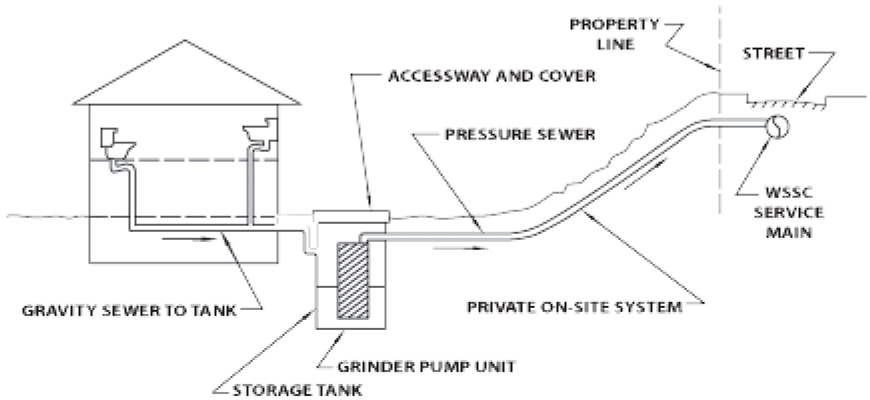

Figure 4.5 Typical Low-Pressure Sewer System (Washington Suburban Sanitary Commission [WSSC] Water, 2019

Table 4.4 Benefits and Challenges for Decentralized Low-Pressure Sewers

Benefits	Challenges
• Small diameter piping, shallow, easily installed. • Independent from land topography restrictions. • No manholes required and no storm water infiltration. • Less clogging and subsequent O&M cleaning or flushing.	• Requires pump/vault installation on each property. • Requires an energy source for the grinder pumps. • Pumps must be maintained on each property.

4.3.4 Vacuum Sewers

Vacuum sewers use differential air pressure (i.e., negative pressure) to transport raw sewage from its source to a treatment facility. It maintains a partial vacuum with an air pressure below the atmospheric pressure inside the pipe network and vacuum station's collection vessel. A vacuum sewer system consists of valve vaults (i.e., collection chambers) at each home, vacuum interface valves that regulate the entry of wastewater and air from the valve vault into the collection system, collection system piping, and one or more vacuum stations. The system requires a normally closed interface valve at each entry point to seal the lines, so that the vacuum is maintained. The valves open when a specific amount of sewage accumulates in the collection chamber, upon which the resulting pressure difference drives the sewage towards the vacuum station and then to the treatment facility (see Figure 4.6). Such a system works best in flat or gently rolling terrain because it has limited capabilities to transport wastewater uphill (a maximum of about 20 feet). The pipes of vacuum sewers have relatively small diameters and can be laid at shallow depths.

Table 4.5 summarizes the benefits and challenges of vacuum sewers. These sewers require vacuum equipment and central vacuum stations to be constructed on an available parcel of land, and they also have relatively high operating costs because of the technology involved and the constant energy requirement for permanent vacuum generation. However, the capital cost can be similar to conventional gravity sewers, depending on the number of homes served by the system.

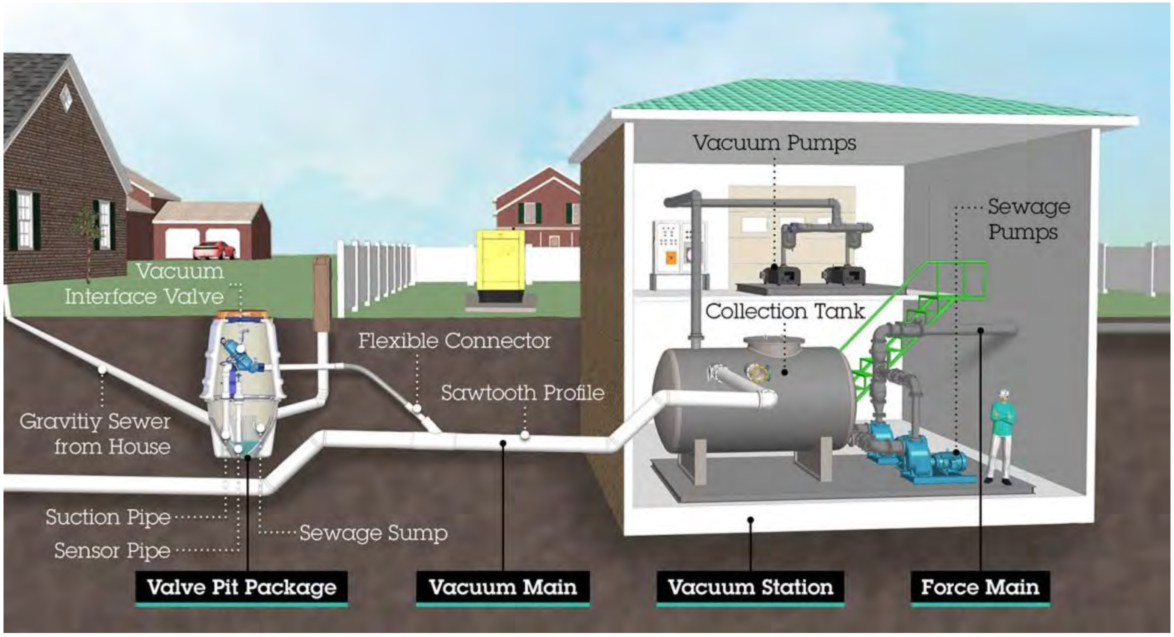

Figure 4.6 Typical Vacuum Sewer System (Airvac ® Vacuum Sewer Systems, QSM, 2020)

Table 4.5 Benefits and Challenges for Decentralized Vacuum Sewers

Benefits	Challenges
• Small diameter piping, shallow, easily installed. • No manholes required and no storm water infiltration. • Closed system with no exfiltration or odors. • Flexible installations regardless of topography and water availability.	• Requires construction of vacuum equipment at each home. Requires land for central vacuum stations • Economic feasibility depends on the number of homes served by the system (the more the better). • Requires energy to create the permanent vacuum. • Vacuum stations require regular O&M checks, typically higher O&M than gravity collection systems.

4.4 Description of Small/Cluster Wastewater Treatment Systems

The second of the three components of a decentralized cluster system is the treatment system which must treat the wastewater collected from the homes to a suitable degree to allow disposal and/or reuse. The process generally consists of the tanks and other process equipment required for separation and storage of solids, oxidation of organic matter, and often disinfection of pathogenic microorganisms. These facilities typically require land space and power, including back-up generators. Treatment facilities must have controlled access (fencing and alarms) and be maintained by certified operators who need 24/7 access. Pre-engineered, package plant type systems are generally more economical for decentralized treatment facilities versus site-specific, ground-up complete designs. Such systems are also modular, facilitating easy expansion due to possible future growth. The different treatment technology options described in this section include:

- Activated Sludge:
  - Conventional.

  - Extended Aeration.
  - Membrane Bioreactor.
- Attached Growth Bioreactors:
  - Textile Filter.
- Moving Bed Bioreactor.
- Constructed Wetlands.

4.4.1 Activated Sludge

The term activated sludge refers to biological treatment via suspended-growth, aerobic mixed liquor consisting of flocs of active bacteria, which consume and remove aerobically biodegradable organic substances from screened or screened and pre-settled raw wastewater.

Activated sludge processes can be used for treating wastewater flows from clusters of homes. They provide a high-quality effluent, with reduction of BOD, TSS, nitrogen, and phosphorus. Activated sludge processes are also flexible because they can be modified to meet specific discharge limits, operate at a range of organic and hydraulic loading rates, and are resistant to organic and hydraulic shock loads.

Specific variations of activated sludge include conventional activated sludge (CAS), extended aeration activated sludge (EAAS), and membrane bioreactors (MBRs). Each is described in the following sections.

4.4.1.1 Conventional Activated Sludge

CAS consists of an aeration tank, which is used for biological degradation, and a secondary clarifier, where the sludge is separated from the treated wastewater (see Figure 4.7). Prior to CAS, screens and degritters are used to remove large and heavy solids, respectively. Primary sedimentation is also commonly used to remove rapidly settling solids in larger facilities but is typically not used for package plants. The pretreated wastewater enters the activated sludge treatment system. In the aeration tank air is transferred to the wastewater to facilitate biological treatment and biodegradation of organics and nutrients. Additional settling and pollutant removal occur in the secondary clarifier prior to disinfection (if needed) and disposal. Waste sludge typically requires additional stabilization and disposal.

Some of the benefits and challenges of CAS are summarized in Table 4.6. CAS technology is suitable for any flow rate in the range considered here (5,000 to 50,000 gpd).

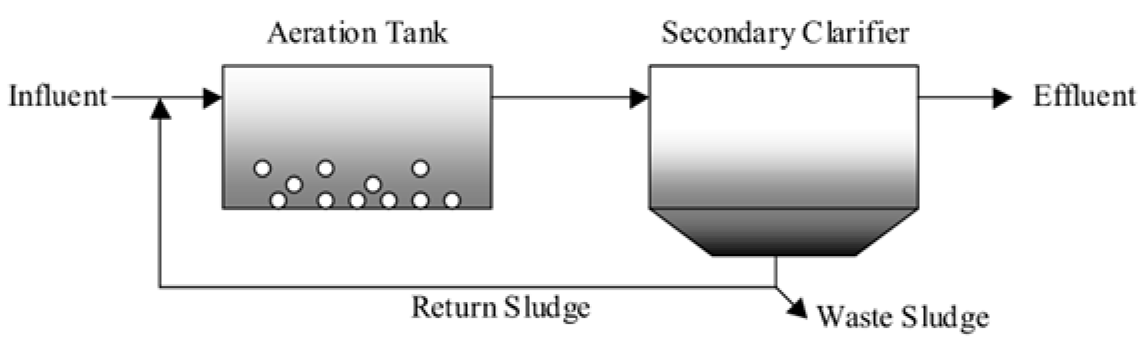

Figure 4.7 Typical Conventional Activated Sludge System (Water Research Foundation and Carollo, Engineers, Inc., 2008)

Table 4.6 Benefits and Challenges of Conventional Activated Sludge Systems

Benefits	Challenges
• High BOD and nitrogen removal, high effluent quality, self-sustaining system. • Small land area requirement. • Free from fly and odor nuisance. • Can be modified to meet specific discharge limits.	• High electricity consumption and costly mechanical parts. • Requires skilled operation and maintenance. • Requires expert design and construction. • Bulking and biological surface foaming.

4.4.1.2 Extended Aeration Activated Sludge

EAAS is a variation of the activated process which provides removal of biodegradable organic wastes under aerobic conditions without primary settling and with a longer aeration time, and a longer sludge age (Figure 4.8). The long aeration time means a larger aeration tank than CAS. The process has a high BOD removal efficiency and generates less sludge than conventional activated sludge.

In a typical EAAS package plant, raw wastewater is screened or goes through a grinder to reduce large suspended, settleable, or floating solids. Then, it is conveyed to the aeration tank where it is mixed with return activated sludge (RAS) and oxygen is provided to microorganisms. The resulting mixed liquor is settled in the clarifier resulting in RAS and clarified effluent. In EAAS, solids are generally allowed to accumulate in the aeration tank for long periods allowing digestion in the same tank and periodic wasting for disposal. If needed, the clarified effluent is then disinfected by chlorine or ultraviolet light (UV) in a disinfection tank.

Some of the benefits and challenges of EAAS are summarized in Table 4.7.

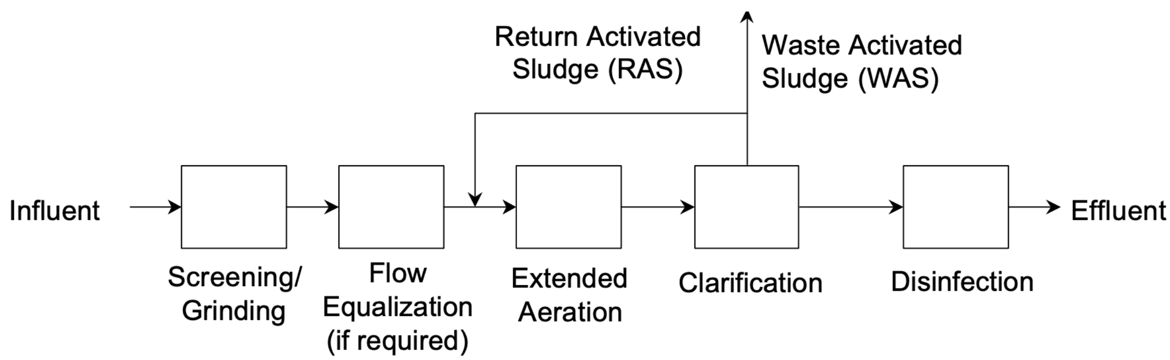

Figure 4.8 Typical Extended Aeration Activated Sludge System (Water Research Foundation and Carollo, Engineers, Inc., 2008)

Table 4.7 Benefits and Challenges of Extended Aeration Activated Sludges Treatment Systems

Benefits	Challenges
• Systems consistently provide high quality effluent in terms of TSS, BOD, and ammonia levels. • Long HRT and complete mixing, minimal impact of a shock load or hydraulic surge. • Produces less sludge due to extended retention of biological solids in the aeration tank.	• Higher energy uses due to longer aeration time. • Larger footprint than CAS. • Less flexibility than CAS should regulations for effluent requirements change.

4.4.1.3 Membrane Bioreactor Activated Sludge

MBR is an activated sludge process which uses membrane filtration instead of a secondary clarifier to separate mixed liquor from treated effluent (Figure 4.9). Fine screening is an essential pre-treatment step to protect the membranes from damaging debris and particles, extending the membrane life, reducing operating costs, and guaranteeing a higher sludge quality. MBR systems nearly always have an anoxic tank and internal pumping of mixed liquor to facilitate nitrogen removal via denitrification. MBR is an ideal process for water reuse applications since the membranes provide a barrier to many pathogens. Better effluent quality comes with a higher capital, operation, and energy costs which present a hurdle to implementing MBR systems for cluster systems.

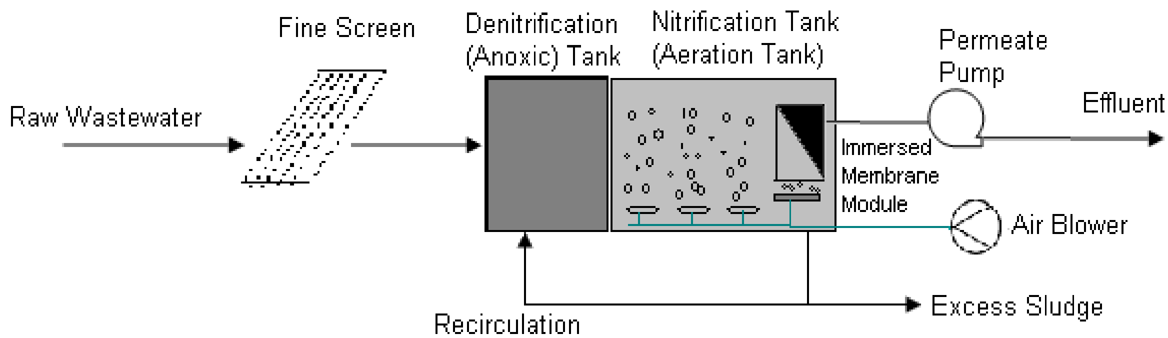

Figure 4.9 Typical Membrane Bioreactor Activated Sludge System (Wastewater Engineering Group 2007)

A typical MBR package plant will consist of a preliminary coarse screen, followed by a fine screen, an anoxic tank/zone, an aeration tank with an integral membrane module, a permeate pump to create effluent, and a blower to provide coarse aeration of the membrane cassette and fine bubble aeration for the remainder of the aeration tank. It will usually include an aerobic digester to treat, thicken, and store WAS prior to periodic pump-out and disposal. The package plant may also contain a disinfection system which most commonly would utilize UV[6].

Some of the benefits and challenges of MBR are summarized in Table 4.8.

Table 4.8 Benefits and Challenges of Membrane Bioreactor Treatment Systems

Benefits	Challenges
• Secondary clarifiers and tertiary filtration processes are eliminated, thereby reducing plant footprint. • High quality effluent.	• Membrane complexity and fouling. • Higher capital, operation, and energy costs. • Hydraulic flow peak capacity is limited to 1.8 times average flows and only for short periods.

4.4.2 Attached Growth Bioreactors – Textile Filter

Like the suspended growth activated sludge processes, attached growth bioreactors take advantage of biological treatment. The biological mass in this case grows as a biofilm on the surface of a media or disk as opposed to suspended flocculated biomass in CAS, EAAS, and MBR processes. The media should have a large surface area to volume ratio to support the microbial growth and form biofilms. Some versions of the process eliminate secondary clarifiers and associated cost and space requirements.

[6] Current recycled water regulations require disinfection following MBR for R-1 water.

A textile filter (TXF) is a variation of an attached growth bioreactor. TXF is a fixed-bed, biological reactor that operates under (mostly) aerobic conditions. TXF systems are available in modular package plant configurations specifically for cluster treatment applications. The system uses fixed spray nozzles and hanging textile media sheets (see Figure 4.10). The sheets are suspended on racks at the top of a tank that is mostly open, and water can accumulate below for recirculation. These systems are designed to treat pre-settled wastewater, most often from a large septic tank.

Some of the benefits and challenges of TXF systems are summarized in Table 4.9. TXF systems are generally low maintenance. Like other systems, the mechanical components (pumps, motor-driven chains, fans, blowers, rotating influent applicators, clarifier mechanisms, etc.) still require regular inspection and maintenance.

Table 4.9 Benefits and Challenges of Textile Filter Systems

Benefits	Challenges
• Can operate at a range of organic and hydraulic loads. • Lower energy input than CAS. • Low sludge production.	• Requires expert design, construction, operation and maintenance. • Some variations have larger footprints. • Risk of clogging, depending on pre and primary treatment.

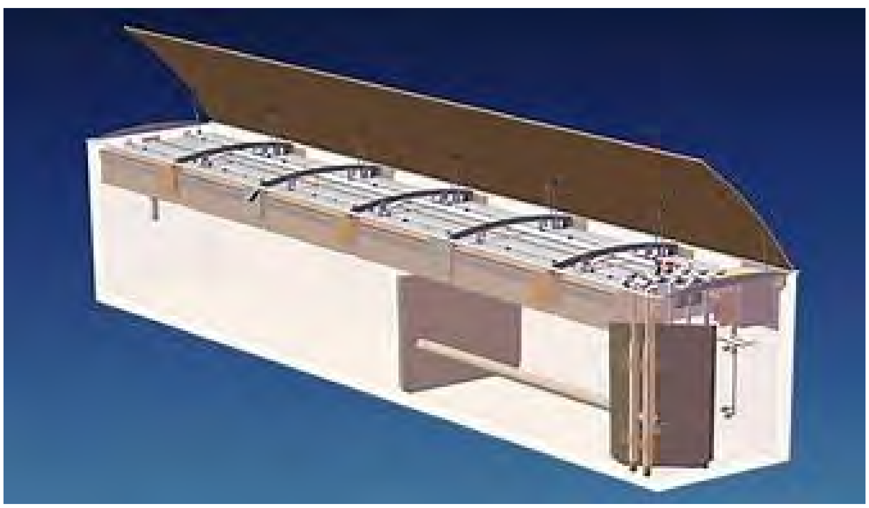

Figure 4.10 Typical Textile Trickling Filter System (Orenco Systems, Inc.)

4.4.3 Moving Bed Biofilm Reactor

The moving bed bioreactor (MBBR) process is a combination of activated sludge (suspended growth) and attached growth processes. It uses plastic floating media within an aeration basin which are carriers of attached growth of biofilm. Pre-treated (settled) influent enters the aeration basin for treatment and may enter a second basin for further treatment (full nitrification). Fine-bubble aeration with high oxygen transfer efficiency is commonly used for mixing/suspension (Figure 4.11). Thousands of small plastic chips, called media or carriers, occupy as much as 50 to 70 percent of the tank volume. In order to keep the carrier media in the tank, there is a strainer attached to the aeration basin effluent pipe. The aeration effluent which contains sloughed biofilm and suspended solids is conveyed either to a secondary settling tank or, more commonly, to a dissolved air flotation separator.

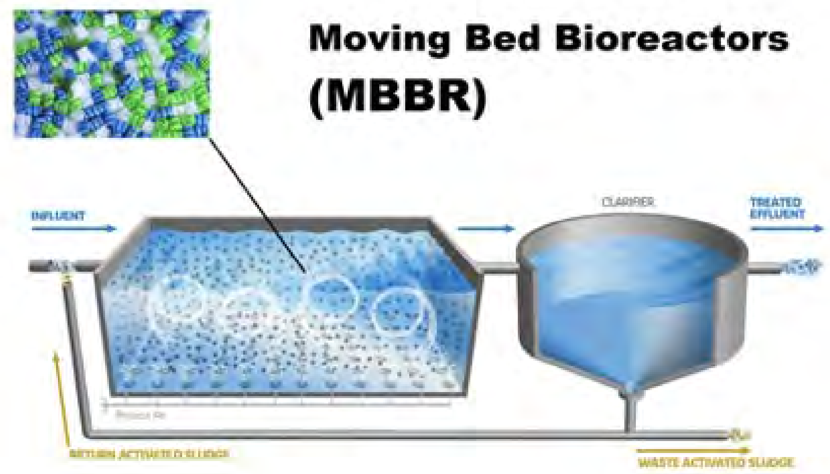

Figure 4.11 Typical Moving Bed Bioreactor System (Lanyu Gustawater Treatment, 2020)

A typical MBBR package plant has a screen, a primary sedimentation tank, one or two MBBR aeration tanks, a blower, a dissolved flotation separator unit, and an aerobic digestion tank to stabilize, thicken, and store the sloughed solids for eventual offsite disposal. If needed, the clarified effluent is then disinfected by chlorine or UV in a disinfection tank. As with all the previous treatment options described, waste sludge requires stabilization and disposal.

Some of the benefits and challenges of MBBR are summarized in Table 4.10. MBBR is known for being a low maintenance process. Construction cost of the MBBR is moderate compared to other highly mechanical wastewater treatment systems but more expensive when compared to simple or natural treatment systems. It does require electricity input and comes with increased associated costs for operation. A disadvantage is that carriers can wash out of the system over time, despite the strainers in place, and must be supplemented with additional new media.

Table 4.10 Benefits and Challenges of Moving Bed Bioreactors Treatment Systems

Benefits	Challenges
• Efficient treatment, low HRT, flexibility to adapt to fluctuating hydraulic and organic loads. • Low Maintenance. • Very compact, due to the maximized surface area the media provide for biofilm growth.	• High-tech system. • Higher capital and operating costs. • Carriers can wash out of the system, necessitating supplemental additions.

4.4.4 Constructed Wetlands

Constructed wetlands (CW) are a "green" technology designed to re-create the processes that naturally treat wastewater in the environment. Wastewater flows to a lined earthen basin or cell containing microorganisms, porous media and plants. A perforated pipe runs along the length of the cell just below the plants to evenly distribute the influent. A second pipe runs along the length of the cell to collect the effluent after it travels through the porous media, where it then flows through a distribution box and into a drain field (see Figure 4.12).

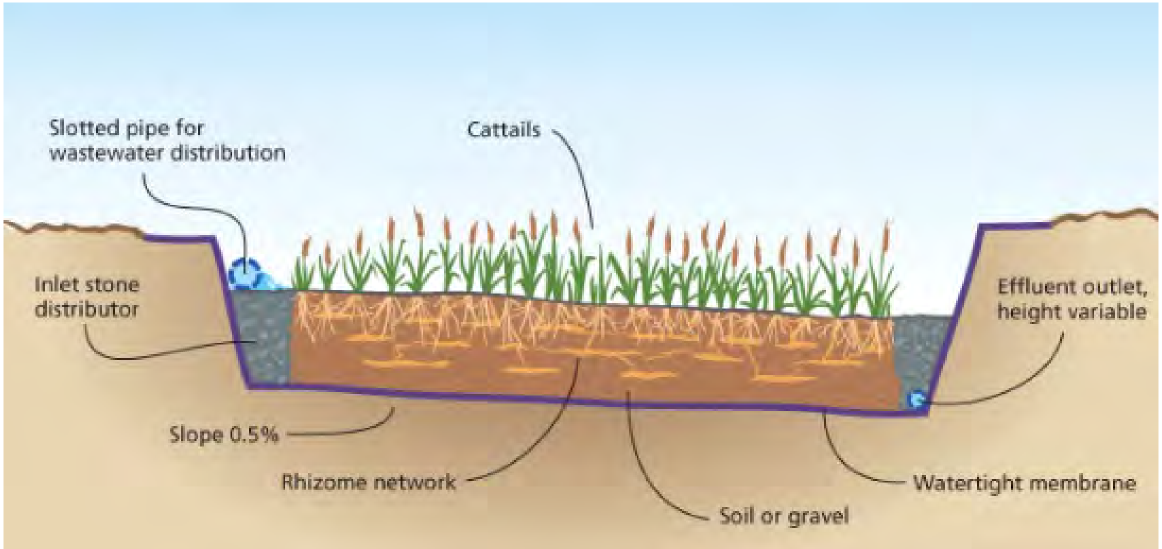

Figure 4.12 Typical Constructed Wetland Treatment System (Grismer and Shepherd, 2011)

Some of the benefits and challenges of CW treatment systems are summarized in Table 4.11. CWs are simple, low-tech, low-energy, natural systems that are easily operated compared to other systems and come with lower costs. However, the main challenges with implementing a CW as a cluster wastewater treatment system are availability of land and vector and odor nuisances. CWs are not available as package plant facilities.

Table 4.11 Benefits and Challenges of Constructed Wetlands Treatment Systems

Benefits	Challenges
• Simple, easily operated natural system. • Inexpensive compared to other treatment options. • Requires little energy when the system operates with gravity flow.	• Large land requirement. • Not available as a package facility. • Vector and odor nuisances.

4.4.5 Package Treatment Plants

Except for CWs, all the above-described treatment technologies are available in pre-engineered, self-contained treatment units of various specific treatment capacities. Installation generally would involve pouring of a concrete pad for the system, bringing-in power supply, influent piping, and possibly seeding with a source of bacteria. The system would then be ready to start operations. Other package systems are less containerized and more like a “kit” or a prefabricated building in which all the necessary components are delivered for assembly, such as tank(s), pumps, pipes, valves, blowers, controls and all the other required components to assemble and start-up the system.

4.5 Description of Treated Effluent and Residual Solids Disposal Strategies

The effluent disposal system must properly dispose or reuse the effluent from the treatment facility. Disposal could normally occur on the same site as the treatment facility (requiring additional land space), while reuse would require conveyance off-site to managed reuse areas. Residual solids must also be properly disposed of at an off-site facility. There are several options for effluent disposal which are described in the following sections, including:

- Percolation:
  - Absorption Trench/Bed.
  - High Pressure Drip.
  - Low Pressure Pipe.
  - Seepage Pit.
- Water Reuse.
- Evapotranspiration.
- Injection Well.
- Surface Discharge.

Effluent disposal systems are regulated in HAR 11-62-25. Some of the basic provisions of these regulations are as follows:

- Disposal systems shall at least consist of a primary disposal component and a separate 100 percent back-up disposal component.
- Both primary and backup disposal units shall be designed to handle the peak flow, determined by county or design engineer and approved by DOH.
- Stricter data monitoring and data submittals are required for subsurface disposal systems.
- Provisions to facilitate operation, maintenance, and inspection are required on a case-by-case basis.
- Disposal systems shall include provisions for purging and chemical shock loading.

4.5.1 Percolation

Percolation disposal strategies include absorption trenches/beds, seepage pits, high-pressure drip dispersal, low-pressure pipe dispersal, seepage pits, and soil aquifer treatment (SAT). These strategies are summarized in the following sections.

4.5.1.1 Absorption Trench/Bed Systems

Absorption systems are an approved subsurface disposal technology that allows partially- or fully treated effluent to percolate into the soil. These systems are installed with a very mild slope to allow effluent to flow by gravity. Effluent comes from a treatment system and is distributed by gravity through perforated pipes laid in either a trench or bed, the surface area of which depends on the hydraulic properties of the native soil.

Absorption systems generally range in depth from 1.5 to 3 feet below grade. Trench widths range from 18 to 36 inches, while bed widths are at least 3 feet. The major distinction between the two is that in an absorption bed, the entire disposal area is excavated and backfilled with gravel, whereas absorption trenches have distinct areas of undisturbed soil. Gravelless trench and bed absorption systems utilize plastic dome-shaped segmented chambers buried in the trench/bed with large open spaces instead of perforated pipes surrounded by gravel (see Figure 4.13).

A summary of benefits and challenges are shown in Table 4.12. The potential to clog the systems is highly dependent on the performance of the upstream treatment operations; therefore, a well-maintained treatment system will keep the absorption system working properly. Observation ports can be installed within the disposal area to check whether the water is percolating into the ground as expected. Absorption disposal systems are common and can achieve high levels of effluent quality when employed downstream from effective treatment. No power is required, and maintenance is generally not necessary. However, they cannot be used in terrain with severe slopes or if groundwater is too close to the surface. Also, overloading, heavy rainfall, or unsuitable soils can cause surfacing (overflows).

Figure 4.13 Typical Gravelless Absorption Bed Disposal System (Infiltratior.com, 2020)

Table 4.12 Benefits and Challenges of Absorption Disposal Systems

Benefits	Challenges
• Common type of disposal system so there are many products available and experience with installation. • When deployed downstream from an aerobic treatment system, it provides some treatment for BOD, TSS, and fecal coliform. • No power is required, and maintenance is generally not necessary. • Gravelless dome systems require less gravel backfill and provide significant additional water storage volume.	• Cannot be used in terrain where natural slope is greater than 12 percent. • Cannot be used if groundwater is too close to the surface, minimum vertical separation of three feet from the bottom of the trench/bed. • Large land requirement. • Overloading, rainfall, or unsuitable soils may cause contaminants to spill out into the surroundings.

4.5.1.2 High Pressure Drip Systems

Drip disposal systems (also called drip irrigation systems) are a disposal technology that uses a network of pipes containing emitters commonly spaced 12 inches apart and installed in excavations similar to but shallower than absorption beds (see Figure 4.14). Rather than working by gravity, these systems receive treated effluent in pumped doses from a dosing tank, which allows for controlled loading rates to the shallow root zone of the surrounding soil.

Figure 4.14 Typical High-Pressure Drip Disposal System (Norweco)

A summary of benefits and challenges are shown in Table 4.13. These systems are cost comparable to alternate disposal systems (low pressure pipe disposal systems) and the operating costs include power, pipe and equipment repair, and monitoring costs. Drip disposal systems are reliable alternatives for areas with low permeability, seasonal high-water tables, or severe slopes. Ability to control dose/rest cycles allows for even spacing or dosing of effluent and facilitates wastewater infiltration by spreading it spatially and temporally. However, they require a large dosing tank and power to run pumps, sensors, and controls.

Table 4.13 Benefits and Challenges of High Pressure Drip Disposal Systems

Benefits	Challenges
• Reliable alternative for areas with low permeability, seasonal high-water tables, or severe slopes. • Ability to control dose/rest cycles allows for even spacing or dosing of effluent and facilitates wastewater infiltration by spreading it spatially and temporally. • Significant evapotranspiration is expected.	• Large dose tank is needed to accommodate timed dose delivery to the drip absorption area. • Power is required to run pumps, sensors, and controls. Some minimal regular maintenance is required. • Clogging of emitters can occur.

4.5.1.3 Low Pressure Pipe Systems

A low-pressure pipe disposal system is a shallow, pressure-dosed soil absorption system that includes a network of small diameter perforated pipes placed in narrow trenches or beds (see Figure 4.15). Pressure distribution is used to uniformly feed the pipes. Lower pressure is used because the pipes have orifices rather than emitters associated with high pressure systems. Alternating the dosing and resting cycles helps improve treatment and promote aeration. Low pressure systems can be either time-dosed or demand-dosed.

The main components of a low-pressure pipe disposal system include:

- Submersible effluent pump in a pumping (dosing) chamber with a high-water alarm, level controls and a supply manifold.
- Small diameter perforated distribution laterals.
- Drain field media (gravel or sand).

A summary of benefits and challenges are shown in Table 4.14. These systems are reliable alternatives for areas with low permeability, seasonal high-water tables, or severe slopes. Ability to control dose/rest cycles allows for even spacing or dosing of effluent and facilitates wastewater infiltration by spreading it spatially and temporally. They require less space and power than high-pressure drip disposal systems but have less storage capacity and higher possibilities of ponding, infiltration, and clogging. Typical O&M is very minimal but includes monitoring ponding at the bottom of trenches, flushing manifold and lateral lines periodically, re-adjusting operating pressure, and reducing flow to overloaded trenches. Costs vary depending on the site and volume and characteristics of the wastewater being treated. These systems are comparable to drip disposal systems and the operating costs include power, pipe and equipment repair, and monitoring.

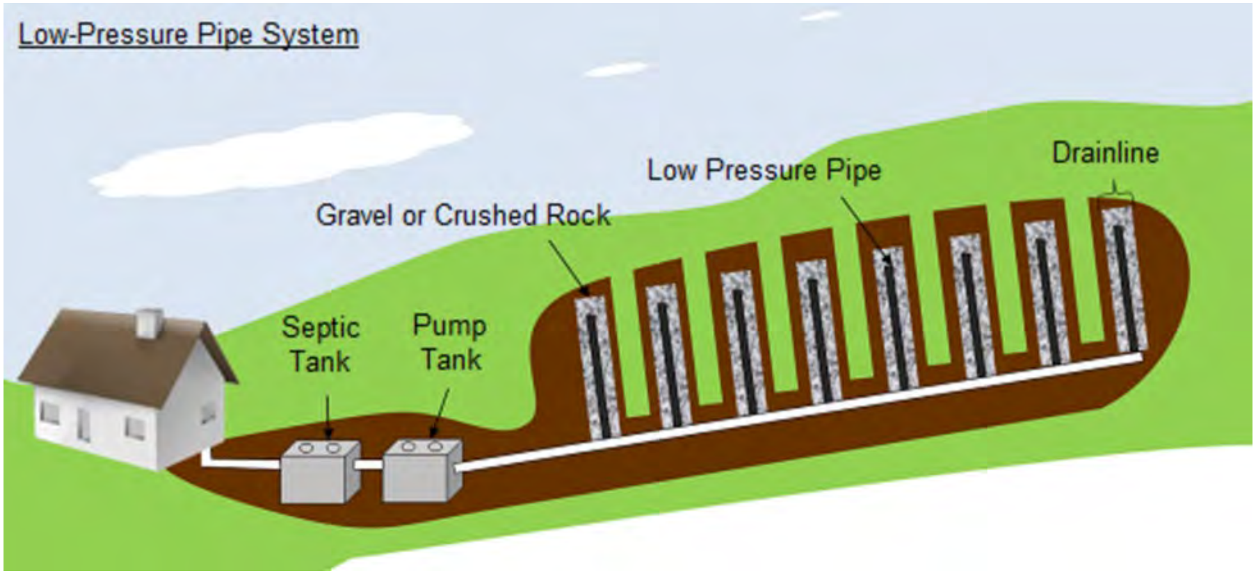

Figure 4.15 Typical Low-Pressure Pipe Disposal System (Three Oaks Engineering)

Table 4.14 Benefits and Challenges of Low-Pressure Pipe Disposal Systems

Benefits	Challenges
• Reliable alternative for areas with low permeability, seasonal high-water tables, and/or severe slopes. • Shallow and narrow trenches reduce site disturbance and land area requirement. • Ability to control dose/rest cycles allows for even spacing or dosing of effluent and facilitates wastewater infiltration by spreading it spatially and temporally.	• Limited storage capacity around laterals. • Possibility of wastewater accumulation in the trenches. • Potential for clogging and infiltration problems.

4.5.1.4 Seepage Pit

A seepage pit is a disposal system constructed in a similar manner as a cesspool, but it receives treated wastewater. These systems are generally constructed from reinforced concrete rings, with a diameter of 8- to 10-feet and a height of 2 feet, that are stacked in order to achieve the depth required (usually 15 to 30 feet) to meet percolation requirements (see Figure 4.16). Each ring has large openings in the sides. A concrete lid with a 4-inch inspection port is placed on top. Water percolates out from the sides and the bottom of the unit into the surrounding soil. The effective percolation area is measured as the pit sidewall area. For a cluster system, multiple seepage pits would be required.

A summary of benefits and challenges of seepage pits are shown in Table 4.15. Seepage pits are the simplest and most compact method to percolate water into the ground. They are viable options when the available land is insufficient for absorption beds, the terrain is steep, or when an impermeable layer overlies more suitable soil. However, seepage pits do not provide additional treatment like most other disposal systems. In general, seepage pit disposal from a decentralized cluster treatment system would be functionally identical to an injection well and thus would not be allowed by the DOH unless other options such as percolation or reuse were not feasible.

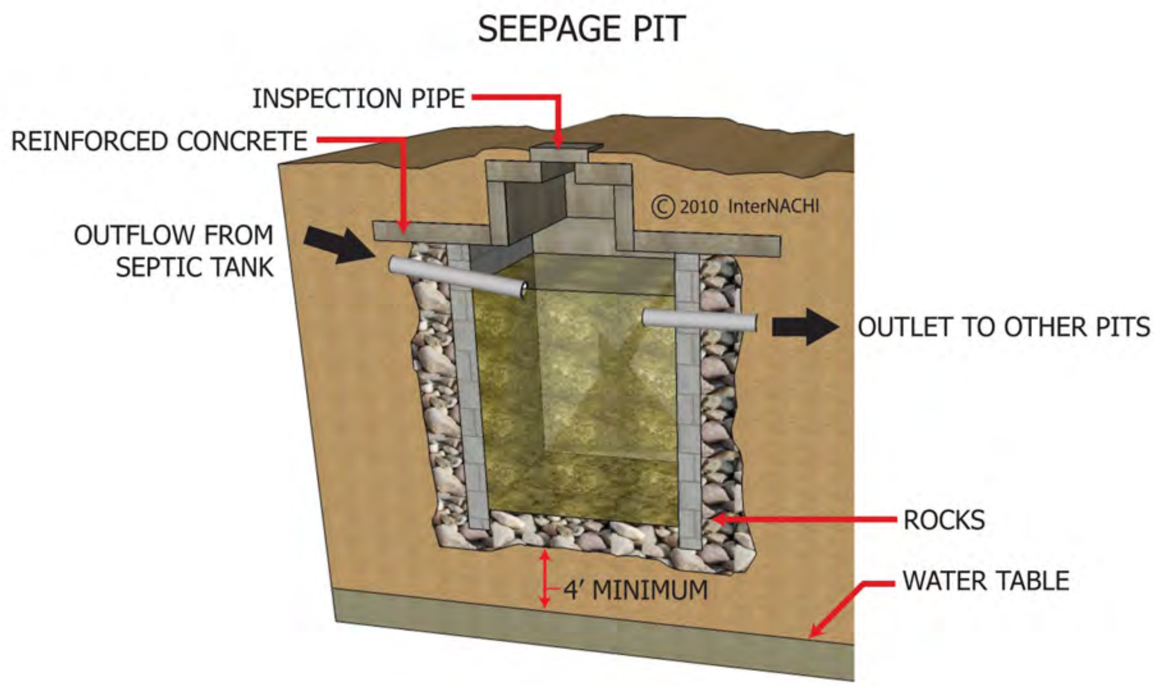

Figure 4.16 Typical Seepage Pit Disposal System (InterNACHI, 2020)

Table 4.15 Benefits and Challenges of Seepage Pit Disposal Systems

Benefits	Challenges
• Simplest and most compact method to percolate water into the ground. • Viable options when land is insufficient for absorption beds or trenches, or the terrain is steep.	• Cannot provide additional treatment or evapotranspiration. • Must have adequate separation from groundwater (at least 3 ft).

4.5.2 Water Reuse

If an effluent from a treatment system meets criteria set by the DOH, then the recycled water can be utilized in landscaping, agricultural irrigation, and even toilet flushing.

The highest quality of recycled water defined by DOH is R-1 and is the only level of recycled water that can be used above the underground injection control (UIC) line. The requirements for R-1 water include tertiary filtration, daily monitoring for fecal bacteria, continuous turbidity monitoring, automatic diversion of off-spec water, 100 percent back-up disposal, and a reuse site with an approved management plan, signage, and a named responsible manager. The requirements for R-1 water are likely too numerous and costly for all but the upper end of cluster system sizes considered here (50,000 gpd). The requirements for R-2 recycled water are less stringent, making recycling of effluent less difficult. However, the acceptable uses of R-2 water are also more limited (generally subsurface use only to prevent human contact). Also, a reuse site is still required as well as an approved management plan/manager.

Systems should be designed such that there are no crossings of recycled water lines and potable water lines. Clear markings should be used to identify recycled water pipelines. Strict and specific monitoring and record keeping are required, depending on the level of effluent quality and the method of application of the recycled water. The DOH has published Guidelines for the Treatment and Reuse of Recycled Water, available at the DOH website.[7]

Although water reuse is feasible for small cluster systems, the up-front capital and on-going O&M costs of a complete water reuse system including off-site reuse area management will almost certainly be greater than any other disposal alternative. A summary of benefits and challenges are shown in Table 4.16.

Table 4.16 Benefits and Challenges of Water Reuse Disposal Systems

Benefits	Challenges
• Helps reduce overall demand on potable water supply. • Utilized in landscaping, agricultural irrigation, and even toilet flushing.	• Often more expensive treatment is required to reach water quality requirements. • Strict rules and regulations to prevent potential environmental or health consequences.

4.5.3 Evapotranspiration

Evapotranspiration is a disposal technology that combines direct evaporation and plant transpiration . Treated effluent is conveyed to a porous bed containing water-tolerant plants. Wicking, or capillary action, draws water to the surface, where it is either taken up by the plants and transpired, or evaporated from the surface (see Figure 4.17). Effluent that is not transpired or evaporated will percolate from the bottom of the bed. This type of system is also known as evapotranspiration-infiltration (ETI).

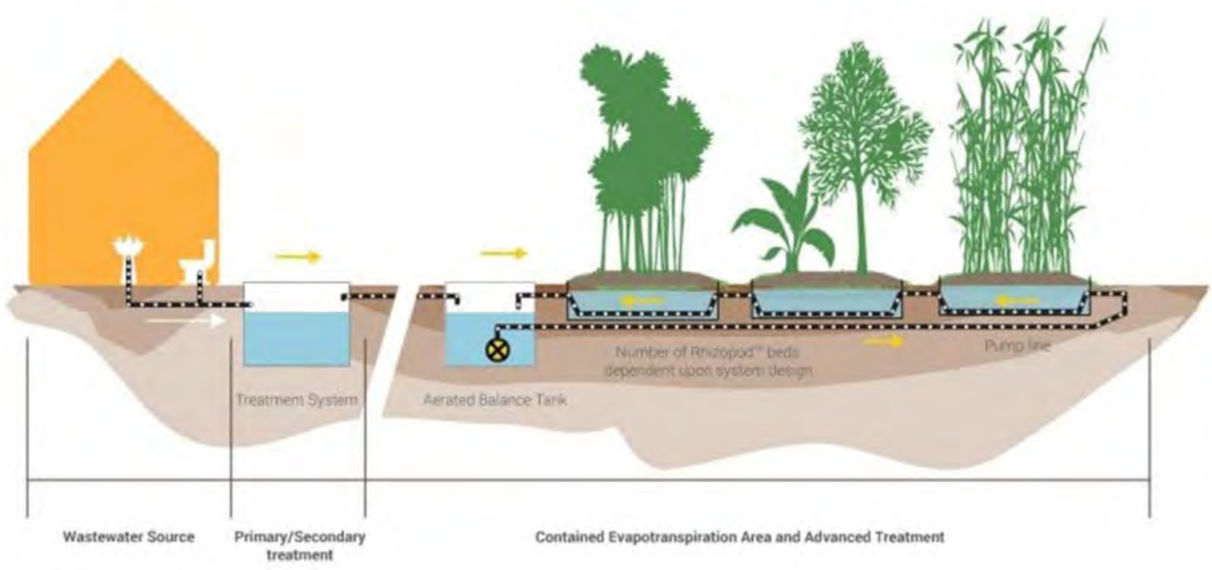

Figure 4.17 Typical Evapotranspiration Disposal System (Rhizopod System Technology)

These systems can also be designed with an underlying impermeable liner for a “zero-discharge” system. In this case, disposal is strictly dependent on evaporation and plant transpiration. Additionally, the liner allows

[7] http://www.hawaii.gov/health/environmental/water/wastewater/forms.html

the system to be placed above a UIC line or where there is shallow groundwater or proximate surface water such as a stream, lake or the ocean. Other components that are typically included are high-or low-pressure distribution lines, flushing or filtering mechanism, controller to automate dosing cycles, distribution pump, and alternating evapotranspiration beds.

A summary of benefits and challenges are shown in Table 4.17. These systems are a simple and low-cost way of achieving effective treated effluent disposal. However, they can require large surface areas and are best applied in locations where evaporation rates are much higher than precipitation rates.

Table 4.17 Benefits and Challenges of Evapotranspiration Disposal Systems

Benefits	Challenges
• If an impermeable liner is included for a "zero-discharge" system, then 100 percent nitrogen removal is achieved. • Low cost, simple disposal system.	• Large surface areas are needed for year-round disposal. The size is controlled by a water balance based on rainfall and pan evaporation rates. • More effective in arid climates where evaporation rates are much higher than precipitation.

4.5.4 Injection Wells

In this system, subsurface disposal of wastewater occurs by injection via a well (HAR 11-23). The current rules in Hawaiʻi are designed to prohibit the contamination of US drinking waters. Wastewater cannot be injected into current sources or potential future sources of drinking water. Injection can only occur into "exempted" aquifers which are already highly contaminated or have total dissolved solids (TDS) greater than 5,000 mg/L, making them brackish. In Hawaiʻi, there is a UIC line, which is a line on the map of each island which designates brackish groundwater near the coast. Makai of the UIC line, wastewater injection could potentially be granted a UIC permit. These types of permits are difficult to obtain and contain restrictions on flow, numerical contaminant limitations, and monitoring and reporting requirements.

A summary of benefits and challenges of injection wells are shown in Table 4.18. For some cesspool replacement areas close to the coast, where decentralized cluster systems could be viable, an injection well is potentially feasible as a disposal alternative. However, the DOH would generally consider it to be a "last resort" type option only applicable if other options are not viable. Currently, due to the 2019 Supreme Court ruling on the Maui County injection wells at the Lahaina WWTP, it is unlikely that any new UIC permits for wastewater will be issued in the foreseeable future.

Table 4.18 Benefits and Challenges of Injection Well Disposal Systems

Benefits	Challenges
• Very simple system. • Little to no maintenance required.	• Limited applicable locations/siting. • Very difficult to obtain a permit.

4.5.5 Surface Water Discharge

Discharge of treated wastewater to surface water requires a National Pollution Discharge Elimination System (NPDES) permit. Permit requirements are found in HAR 11-62 Wastewater Systems and in the EPA's Clean Water Act. Obtaining a new NPDES permit for wastewater discharges in Hawaiʻi is generally avoided due to cost, complexity, monitoring requirements, 5-year duration/renewal requirements, etc.

A summary of benefits and challenges of surface water discharges are shown in Table 4.19. For decentralized cluster systems near a stream or inland lake, a surface discharge permit is technically an option, and these permits are handled by the Hawaiʻi DOH. However, similar to an injection well, the DOH would generally consider it to be a "last resort" type option only applicable if other options are not viable. In addition, there are very few permitted discharges to inland lakes and streams and high levels of treatment are generally required.

Table 4.19 Benefits and Challenges of Surface Water Discharge Disposal Systems

Benefits	Challenges
• Simple system. • Effectively recycles water back into the environment. • Can augment stream flow.	• Potential negative impacts on natural bodies of water or drinking water. • NPDES permit required. Expensive monitoring and reporting required. • Very limited applicable locations/siting.

4.5.6 Residual Solids Management and Disposal

Decentralized cluster treatment systems generate residual sludges that require proper treatment and disposal just like any other WWTP. Regulations regarding sludge treatment/disposal/reuse are contained in HAR 11-62 subchapter 4. For cluster systems, the most feasible method for handling residual sludges is periodic pumping and transport of the liquid material to an offsite facility willing to accept the sludge for a fee. Typically, this is a county-owned facility, such as the regional WWTP. In some cases, it could be a privately owned and operated facility.

It is possible to process residual sludges via stabilization and dewatering within the decentralized treatment system, followed by transport of these materials to a proper disposal site such as a landfill for a fee. However, this would be very unusual for a small cluster system because the additional treatment processes and equipment and O&M required would not be cost effective compared to hauling/disposal of residual sludges to a WWTP in Hawaiʻi.

4.6 Summary of Decentralized Cluster Systems

The data and information included in this evaluation were gathered from previous studies, technical literature, vendor websites, and other publicly available resources. The evaluation is limited to common and accepted technologies available in the wastewater industry, with a focus on those treatment technologies that are available in "package plant" configurations. Package plants typically use proven technologies, are easily transported and installed, and have a small footprint. Collection systems and disposal systems are generally not configured as pre-engineered package units and must be customized to each site.

The services of a licensed engineer are required for the planning and design of a complete decentralized system consisting of a wastewater collection network, treatment facility, and a method of effluent disposal and/or reuse. There are several approaches and numerous combinations of technologies that can be applied for a complete and operable system. Some of the considerations that are involved in selecting the best overall cluster system discussed in the following sections, including:

- Benefits and challenges inherent in each technology/system.
- O&M requirements.
- Land area requirements
- Life cycle costs.

Although the performance of treatment options varies, it is not an evaluation criterion, because all the systems evaluated are assumed to meet all applicable rules and regulations for siting, sizing, and treatment performance with proper design.

4.6.1 Benefits and Challenges

The benefits and challenges of each of the decentralized collection systems, treatment systems, and disposal systems are described in Sections 4.4, 4.5, and 4.6, respectively and summarized in Table 4.20. These are some of the considerations that an engineer will make when deciding which collection, treatment, or disposal systems to include in the overall decentralized system design.

4.6.2 Operation and Maintenance Requirements

Table 4.20 also summarizes the general O&M requirements for the collection, treatment, and disposal options. All three types of systems (collection, treatment, and disposal) must be operated, serviced, maintained and ultimately replaced after expiration of their useful life. This requires appropriate labor, electricity, expendable supplies, and outside services such as water quality analyses, etc. Appendix A, Table A.1 includes a list of representative O&M providers.

4.6.3 Land Area Requirements

Land values and property acquisition is a very challenging issue for most projects in Hawaiʻi. Often, the inability to obtain necessary lands for projects becomes an insurmountable hurdle and ultimately cancelling project implementation. Likewise, for decentralized cluster systems to be successfully implemented, available land is a necessity.

A significant difference in planning for onsite wastewater treatment versus decentralized treatment is the land area required. Similar to centralized wastewater systems, decentralized cluster collection systems are located partly on private property and partly in public rights-of-way.

Decentralized treatment and disposal systems are assumed to be sited on available land or common area in/near the neighborhood/community it serves. Most, but not all, of the treatment technologies described are available as compact package plants which require only a small space. Typically, the disposal system will be co-located on the same site as the treatment plant. The area required for disposal is dependent upon the type of disposal. For percolation methods (most common disposal method), the area required is based on the soil type.

The total land area requirements for package plant-based systems can range from 0.25 to 0.75 acres for a 10 home cluster system, and from one to several acres for a 100 home cluster system, depending on the type of soil (percolation rate) at the treatment plus disposal site. The land areas required for constructed wetland-based treatment facilities are larger than package plant systems and could require twice as much land area.

Additional information on estimated land requirements is provided in Appendix B.

4.6.4 Construction, O&M, and Life-Cycle Costs

The cost of a technology/facility/system is always a very important consideration. There are up-front capital costs for system planning, design, and construction, followed by on-going, permanent, annual costs for O&M. These are normally combined in a net present worth analysis by the design engineer to determine life-cycle costs when making system comparisons.

Costs were adapted from a 2010 study conducted by WERF (see Appendix C). However, these costs should only be used for relative comparison purposes. Similar to OSWT systems, a more detailed, site-specific engineering evaluation is necessary to gain a better grasp of potential conversion costs for decentralized cluster systems. A comparison of individual OSWT conversions and decentralized cluster system conversions can facilitate homeowner's decision processes.

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Table 4.20 Summary of Benefits, Challenges, and Operation and Maintenance Requirements for Decentralized Cluster Systems

Technology[1]	Benefits	Challenges	Technology Status	Replace Interval (yr)	O&M Effort[2]	O&M Requirements[3]
Collection System Options						
Gravity Sewers	• Can handle grit and other solids, as well as large volumes of flow. • Does not require onsite treatment or storage of the household wastewater before it is discharged. • Little impact to homeowners and their properties. • Presents a viable option if there is an appropriate difference in elevation. • No electricity for pumping and no pump maintenance.	• Flat or large variations in terrain can increase costs • Larger pipes compared to other collection system options. • Prone to clogging. • Manholes associated with gravity sewers are a potential source of inflow and infiltration. • Higher capital costs.	Most common, highly developed	60	L	• Inspect on a regular schedule, this can be accomplished via surface inspections of manholes, lowering hand-held camera or robotic CCTV. • Proactively flush accumulated debris and FOG. • Remove blockages and tree roots as required.
Liquid-Only Pressure Sewers	• Independent from land topography restrictions. • The septic tank retains most of the FOG and solids reducing clogging problems. • Septic tanks have storage capacity to operate during power outages. • Smaller pipes compared to conventional gravity sewers. • Can be installed at a shallow depth and do not require a minimum flow velocity or slope to function.	• Requires an onsite septic tank and pump on each property. • Grease and sludge must be pumped from each individual septic tank. • Anaerobic septic tanks can generate odors and methane gas. • Leaks pose a risk of wastewater exfiltration. • Pumps and filters must be maintained.	Highly developed	Pump - 20 Septic tank - 60 Piping - 60	M	• Provide/maintain electricity to each unit. • Inspect and clean filter on pump monthly. • Periodically remove accumulated sludge and scum from the septic tank. • Remove any blockages in the pressure pipe network.
Low-Pressure Sewers	• Small diameter piping, shallow, easily installed. • Independent from land topography restrictions. • No manholes required and no storm water infiltration. • Less clogging and subsequent O&M cleaning or flushing.	• Requires pump/vault installation on each property. • Requires an energy source for the grinder pumps. • Pumps must be maintained on each property.	Highly developed	Pump - 20 Piping - 60	M	• Provide/maintain electricity to each unit. • Inspect pump and chamber on a regular basis, remove any accumulated materials. • Inspect and maintain backflow preventers. • Remove any blockages in the pressure pipe network.
Vacuum Sewers	• Small diameter piping, shallow, easily installed. • No manholes required and no storm water infiltration. • Closed system with no exfiltration or odors. • Flexible installations regardless of topography and water availability.	• Requires construction of vacuum equipment at each home. Requires land for central vacuum stations • Economic feasibility depends on the number of homes served by the system (the more the better). • Requires energy to create the permanent vacuum. • Vacuum stations require regular O&M checks, typically higher O&M than gravity collection systems.	Uncommon, Highly developed	Pumps - 20 Equipment - 20 Piping - 60	H	• Provide/maintain electricity to each unit and vacuum station. • Regular pressure/vacuum testing. • Vacuum stations require regular O&M checks • Remove any blockages in the pressure pipe network.

Technology[1]	Benefits	Challenges	Technology Status	Replace Interval (yr)	O&M Effort[2]	O&M Requirements[3]
Treatment System Options						
Conventional Activated Sludge	• High BOD and nitrogen removal, high effluent quality, self-sustaining system. • Small land area requirement. • Free from fly and odor nuisance. • Can be modified to meet specific discharge limits.	• High electricity consumption and costly mechanical parts. • Requires skilled operation and maintenance. • Requires expert design and construction. • Bulking and biological surface foaming.	Most common, highly developed	30	M	• Monitoring of DO, pH, and MLSS. • Influent and effluent must be monitored, changing the parameters accordingly. • Regular cleaning of influent screens. • Regular sludge wasting and disposal. • Control of concentrations of sludge and oxygen levels in the aeration tanks. • Maintenance includes inspecting the aeration system and following manufacturer recommendations for maintenance of all equipment.
Extended Aeration Activated Sludge	• Systems consistently provide high quality effluent in terms of TSS, BOD, and ammonia levels. • Long HRT and complete mixing, minimal impact of a shock load or hydraulic surge. • Produces less sludge due to extended retention of biological solids in the aeration tank.	• Higher energy uses due to longer aeration time. • Larger footprint than CAS. • Less flexibility than CAS should regulations for effluent requirements change.	Most common, highly developed	30	M	• Monitoring of DO, pH, and MLSS. • Influent and effluent must be monitored, changing the parameters accordingly. • Regular cleaning of influent screens. • Regular sludge wasting and disposal. • Control of concentrations of sludge and oxygen levels in the aeration tanks. • Maintenance includes inspecting the aeration system and following manufacturer recommendations for maintenance of all equipment.
Membrane Bioreactor Activated Sludge	• Secondary clarifiers and tertiary filtration processes are eliminated, thereby reducing plant footprint. • High quality effluent.	• Membrane complexity and fouling. • Higher capital, operation, and energy costs. • Hydraulic flow peak capacity is limited to 1.8 times average flows and only for short periods.	Highly developed	30	M	• Maintenance includes chemical cleaning of membranes. • Monitoring of DO, pH, and MLSS. • Influent and effluent must be monitored, changing the parameters accordingly. • Regular cleaning of influent screens. • Regular sludge wasting and disposal. • Control of concentrations of sludge and oxygen levels in the aeration tanks. • Maintenance includes inspecting the aeration system and following manufacturer recommendations for maintenance of all equipment.
Textile Filter (Attached Growth Systems)	• Can operate at a range of organic and hydraulic loads. • Lower energy input than CAS. • Low sludge production.	• Requires expert design, construction, operation and maintenance. • Some variations have larger footprints. • Risk of clogging, depending on pre and primary treatment.	Highly developed	30	L	• Monitoring of influent and effluent. • Maintenance of all equipment following manufacturer's recommendations. • Optimum dosing rates and flushing frequency are determined from the field operation. • The packing should also be kept moist which can be problematic at night or during power failures. • Regular cleaning of influent screens. • Regular sludge wasting and disposal. • The sludge that accumulates on the filter must be periodically washed away to prevent clogging and to keep the biofilm thin and aerobic.

Technology[1]	Benefits	Challenges	Technology Status	Replace Interval (yr)	O&M Effort[2]	O&M Requirements[3]
Moving Bed Biofilm Reactor	• Efficient treatment, low HRT, flexibility to adapt to fluctuating hydraulic and organic loads. • Low Maintenance. • Very compact, due to the maximized surface area the media provide for biofilm growth.	• High-tech system. • Higher capital and operating costs. • Carriers can wash out of the system, necessitating supplemental additions.	Uncommon, Highly developed	30	H	• Monitoring of influent and effluent. • Maintenance of all equipment following manufacturer's recommendations. • Observation of media color and adjustment of air. • Monitoring and adjustment of dissolved air flotation units. • Regular cleaning of influent screens. • Regular sludge wasting and disposal. • Operators must take samples periodically and analyze them to ensure the bacteria on the carriers are still thriving.
Constructed Wetland	• Simple, easily operated natural system. • Inexpensive compared to other treatment options. • Requires little energy when the system operates with gravity flow.	• Large land requirement. • Not available as a package facility. • Vector and odor nuisances.	Uncommon, Highly developed	30	L	• Vector control to prevent population growth of insects and odor control. • Occasional maintenance of the vegetation promotes growth of desired vegetation and maintains hydraulic capacity. • Monitoring of influent and effluent.
Effluent Disposal Options						
Absorption Trench/Bed	• Common type of disposal system so there are many products available and experience with installation. • When deployed downstream from an aerobic treatment system, it provides some treatment for BOD, TSS, and fecal coliform. • No power is required, and maintenance is generally not necessary. • Graveless dome systems require less gravel backfill and provide significant additional water storage volume.	• Cannot be used in terrain where natural slope is > 12 percent. • Cannot be used if groundwater is too close to the surface, minimum vertical separation of three feet from the bottom of the trench/bed. • Large land requirement. • Overloading, rainfall, or unsuitable soils may cause contaminants to spill out into the surroundings.	Most common, highly developed	60	N	• Normally none. • Some systems use a dosing pump - if present, it must be checked and cleaned. • Observation ports can be installed within the disposal area to check whether the water is percolating into the ground as expected.
High-Pressure Drip	• Reliable alternative for areas with low permeability, seasonal high-water tables, or severe slopes. • Ability to control dose/rest cycles allows for even spacing or dosing of effluent and facilitates wastewater infiltration by spreading it spatially and temporally. • Significant evapotranspiration is expected.	• Large dose tank is needed to accommodate timed dose delivery to the drip absorption area. • Power is required to run pumps, sensors, and controls. Some minimal regular maintenance is required. • Clogging of emitters can occur.	Highly developed	30	L	• Provide continuous electricity to small dosing pumps. • Typical inspections may include observing and reporting of the general condition of the system, water level in tanks, ponding around the system, clogging at pumps and filters, pump cycles, and readings of any meters. • Regular monitoring and maintenance of pump, filter and piping shall be performed.
Low Pressure Pipe	• Reliable alternative for areas with low permeability, seasonal high-water tables, and/or severe slopes. • Shallow and narrow trenches reduce site disturbance and land area requirement. • Ability to control dose/rest cycles allows for even spacing or dosing of effluent and facilitates wastewater infiltration by spreading it spatially and temporally.	• Limited storage capacity around laterals. • Possibility of wastewater accumulation in the trenches. • Potential for clogging and infiltration problems.	Highly developed	60	L	• Monitoring ponding at the bottom of trenches, readjusting operating pressure, and reducing flow to overloaded trenches. • Flushing manifold and lateral lines periodically.

Technology(1)	Benefits	Challenges	Technology Status	Replace Interval (yr)	O&M Effort(2)	O&M Requirements(3)
Seepage Pit	• Simplest and most compact method to percolate water into the ground. • Viable options when land is insufficient for absorption beds or trenches, or the terrain is steep.	• Cannot provide additional treatment or evapotranspiration. • Must have adequate separation from groundwater (at least 3 ft).	Uncommon, unlikely to be approved	60	N	• Inspection and pumping every 2 to 4 years.
Water Reuse	• Helps reduce overall demand on potable water supply. • Utilized in landscaping, agricultural irrigation, and even toilet flushing.	• Often more expensive treatment is required to reach water quality requirements. • Strict rules and regulations to prevent potential environmental or health consequences.	Highly developed	60	H	• Extensive monitoring at the treatment facility is required; for R-1 water: continuous for NTU and fecal coliforms. • A water reuse plan is required for the reuse site, with monitoring and reporting. Signage is required at the site.
Evapotranspiration	• If an impermeable liner is included for a "zero-discharge" system, then 100 percent nitrogen removal is achieved. • Low cost, simple disposal system.	• Large surface areas are needed for year-round disposal. The size is controlled by a water balance based on rainfall and pan evaporation rates. • More effective in arid climates where evaporation rates are much higher than precipitation.	Uncommon, highly developed	60	L	• Provide continuous electricity to small dosing pumps. • Inspection of observation wells. • Trim vegetated area of ET system, replace plants as needed.
Injection Well	• Very simple system. • Little to no maintenance required.	• Limited applicable locations/siting. • Very difficult to obtain a permit.	Uncommon, unlikely to be approved	60	M	• Sampling and reporting.
Surface Water Discharge	• Simple system. • Effectively recycles water back into the environment. • Can augment stream flow.	• Potential negative impacts on natural bodies of water or drinking water. • NPDES permit required. Expensive monitoring and reporting required. • Very limited applicable locations/siting.	Uncommon, unlikely to be approved	60	M	• Sampling and reporting.

Notes:
(1) CAS = conventional activated sludge, LPP = low pressure pipe, ET = evapotranspiration.
(2) O&M = operations and maintenance, N = no maintenance, L = low maintenance, M = moderate maintenance, H = high maintenance.
(3) CCTV = closed circuit television, DO = dissolved oxygen, MLSS = mixed liquor suspended solids, BOD = biochemical oxygen demand, TSS = total suspended solids, HRT = hydraulic retention time, mg/L = milligrams per liter, mL = milliliter, NTU = nephelometric turbidity units.

4.7 Recommendations

Decentralized systems may make sense to convert several cesspools that have a high density, are within high priority areas, and where there is community support for this kind of a solution. The benefits of implementing cluster systems, where feasible include:

- **Potential for rapid conversions.** If cluster systems are implemented, this would help the state to convert more cesspools at a time. This could help to mitigate the public health and environmental risks of cesspools in high priority areas in the near term.
- **Reducing the administrative oversight and enforcement burden on state/county agencies.** For the county/state, having all systems converted on an individual is a much larger task than having decentralized cluster systems. Just in terms of sheer numbers of permitted units, it could reduce the number by orders of magnitude (e.g. instead of 88,000 individual units; 880 to 8,800 cluster systems).
- **Reduce the burden on individual homeowners to hire engineers and contractors independently to design and construct onsite systems.** A coordinated, organized effort to evaluate a cluster system for a neighborhood would relieve the burden on individual homeowners to understand and determine their cesspool upgrade needs.
- **Ensure proper operations and ongoing maintenance of the systems by requiring a licensed wastewater operator.** Cluster systems are regulated and inspected by the Hawaii DOH WWB the same manner as existing WWTPs. The rules and procedures are already in place, including the requirement that state-licensed WWTP operators oversee the cluster systems. This is more likely to ensure that systems are inspected, operated, maintained, repaired, and function as required to meet the treatment and disposal regulations.
- **Potentially broaden the range of funding opportunities.** One of the hurdles in funding cesspool conversions is that many existing funding options require a conduit agency or intermediate party to manage and administer available grant or low interest loans to individual homeowners for cesspool conversions. Given that decentralized systems will need to be managed and operated by a third party, this also opens the door for more funding options. In addition, if water reuse is a disposal option for the decentralized system, there are additional funding opportunities that may apply. Water reuse is not allowed for onsite systems; thus, those funding opportunities would not be available.

The challenges to implementing cluster systems for cesspool conversions in Hawaiʻi are:

- **Need for neighborhood-level coordination.** One of the greatest hurdles to implementing decentralized solutions for cesspool conversions is that a group of homeowners would need to take the initiative to form an association or district to collect fees and procure various professional services. To truly evaluate the feasibility of decentralized systems for certain neighborhoods, a licensed engineer needs to perform a site-specific analysis and develop costs for a recommended system. Legislative measures may be necessary to facilitate neighborhood-level coordination especially if participation will be required of homeowners.
- **Cost.** Decentralized cluster systems require higher up-front planning and design fees and have higher construction costs than OSWT and disposal systems. A site-specific analysis is necessary to evaluate the feasibility and best overall system options for a neighborhood. The engineering evaluation could be quite expensive – easily 5 to 10 times the cost of an onsite design for a single homeowner. In addition, the construction would be more extensive than onsite systems, and construction costs would accordingly be higher on a per lot basis.

- **Need for skilled operators.** Licensed wastewater operations professionals would be required to operate and maintain the cluster system components in perpetuity.
- **Land/space requirement.** Decentralized systems would likely need to be constructed on newly acquired land and may require easements. These cluster systems would only be a viable option if the required land is available.

A countywide or statewide study of potential neighborhoods/sites for cluster systems with an initial focus on priority areas, including planning level cost estimates could facilitate this process. Such a study could help the state to evaluate and upgrade those cesspools deemed to pose the greatest risks to public health and the environment more rapidly. The information provided within this TM can help to facilitate future studies and evaluations of decentralized cluster wastewater systems by licensed engineers.

4.8 References

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Appendix A

REPRESENTATIVE OPERATOR AND PACKAGE TREATMENT PLANT VENDOR INFORMATION

Table A.1 Representative Operation and Maintenance Providers

Service Provider	County	Facilities Operated	Web Page
Aqua Engineers	Kaua'i, O'ahu, Hawai'i	30 facilities, including Schofield Barracks WWTP and Poipu WWTP	www.aquaengineers.com
Hawai'i American Water	O'ahu, Hawai'i	East Honolulu WWTP	www.amwater.com
Hawai'i Water Service, part of California Water Service Group	Hawai'i	Waikoloa WWTPs	www.calwatergroup.com
Aqua Certified Operations	O'ahu	Various	NA Aiea
O&M Enterprises	O'ahu	Various	NA Kapolei

Table A.2 Representative Collection System Vendors

Vendor	Product	Type	Capacities	Web Page
Environment One Inc. Niskayuna, NY Local Rep: Engineered Systems, Paul Scott	All-Terrain Sewer ™	Low pressure sewer with grinder pumps	unlimited number of individual homes	https://eone.com/
Orenco Systems Inc. Sutherlin, OR	Prelos ™	Pressure liquid-only sewer system	unlimited number of individual homes	www.orenco.com/
Flovac Inc, Palm Coast, FL	Flovac ™	Vacuum sewer system	unlimited number of individual homes	https://flovac.com/
Aqseptance Group Inc, Rochester, IN	Airvac ™ Roediger	Vacuum sewer system	unlimited number of individual homes	www.aqseptence.com/app/en/keybrands/airvac/
Redivac, Northamptonshire, UK. RDC Sale, Richmond, VA	Redivac ™	Vacuum sewer system	unlimited number of individual homes	www.iseki-vacuum.com/

Table A.3 Representative Package Plant Vendors

Vendor	Product	Type	Capacities	Web Page
Smith and Loveless Inc. Lenexa, KS Local Rep: Fluid Technologies Mike Choy	FAST™	Submerged media activated sludge	Modular: Non-modular: up to 1,000,000 gpd	www.smithandloveless.com
	Titan™	MBR	Titan MBR QUBE™ 0-20,000 gpd (containerized) Titan MBR MEM-BOX™ and Titan MBR MEM-FRAME™ 0-190,000 gpd (retrofit)	
	Oxigest™	CAS	ADDIGEST™ 0-56,000 gpd (modular) Model R Oxigest ™ 100,000-1,000,000 gpd	
Delta Treatment Systems. Infiltrator Water Technologies LLC. Old Saybrook, CT	ECOPOD-D™	Submerged media activated sludge	1,500-250,000 gpd	www.infiltratorwater.com/delta-treatment-systems
	Delta Extended Aeration Package Plant	Extended aeration activated sludge	500-250,000 gpd	
WesTech Engineering, Inc. Salt Lake City, UT Local Rep: Hawaiʻi Eng. Services, Mike Elhoff	STM-Aerotor™	Submerged media activated sludge	5,000-5,000,000 gpd	www.westech-inc.com/
	ClearLogic™	MBR	5,000-5,000,000 gpd	
Alfa Laval Inc. Richmond, VA	AS-H	Activated sludge: Complete Mix, MBR and SBR configurations	5,000-200,000 gpd	www.alfalaval.us/products/process-solutions/wastewater-treatment-plants/
International Wastewater Technologies, Honolulu, HI Rep: Glen Lindbo	CBT™	Sequencing batch activated sludge	1,000-50,000 pgd	https://internationalwastewater.com/
Lakeside Equipment Inc. Bartlett, IL. Local Rep: Promark Corp Freddy Lenore	E. A. Aerotor™	Extended Aeration complete-mix activated sludge	10,000-500,000 gpd	www.lakeside-equipment.com/product/package-treatment-plants/

Vendor	Product	Type	Capacities	Web Page
Pollution Control Systems Inc. Milford, OH	Package Plants	Activated Sludge	500-100,000 gpd	www.pollutioncontrolsystem.com/packaged-plants
WSI International, Annapolis, MD	Package Plants	MBBR	1,000-100,000 gpd Several in Hawaiʻi	www.wsi-llc.com/
EDI, Inc. Columbia, MO Local Rep: H2O Process Milton Choi	IDEAL™	Activated Sludge Lagoon: Intermittently Decanted Extended Aeration Lagoon	>10,000 gpd	www.wastewater.com/valueaddedsolutions/lagoonsolutions
Orenco Systems Inc. Sutherlin, OR	Advantex™	Recirculating textile filter for septic effluent or raw sewage. Modular.	AX100: 0-2,500 gpd/unit for septic effluent. AX-Max: 0-15,000 gpd/unit for septic effluent, or 0-5,000 gpd for raw sewage.	www.orenco.com/

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Appendix B

ESTIMATED LAND AREA REQUIREMENTS

Table B.1 Estimated Land Area Requirements for Decentralized Cluster Treatment and Disposal System

System Size (gpd)	Treatment System Technology (area range, sf)(1)(2)	Disposal System Technology (area range, sf)(1)(3)	Total Treatment and Disposal (area range)(4)	
			square feet (sf)	acres
	CAS, EAAS, MBR, TXF, MBBR	ABS, LPP		
5,000	8,000-10,000	3,500-16,000	11,500-26,000	0.25-0.6
10,000	10,000-15,000	7,000-32,000	17,000-48,000	0.4-1.1
50,000	20,000-25,000	35,000-160,000	55,000-185,000	1.3-4.2
	CAS, EAAS, MBR, TXF, MBBR	DRIP, ET, Water Reuse		
5,000	8,000-10,000	7,000-32,000	15,000-32,000	0.35-0.75
10,000	10,000-15,000	14,000-64,000	24,000-79,000	0.6-1.8
50,000	20,000-25,000	70,000-320,000	90,000-345,000	2.1-7.9
	CW	ABS, LPP		
5,000	20,000	3,500-16,000	23,500-36,000	0.5-0.8
10,000	30,000	7,000-32,000	37,000-62,000	0.8-1.4
50,000	85,000	35,000-160,000	120,000-245,000	2.8-5.6
	CW	DRIP, ET, Water Reuse		
5,000	20,000	7,000-32,000	27,000-52,000	0.6-1.2
10,000	30,000	14,000-64,000	44,000-94,000	1.0-2.1
50,000	85,000	70,000-320,000	155,000-405,000	3.6-9.3

Notes:

(1) CAS = conventional activated sludge, EAAS = extended aeration activated sludge, MBR = membrane bioreactor, TXF = textile filter (attached growth system), MBBR = moving bed biofilm reactor, CW = constructed wetland, ABS = absorption trench/bed, DRIP = high-pressure drip, LPP = low pressure pipe, ET = evapotranspiration.

(2) For typical package plant treatment systems, the following assumptions were made: Package unit dimensions: 5000 gallons per day (gpd): 8 feet (ft) x 24 ft; 10,000 gpd: 10 ft x 50 ft; 50,000 gpd: 12 ft x 120 ft; Buffer to adjacent properties: 25 ft; Small building with lab and generator: 10 ft x 20 ft; Access driveway/parking/turnaround for truck: 30 ft x 30 ft. For a constructed wetland system, it was assumed that the area required is 1 sf per gpd of flow (Purdue Wetland Manual). The facility would also require a small building, access/turnaround and 25 ft buffer all around. The resulting lot size for a CW system are as follows: 5000 gpd: 20,000 square feet (sf) or 1/2 acre; 10,000 gpd: 30,000 sf or 3/4 acre; 50,000 gpd: 85,000 sf or 2 acres.

(3) The area required for disposal is dependent upon the type of system. For percolation methods, the area required is based on the soil type. The area required for infiltration is determined and then normally 100 percent backup is required which doubles the area. In HAR 11-62 (Appendix D, Table III), the maximum application rates are specified 0.61 and 2.86 gallons per day per square feet (gpdsf) which correspond to percolation rates between 1 and 60 minutes per inch (determined from average results of field percolation tests). The range of areas required for percolation systems including absorption, and low-pressure pipe are as follows (drip irrigation and evapotranspiration systems will require double these areas): 5000 gpd: 3,500-16,000 sf or 0.1 to 0.4 acre; 10,000 gpd: 7,000-32,000 sf or 0.2 to 0.8 acre; 50,000 gpd: 35,000-160,000 sf or 1 to 4 acres.

(4) The required areas for treatment and disposal technologies must be summed to obtain the size of a decentralized cluster treatment and disposal facility. The total land area requirements for package plant-based systems range from 0.25 to 0.75 acres for a 10-home cluster system, and from 1.3 to 7.9 acres for a 100 home cluster system, depending on the type of soil (percolation rate) at the treatment plus disposal site. The land areas required for constructed wetland-based treatment facilities are larger, ranging from 0.5-1.2 acres for a 10 home cluster to 2.8-9.3 acres for a 100-home cluster. The CW land areas are roughly twice as large for the smaller clusters; however, the required areas are not so large as to rule out the CW-based systems.

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Appendix C

ESTIMATED CONSTRUCTION, O&M, AND LIFE CYCLE COSTS

Estimated Construction, O&M, and Life-Cycle Costs

Costs were adapted from developed by the Water Environment Research Foundation (WERF) (2010). The WERF report provided costs in 2009 dollars for mainland USA for construction, O&M, and 60-year life cycle costs (5.5 percent discount rate) for three different sizes of systems. Their construction costs include the on-property and off-property equipment and installation costs and 20 percent for contractor overhead and profit. It does not include engineering design costs. They estimated costs for 20, 40, and 200 homes with corresponding flows of 5,000, 10,000 and 50,000 gpd. The WERF flow per home assumption is 250 gpd/home which is one half of the value assumed in this TM04. (500 gpd). For those systems which were included in the WERF report, the 2009 costs for construction and O&M were adjusted to 2020 dollars in Hawaiʻi using a ratio of the RS Means Construction Cost Index - 239.1/180.1 = 1.328. The 60-year net-present-worth life-cycle costs were recalculated using the adjusted costs, the replacement schedules in Tables C.1 through C.3, and a discount rate of 3.0 percent.

The WERF report included cost estimates for all of the collection and disposal options described in TM04. For evapotranspiration disposal, the WERF report stated that ET should cost slightly more than percolation - absorption systems, and thus the costs for ET were estimated as 5 percent greater than ABS disposal.

The WERF report did not include cost estimates for CW, MBR, MBBR, and TXF. For CW treatment, it was assumed that the costs should be similar to the cost of percolation-absorption disposal system with the addition of a synthetic liner system. The liner is assumed to add 5 percent to the construction cost of an absorption system to derive the CW cost. For MBRs costs, it is assumed that MBRs are 50 percent greater construction cost due to additional equipment required for the membrane separation system. TXF are recirculating media filters that use textile instead of traditional sand media. The basic components are the same and thus the WERF cost estimates for recirculating media filters were used in Table C.2.

Table C.1 Estimated Costs for Decentralized Cluster Collection System Technologies

Collection System Technology	Size (gpd)	Costs ($)		
		Construction(1)	Annual O&M	60-year Life-Cycle
Conventional Gravity Sewers	5,000	311,000-467,000	24,000-36,000	976,000-1,467,000
	10,000	623,000-934,000	33,000-49,000	1,523,000-2,286,000
	50,000	3,226,000-4,839,000	102,000-153,000	6,056,000-9,066,000
Liquid-Only Pressure Sewers(2)	5,000	117,000-177,000	8,000-12,000	337,000-507,000
	10,000	235,000-352,000	16,000-24,000	676,000-1,013,000
	50,000	1,197,000-1,795,000	80,000-120,000	3,402,000-5,103,000
Low-Pressure Sewers	5,000	175,000-264,000	15,000-21,000	580,000-852,000
	10,000	352,000-527,000	28,000-42,000	1,124,000-1,703,000
	50,000	1,781,000-2,672,000	141,000-211,000	5,677,000-8,516,000
Vacuum Sewers	5,000	248,000-372,000	12,000-18,000	584,000-876,000
	10,000	496,000-745,000	24,000-36,000	1,169,000-1,752,000
	50,000	2,482,000-3,724,000	122,000-182,000	5,845,000-8,759,000

Notes:
(1) Excludes engineering, easements, permits, and contingencies for difficult site conditions.
(2) Excludes the cost of an onsite septic tank.

Table C.2 Estimated Relative Costs for Decentralized Cluster Treatment System Technologies

Treatment System Technology	Size (gpd)	Costs ($)		
		Construction[1]	Annual O&M	60-year Life-Cycl
Conventional and Extended Aeration Activated Sludge, and Moving Bed Biofilm Reactor	5,000	133,000-199,000	8,000-12,000	415,000-627,000
	10,000	197,000-296,000	14,000-21,000	674,000-995,000
	50,000	544,000-818,000	57,000-86,000	2,349,000-3,544,000
Membrane Bioreactor	5,000	199,000-299,000	16,000-25,000	737,000-1,113,000
	10,000	295,000-444,000	29,000-42,000	1,210,000-1,781,000
	50,000	817,000-1,227,000	114,000-173,000	4,314,000-6,511,000
Textile Filter	5,000	40,000-61,000	6,000-9,000	220,000-325,000
	10,000	139,000-195,000	11,000-16,000	485,000-731,000
	50,000	381,000-572,000	46,000-68,000	1,810,000-2,679,000
Constructed Wetlands	5,000	75,000-113,000	3,000-5,000	163,000-242,000
	10,000	146,000-220,000	6,000-9,000	314,000-471,000
	50,000	721,000-1,082,000	29,000-43,000	1,520,000-2,280,000

Notes:
(1) Excludes engineering, easements, permits, and contingencies for difficult site conditions.

Table C.3 Estimated Relative Costs for Decentralized Cluster Disposal Systems

Disposal System Technology	Size	Costs ($)		
		Construction(1)	Annual O&M	60-year Life-Cycle
Absorption Systems	5,000 gpd	72,000-108,000	3,000-5000	159,000-237,000
	10,000 gpd	139,000-210,000	6,000-9000	307,000-461,000
	50,000 gpd	687,000-1,031,000	29,000-43,000	1,486,000-2,229,000
Drip Systems	5,000 gpd	49,000-74,000	5,000-7,000	199,000-302,000
	10,000 gpd	113,000-169,000	10,000-14,000	431,000-632,000
	50,000 gpd	437,000-656,000	44,000-67,000	1,844,000-2,786,000
Low Pressure Pipe	5,000 gpd	112,000-169,000	7,000-10,000	297,000-449,000
	10,000 gpd	244,000-365,000	14,000-20,000	622,000-932,000
	50,000 gpd	1,813,000-2,718,000	89,000-133,000	4,289,000-6,396,000
Seepage Pit	Any	NA	NA	NA
Water Reuse via Spray Irrigation	5,000 gpd	183,000-274,000	3,000-5,000	273,000-412,000
	10,000 gpd	352,000-527,000	6,000-10,000	527,000-791,000
	50,000 gpd	1,673,000-2,510,000	31,000-46,000	2,530,000-3,778,000
Evapotranspiration Systems	5,000 gpd	75,000-113,000	3,000-5,000	163,000-242,000
	10,000 gpd	146,000-220,000	6,000-9,000	314,000-471,000
	50,000 gpd	721,000-1,082,000	29,000-43,000	1,520,000-2,280,000
Injection Well	Any	NA	NA	NA
Surface Water Discharge	Any	NA	NA	NA

Notes:
(1) Excludes engineering, easements, permits, and contingencies for difficult site conditions.
(2) NA = not applicable

Appendix B

Onsite Treatment Technologies

Septic Tank

APPROVED ONSITE TREATMENT TECHNOLOGY

A septic tank serves as both a settling and skimming tank and partial anaerobic treatment. The baffles in the tank cause solids to settle to the bottom and create a layer of sludge, while fats, oils, grease, and other floatables rise to the top and create a layer of scum. Based on Hawaiʻi's design requirements, a screen should also be installed on the effluent end to enhance solids removal and prevent clogging of downstream disposal system. If high quality effluent is desired, a septic tank could be used to pretreat wastewater prior to a more advanced treatment process.

IDEAL APPLICATION

- Installation location is greater than 50 feet from inland or coastal waters.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps.
- Where a basic level of treatment is required.

BENEFITS

- Power is not required to operate a septic tank.
- Simple, passive system that does not require significant maintenance.

CHALLENGES / RESTRICTIONS

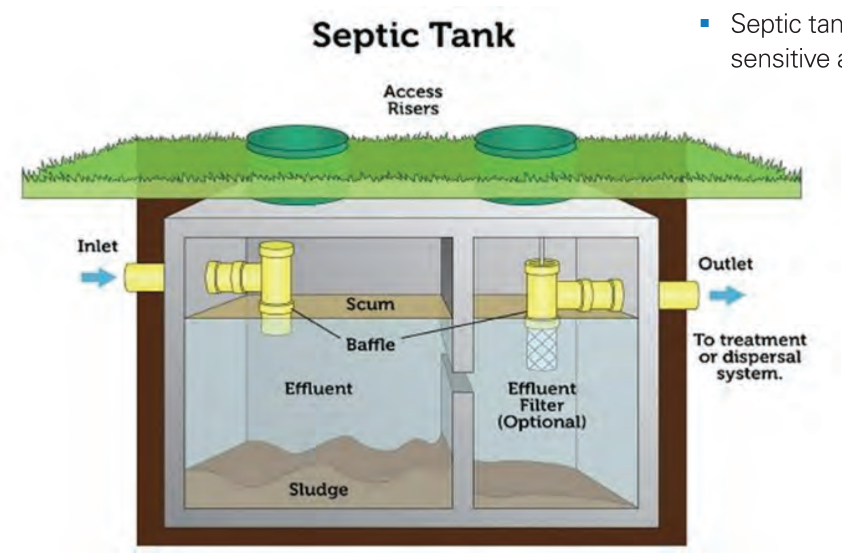
- Accumulated sludge and scum must be removed on a regular basis to prevent carryover of these materials into downstream processes.
- The effluent filter must be cleaned periodically to prevent clogging.
- Odor – objectionable odors can be emitted.

OPERATIONS AND MAINTENANCE

- Septic tanks need to be pumped out and inspected approximately once every 2 years.

EFFLUENT QUALITY

- Water quality does not meet NSF245 criteria for total nitrogen removal, or NSF40 criteria for CBOD5, TSS, and pH without further treatment.
- Septic tanks may not apply to environmentally sensitive areas.



Septic Tank with Two Chambers (US EPA, 2018).

Aerobic Treatment Unit (with and without Denitrification)

APPROVED ONSITE TREATMENT TECHNOLOGY

An aerobic treatment unit, or ATU, is a self-contained onsite system that is designed to provide secondary biological treatment, allowing effluent to discharge into an approved disposal system. These units typically include nitrification in the aerobic zone (conversion of ammonia to nitrate) and may include denitrification in an anoxic zone (conversion of nitrate to nitrogen gas).

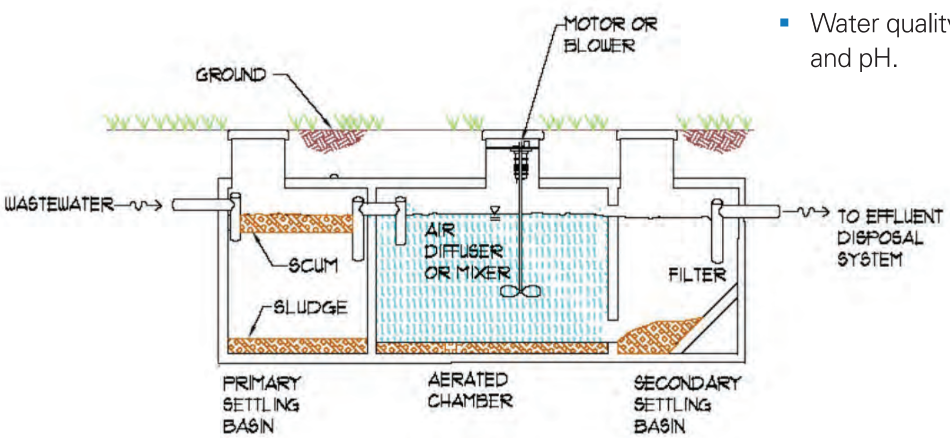
A combined attached and suspended-growth flow-through biological treatment system is a type of ATU where the aerated part of the unit contains plastic media. This allows microorganisms to attach and grow and other microorganisms are kept in suspension by mixing air with wastewater influent and concentrated underflow or sludge (from a clarifier) in an aeration tank. This configuration allows microorganisms to form a slime layer on the surface of submerged plastic media which essentially allows incorporation of more biomass in the same volume. Wastewater is treated as it passes through the media.

IDEAL APPLICATION

- Areas where a higher level of treatment is required (i.e. compliance with NSF245).
- Installation location is greater than 50 feet from inland or coastal waters.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps.

BENEFITS

- Since the biological process takes place in an aerobic environment where free oxygen is available, complete nitrification of ammonia can occur.
- ATUs can also be designed to include denitrification.



Combined Attached and Suspended Growth ATU.

CHALLENGES / RESTRICTIONS

- Power is needed to operate the blowers, controls, and monitoring and alarm systems in the ATU.
- ATUs are sensitive to high and low temperatures, heavy loading of solids, toxic chemicals, power failures, and large influent flow variability.

OPERATIONS AND MAINTENANCE

- Trained professionals should inspect the system every four to six months, along with sludge/scum pumping, as needed.

EFFLUENT QUALITY

- Water quality does not meet NSF245 criteria for total nitrogen removal (for nitrifying ATU).
- Water quality does meet NSF245 criteria for total nitrogen removal (for denitrifying ATU).
- Water quality meets NSF40 criteria for CBOD5, TSS, and pH.

Chlorine Disinfection

APPROVED ONSITE TREATMENT TECHNOLOGY

Wastewater disinfection reduces the possibility of pathogenic organisms entering the environment. Chlorine is a powerful oxidizing chemical often used as a disinfectant following wastewater treatment. Powder or tablets of solid hypochlorite (calcium hypochlorite and sodium hypochlorite) are the forms that can be used for onsite systems. All forms of chlorine are toxic, corrosive, and require careful handling and storage. For small onsite systems, the most common disinfection method is a tablet chlorinator—it does not require electricity, is easy to operate and maintain, and is relatively inexpensive.

IDEAL APPLICATION

- Following a wastewater treatment system such as an ATU where disinfection is required (e.g. near coastal or sensitive waters).

BENEFITS

- Chlorine is readily available, low cost, and is effective against a wide range of pathogenic organisms.
- Units are inexpensive and do not require energy to operate.
- Easy to operate and maintain.

CHALLENGES / RESTRICTIONS

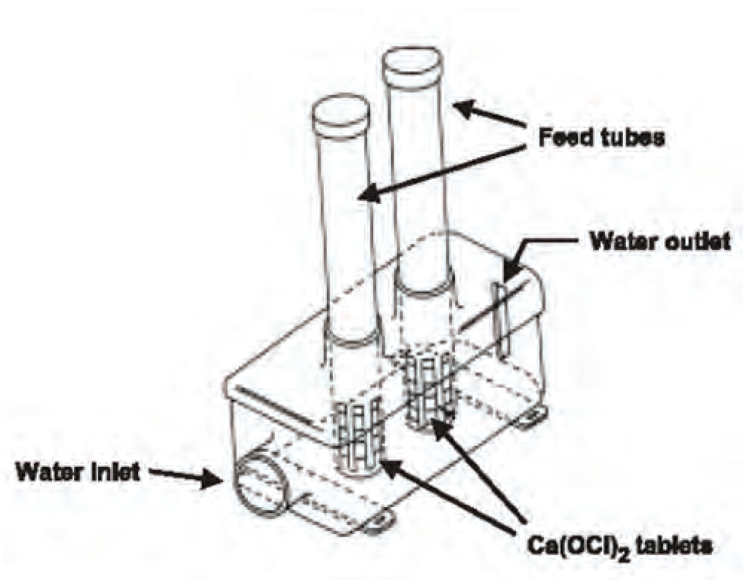
- Requires substantial treatment prior to disinfection.
- Chlorine chemicals need to be stored and handled carefully.
- Require periodic chemical addition. Chlorine tablet feeder may jam and cause system to not work properly.
- Residual chlorine released in treated wastewater may have adverse effects on other organisms in the environment.
- Obtaining the correct type of chlorine tablets can be difficult; wastewater-type tablets are different than pool-type chlorine tablets which expand when wetted.

OPERATIONS AND MAINTENANCE

- Systems should be inspected monthly to ensure operation. For a typical system, tablets may need to be added every 4 to 6 months.

EFFLUENT QUALITY

- Can remove a high percentage of fecal coliform.



Stack-Feed Tablet Chlorinator.

Ultraviolet Disinfection

APPROVED ONSITE TREATMENT TECHNOLOGY

Ultraviolet (UV) disinfection employs mercury-type lamps separated from the water by a quartz sleeve contained in a flow through stainless-steel reaction vessel (pipe). UV light acts as a physical disinfection agent due to the germicidal properties of UV in the range of 240 to 270 nanometers. The radiation penetrates the cell wall of microorganisms and causes cellular mutations that prevent reproduction. Effectiveness of UV disinfection depends on the clarity of the treated wastewater, UV intensity, time of exposure, and reactor configuration.

IDEAL APPLICATION

- Following a wastewater treatment system such as an ATU where disinfection is required (e.g. near coastal or sensitive waters).

BENEFITS

- UV successfully inactivates most bacteria, viruses, spores, and cysts.
- In contrast to chlorine, this method does not involve handling or storing of hazardous or toxic chemicals.
- Does not leave residual chemical or toxicity in the water.
- Very compact system.

An ultraviolet disinfection system (steel cylinder to the right of the control box) used to treat sand filter effluent before landscape irrigation.

CHALLENGES / RESTRICTIONS

- Requires a high level of treatment prior to disinfection.
- A continuous power supply is required to operate the UV bulbs.
- Periodic cleaning of the quartz sleeves is required to ensure transmission of the UV radiation into the wastewater (monthly minimally).
- Bulbs must be replaced (typically annually)
- UV treatment is rendered ineffective in wastewater with low clarity due to bacteria being shielded by high turbidity and total suspended solids.

OPERATIONS AND MAINTENANCE

- Requires that the lamps be cleaned and/or changed periodically to maintain a high level of treatment. Because the system uses electrical power it will need regular inspection to ensure correct operation.

EFFLUENT QUALITY

- Can remove a high percentage of fecal coliform.

Recirculating Filter

APPROVED ONSITE TREATMENT TECHNOLOGY

A recirculating filter is a treatment technology in which septic tank effluent is percolated through a bed of sand or textile material where it undergoes further biological treatment. Carbon oxidation, nitrification, and denitrification can all occur. A portion of the percolated water is pumped back to the pump chamber or the treatment process, and another portion passes on to a dispersal system such as drip irrigation or a seepage pit. The nitrate in the recirculated water undergoes denitrification under anaerobic conditions (Barnstable County Department of Health and Environment, 2018).

IDEAL APPLICATION

- Where additional treatment of septic tank effluent is needed prior to disposal.
- Installation location is greater than 50 feet from inland or coastal waters.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps.

BENEFITS

- Can remove up to 50 percent total nitrogen.
- Secondary effluent quality can be obtained without aeration.

CHALLENGES / RESTRICTIONS

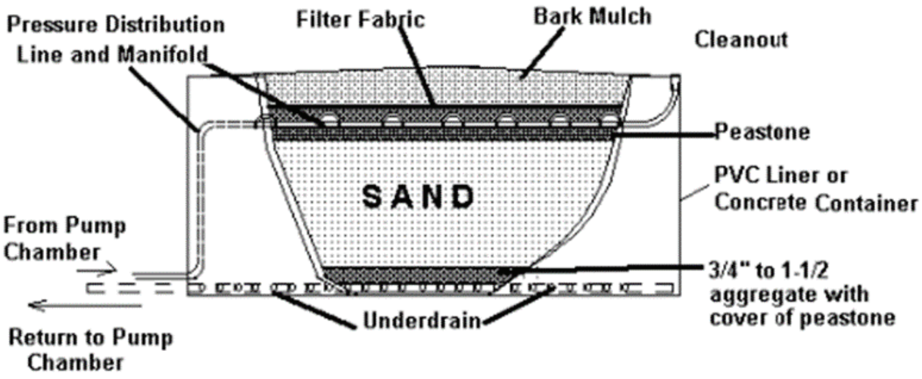
- A septic tank is needed for preliminary treatment of the wastewater.
- Large land area may be required for effluent disposal.
- Filters need to be covered to protect against odor, debris, algae fouling, and precipitation.
- A pump is needed for recirculating the wastewater.

OPERATIONS AND MAINTENANCE

- Operational costs include electricity for the pump and labor. The filter should be inspected every 3 to 4 months, and the filter media must be removed and replaced periodically.

EFFLUENT QUALITY

- Water quality can meet NSF245 criteria for total nitrogen removal or NSF40 criteria for CBOD5, TSS, and pH depending upon the selected unit.



Typical Recirculating Sand Filter.

Eliminite Wastewater Treatment Process

INNOVATIVE ONSITE TREATMENT TECHNOLOGY – APPROVAL REQUIRED

The Eliminite wastewater treatment process is a denitrifying septic system utilizing multiple tanks and a patented, proprietary treatment media called MetaRocks® to remove nitrogen. MetaRocks® provide a surface for nitrifying and denitrifying bacteria to thrive. The first tank is used as a septic tank, and the second tank has two chambers to house the MetaRocks® and provide BOD5, TSS, and total N removal. The Eliminite system is followed by a disposal system such as absorption or seepage pit (Eliminite, Inc., 2018).

IDEAL APPLICATION

- Where nitrogen removal is required in addition to BOD and TSS.
- Installation location is greater than 50 feet from inland or coastal waters.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps

BENEFITS

- Average total nitrogen removal is expected to be approximately 60 percent.

CHALLENGES / RESTRICTIONS

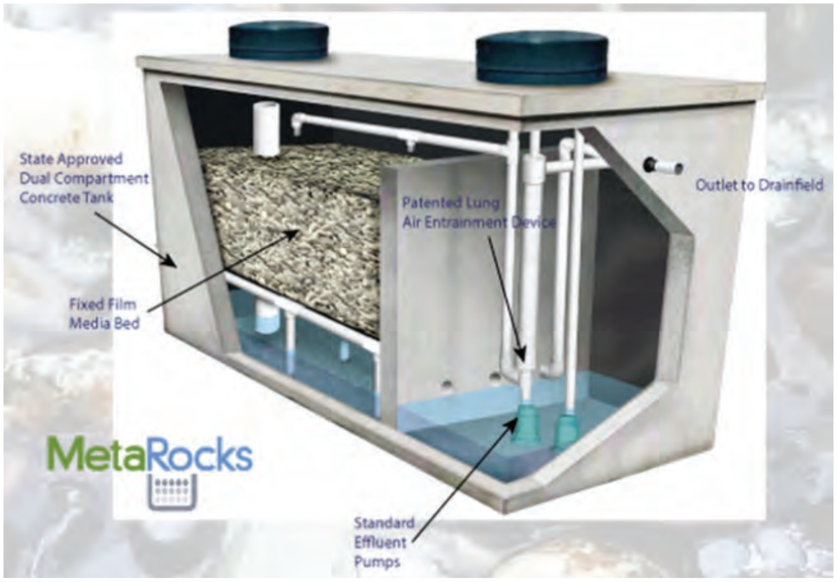
- Pump operation and electrical power are needed.
- This innovative technology is new to Hawai'i, so a pilot program with a robust inspection and sampling program would be necessary. Design would need to be reviewed and approved by DOH WWB.

OPERATIONS AND MAINTENANCE

- Inspections to verify the recirculation pump is functional and repair/replace as needed.
- Annual inspection of rock media chamber, with cleaning and addition of lost media as needed.

EFFLUENT QUALITY

- Meeting NSF245 criteria for total nitrogen removal is a goal, but certification has not yet been granted.
- Meeting NSF40 criteria for CBOD5, TSS, and pH is a goal, but certification has not yet been granted.



Nitrogen Reduction by Eliminite's MetaRocks® (Eliminite, Inc., 2018).

NITREX™ Nitrogen Removal Process

INNOVATIVE ONSITE TREATMENT TECHNOLOGY – APPROVAL REQUIRED

The NITREX™ system utilizes a proprietary reactive media to achieve denitrification of nitrate-rich wastewaters. As such, the process requires an aerobic treatment unit or the combination of a septic tank/ recirculating sand filter as a pretreatment step to treat BOD and TSS and provide nitrification (conversion of ammonia to nitrate). The nitrate contaminated wastewater is fed through NITREX™ media, which is contained in a prefabricated tank, or for larger installations, in an engineered excavation. NITREX™ is a relatively passive system that requires no pumping or chemical addition.

IDEAL APPLICATION

- Where a high degree of nitrogen removal is required.
- Installation location is greater than 50 feet from inland or coastal waters.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps.

BENEFITS

- Average total nitrogen removal is expected to be over 90 percent.
- There is no pumping or chemical addition requirement.
- The NITREX™ media has an expected performance period of 50 years.
- Virtually no maintenance of the system is needed, but routine operation and maintenance of the upstream treatment system will be necessary.

CHALLENGES / RESTRICTIONS

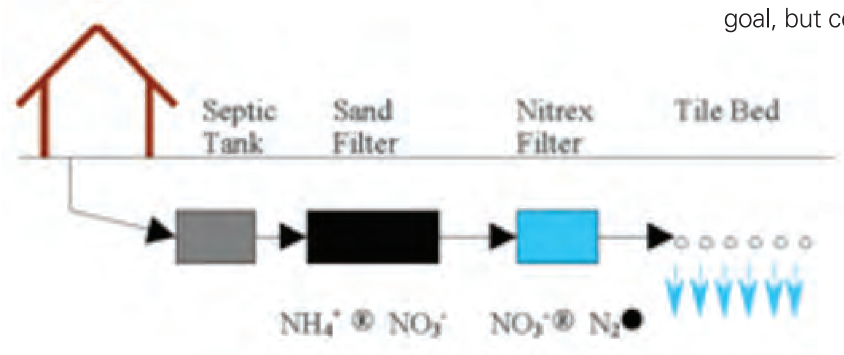
- This innovative technology is new to Hawai'i, so a pilot program with a robust inspection and sampling program would be necessary. Design would need to be reviewed and approved by DOH WWB.
- Requires pretreatment step such as the combination of a septic tank/recirculating sand filter or ATU to remove BOD and TSS and provide nitrification.

OPERATIONS AND MAINTENANCE

- Annual inspection of media chamber, with cleaning and addition of lost media as needed.
- Routine operation and maintenance of the upstream treatment system.

EFFLUENT QUALITY

- Water quality does not meet NSF245 criteria for total nitrogen removal.
- Routine operation and maintenance of the upstream treatment system.
- Meeting NSF40 criteria for CBOD5, TSS, and pH is a goal, but certification has not yet been granted.



Nitrogen Reduction by NITREX™ Filter in a Septic Tank System (Lombardo Associates, Inc., 2018).

Recirculating Gravel Filter

EMERGING ONSITE TREATMENT TECHNOLOGY – APPROVAL REQUIRED

The recirculating gravel filter system is a multi-step process that provides both aerobic and anaerobic conditions for nitrification and denitrification, respectively. The process is based on the use of a septic tank as a pretreatment step.

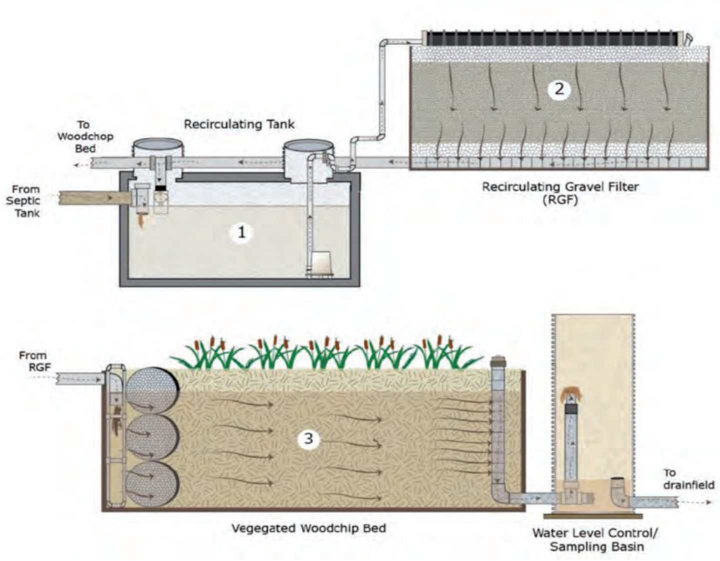
There are three zones in this system, with effluent continually circulated through the first two zones. With each circulation cycle, a portion of the nitrified effluent is released to the third zone for denitrification. The different zones are denoted by numbers in circles in the figure below. Effluent could be transferred to an absorption bed or trench.

IDEAL APPLICATION

- Where a high degree of nitrogen removal is required.
- Installation location is greater than 50 feet from inland or coastal waters.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps.

BENEFITS

- Average total nitrogen removal is over 90 percent.
- Local materials may be used for the woodbed media.



Recirculating Gravel Filter with Vegetated Woodbed System (Washington State Department of Health and University of Washington Civil and Environmental Engineering Department, 2012).

CHALLENGES / RESTRICTIONS

- Pump operation and electricity are needed for the recirculation system.
- This emerging technology is new to Hawai'i, so a pilot program with a robust inspection and sampling program would be necessary. Design would need to be reviewed and approved by DOH WWB.
- Requires a septic tank as a pretreatment step.

OPERATIONS AND MAINTENANCE

- Routine inspections should include the pump and control panel, adequacy of pumped dosage frequency, and effluent filter on the septic tank outlet.
- The septic tank should be maintained to ensure proper functioning of the subsequent treatment and disposal steps.

EFFLUENT QUALITY

- Water quality does not meet NSF245 criteria for total nitrogen removal.
- Meeting NSF40 criteria for CBOD5, TSS, and pH is a goal, but certification has not yet been granted.

Appendix C

Onsite Disposal Technologies

Absorption

APPROVED EFFLUENT DISPOSAL TECHNOLOGY

Absorption systems are an approved subsurface disposal technology that allows partially, or fully treated effluent to percolate into the soil. These systems are installed with a very mild slope to allow effluent to flow by gravity. Effluent comes from a treatment system and is distributed by gravity through perforated pipes laid in either a trench or bed, the surface area of which depends on the hydraulic properties of the native soil. Due to the aerobic conditions in the shallow soil layer, further treatment including filtration of suspended solids and microorganisms, oxidation of organic wastes, and nitrification can occur. The extent of such treatment is dependent upon the characteristics of the native soil, the loading rate, and other factors which can cause treatment as high as 90 percent.

Absorption systems generally range in depth from 1.5 to 3 feet below grade. Trench widths range from 18 to 36 inches, while bed widths are at least 3 feet.

Gravelless trench and bed absorption systems utilize plastic dome-shaped segmented chambers buried in the trench/bed in with large open spaces instead of perforated pipes surrounded by gravel.

IDEAL APPLICATION

- Soil percolation rate is less than 60min/in.
- Installation location is greater than 50 feet from inland or coastal waters.
- Maximum ground slope is 8 percent for absorption beds, and 12 percent for absorption trenches.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps.
- Cannot be used if groundwater is too close to the surface, minimum vertical separation of three feet from the bottom of the trench/bed.

Gravelless Absorption Bed Disposal System.

BENEFITS

- Common type of disposal system, so there are many products available and experience with installation.
- When deployed downstream from an aerobic treatment system, it provides some treatment for BOD, TSS, and fecal coliform.
- No power is required, and maintenance is generally not necessary.
- Gravelless dome systems require less gravel backfill and provide significant additional water storage volume.

CHALLENGES / RESTRICTIONS

- Large land requirement.
- Overloading, rainfall, or unsuitable soils may cause contaminants to spill out into the surroundings.
- Root intrusion can adversely impact performance.

OPERATIONS AND MAINTENANCE

- Normally none. Some systems use a dosing pump - if present, it must be checked and cleaned.
- Observation ports can be installed within the disposal area to check whether the water is percolating into the ground as expected.

EFFLUENT QUALITY

- Can effectively remove a high percentage of fecal coliform, depending on soil type.

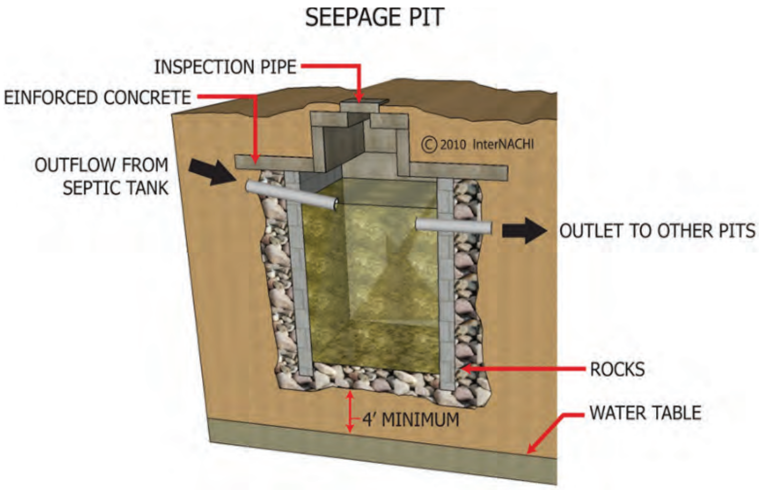
Seepage Pit

APPROVED EFFLUENT DISPOSAL TECHNOLOGY

A seepage pit is constructed the same as a cesspool (often it is a former cesspool that has been cleaned and repurposed), but it receives treated wastewater, whereas a cesspool receives untreated wastewater. These systems are generally constructed from reinforced concrete rings, with a diameter of 8 or 10 feet and a height of 2 feet, that are stacked in order to achieve the depth required (usually 15-30 feet) to meet percolation requirements. Each ring has large openings in the sides and looks like Swiss cheese. A concrete lid with a 12-inch inspection port is placed on top. Water percolates out from the sides and the bottom of the unit into the surrounding soil. The effective percolation area is measured as the pit sidewall area

IDEAL APPLICATION

- Soil percolation rate is less than 60min/in.
- Installation location is greater than 50 feet from inland or coastal waters.
- Maximum ground slope is 12 percent and an absorption system is not feasible.
- Groundwater table depth is greater than 3 feet from the bottom of the seepage pit.
- Should not be installed in areas with more than approximately 1 unit per acre because a higher level of treatment is necessary to avoid negative cumulative impacts.



Seepage Pit Disposal System (InterNACHI, 2020).

BENEFITS

- Seepage pits are the simplest and most compact method to percolate water into the ground.
- They are viable options when the available land area is insufficient for absorption beds or trenches, the terrain is steep, or when an impermeable layer overlies more suitable soil.
- These units can be maintained (accumulated solids from poorly functioning upstream treatment units can be accessed and pumped out) unlike absorption trenches/beds.

CHALLENGES / RESTRICTIONS

- Seepage pits generally cannot provide the same level of treatment as absorption bed and trench systems.
- There can be a danger of structural stability including potential cave-ins when converting an old cesspool with un-lined walls or lined walls in poor condition into a seepage pit.

OPERATIONS AND MAINTENANCE

- Proper functioning of a seepage pit relies heavily on maintenance of the upstream treatment process. This prevents clogging of the seepage pit. Otherwise, periodic pumping of any accumulated sludge will be required.

EFFLUENT QUALITY

- No additional treatment of BOD, TSS, nutrients, or fecal coliform.

Presby Advanced Enviro-Septic® System

APPROVED EFFLUENT DISPOSAL TECHNOLOGY

The Presby Advanced Enviro-Septic® System is a network of 10-foot long pipes used for further treating and percolating septic tank effluent. It consists of special pipes embedded in a specific type of System Sand. The pipes contain ridges, perforations with skimmers, geotextile fabric, green plastic fiber mat, and Bio-Accelerator® fabric. These work together to treat wastewater as depicted in figure below (Presby Environmental, 2018). Without using any electricity or replacement media, the Advanced Enviro-Septic® system can remove BOD5, TSS, and provide full nitrification. (Presby Environmental, 2018).

IDEAL APPLICATION

- Soil percolation rate is less than 60min/in.
- Installation location is greater than 50 feet from inland or coastal waters.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps.
- Groundwater table depth is greater than 3 feet below the Presby system.
- Where a higher level of treatment is required.

Presby Advanced Enviro-Septic® Treatment System (Presby Environmental, 2018).

BENEFITS

- Passive system that does not need electricity. There are no moveable parts and no replaceable media.
- Enhanced treatment and disposal of wastewater are combined in this system.
- No maintenance of the system is needed, but routine inspections and pumping of the upstream septic tank will be necessary.

CHALLENGES / RESTRICTIONS

- This technology is still relatively new to Hawaiʻi, so the practical lifespan is unknown.

OPERATIONS AND MAINTENANCE

- This is a buried, passive system which does not require operation or maintenance.

EFFLUENT QUALITY

- Water quality does not meet NSF245 criteria for total nitrogen removal.
- Water quality does meet NSF40 criteria for CBOD5, TSS, and pH.
- Can effectively remove a high percentage of fecal coliform, depending on soil type.

Evapotranspiration

EFFLUENT DISPOSAL TECHNOLOGY – APPROVAL REQUIRED

Evapotranspiration combines direct evaporation and plant transpiration for wastewater disposal. Pretreated effluent (usually an aerobic treatment unit) is conveyed to a porous bed containing water-tolerant plants. Wicking, or capillary action, draws water to the surface, where it is either taken up by the plants and transpired, or evaporated from the surface. Effluent that is not transpired or evaporated will percolate from the bottom of the bed. This type of system is known as evapotranspiration-infiltration.

These systems can also be designed with an underlying impermeable liner for a "zero-discharge" system. In this case, disposal is strictly dependent on evaporation and plant transpiration. Additionally, the liner allows the system to be placed above an Underground Injection Control (UIC) line or where there is shallow groundwater or proximate surface water such as a stream, lake or the ocean.

Other components that are typically included are drip or distribution lines, flushing or filtering mechanism, controller to automate dosing cycles, distribution pump, and alternating evapotranspiration beds.

IDEAL APPLICATION

- Installation location is greater than 50 feet from inland or coastal waters.
- Maximum ground slope is 12 percent.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps.

BENEFITS

- If an impermeable liner is included for a "zero-discharge" system, then 100 percent nitrogen removal is achieved.

CHALLENGES / RESTRICTIONS

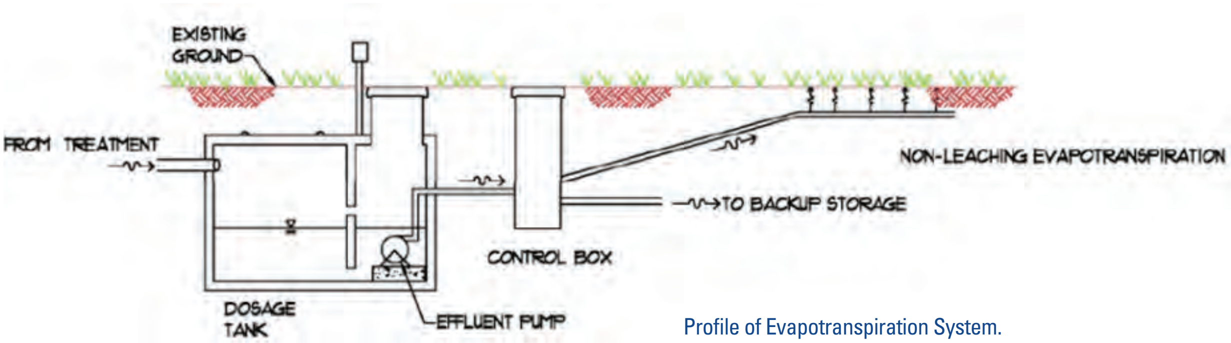
- Large surface areas are needed for year-round disposal. The size is controlled by a water balance based on rainfall and pan evaporation rates.
- These systems are more effective in arid climates where evaporation rates are much higher than precipitation rates.
- Recordkeeping of lysimeter (soil pore water sampler) data is required to ensure proper functioning.

OPERATIONS AND MAINTENANCE

- O&M tasks will include simple inspection of observation wells, electrical costs for pumping, as needed, minor landscaping, and maintaining upstream processes to avoid overflow of solids into the evapotranspiration bed.

EFFLUENT QUALITY

- Water quality does meet NSF245 criteria for total nitrogen removal.
- Water quality does meet NSF40 criteria for CBOD5, TSS, and pH.
- Discharges zero quantity of fecal coliforms to the environment when lined.



Profile of Evapotranspiration System.

Constructed Wetland

EFFLUENT DISPOSAL TECHNOLOGY – APPROVAL REQUIRED

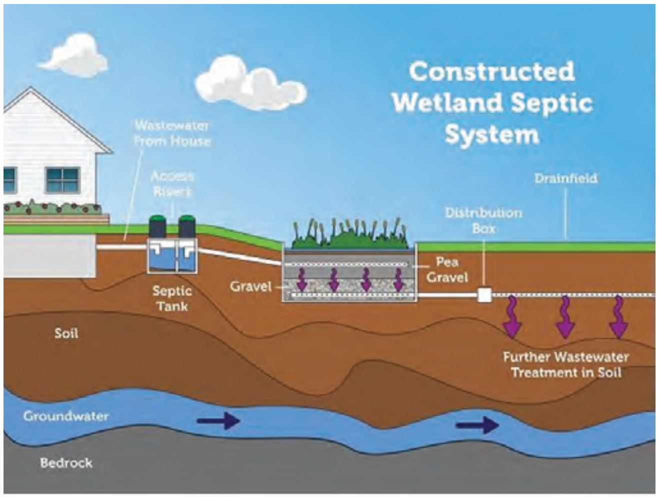
A constructed wetland is a disposal technology that is designed and constructed to recreate the processes that naturally treat wastewater by the environment. Septic tank effluent flows (typically by gravity) to an earthen basin or cell containing microorganisms, porous media and plants. A perforated pipe runs along the length of the cell just below the plants to evenly distribute the effluent. A second pipe runs along the length of the cell to collect the effluent as it travels through the porous media, where it then flows through a distribution box and into a drain field. As the wastewater flows through the constructed wetland it undergoes filtration, nitrification, denitrification, and absorption. In residential applications, wastewater flows are kept beneath the ground surface to limit potential human contact with wastewater.

IDEAL APPLICATION

- Installation location is greater than 50 feet from inland or coastal waters.
- Maximum ground slope is 12 percent.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps.
- Groundwater table depth is greater than 3 feet.

BENEFITS

- A constructed wetland provides suitable conditions for denitrification to occur.
- Power is not required to operate a wetland.



Constructed Wetland with Primary Treatment by Septic Tank
(United States Environmental Protection Agency, 2018).

CHALLENGES / RESTRICTIONS

- Large land area may be required.
- It is important to maintain an even cross-sectional flow throughout the constructed wetland.
- The water level should be maintained in the cell during low- or no-flow periods to maintain survival of the plants.

OPERATIONS AND MAINTENANCE

- Routine maintenance of the vegetation should be conducted to prevent problems caused by root systems, such as surface ponding.
- Frequent inspection of the vegetation, inlet distributor, liner, berms or retaining walls, pumps, if present, and drain field is required. A maintenance plan should be completed to detail O&M requirements (Beharrell, 2004).

EFFLUENT QUALITY

- Can effectively remove a high percentage of fecal coliform, depending on soil type.

Drip Dispersal

EFFLUENT DISPOSAL TECHNOLOGY – APPROVAL REQUIRED

Drip dispersal systems use a network of pipes containing emitters commonly spaced 12 inches apart and installed in excavations similar to but shallower than absorption beds. Rather than working by gravity, these systems receive treated effluent in pumped doses from a dosing tank, which allows for controlled loading rates to the shallow root zone of the surrounding soil. While some of the treated wastewater percolates into the ground, drip disposal systems act partially as an evapotranspiration system since some of the effluent is taken up by the plants at the ground surface.

IDEAL APPLICATION

- Installation location is greater than 50 feet from inland or coastal waters.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps.
- Groundwater table depth is greater than 3 feet below the drip system.

BENEFITS

- Reliable alternative for areas with low permeability, seasonal high-water tables, or severe slopes.
- Ability to control dose/rest cycles allows for even spacing or dosing of effluent. This facilitates wastewater infiltration by spreading it spatially and over time.

Drip Irrigation System.

CHALLENGES / RESTRICTIONS

- In some cases, a large dose tank is needed to accommodate timed dose delivery to the drip absorption area.
- The septic tank and its effluent filter must be monitored and maintained in order to prevent clogging and possible failure of the drip emitters.
- Drip disposal systems are active systems, meaning power is required to run pumps, sensors and controls.

OPERATIONS AND MAINTENANCE

- Regular monitoring and maintenance of pump, filter and piping shall be performed by an authorized service provider as described in an O&M manual provided by the manufacturer. Typical inspections may include observing and reporting of the general condition of the system, water level in tanks, ponding around the system, clogging at pumps and filters, pump cycles, and readings of any meters (NJDEP, 2008).

EFFLUENT QUALITY

- Can effectively remove a high percentage of fecal coliform, depending on soil type.

Passive Treatment Unit

INNOVATIVE EFFLUENT DISPOSAL TECHNOLOGY – APPROVAL REQUIRED

Several variations of passive-type systems have been developed during a large research project in the State of Florida. These systems are a disposal technology that follow a septic tank and typically include multiple saturated and unsaturated stages, with or without recirculation to facilitate nitrification and denitrification.

The unit shown here provides treatment of septic tank effluent in a Stage 1 unsaturated biofilter and Stage 2 saturated biofilter. The denitrified effluent is then disposed of in an absorption bed or trench. The Stage 1 biofilter hydraulics can be either single pass or recirculation. The pump tank can be run either with single pass or with a recycle stream for internal recirculation to spray nozzles located above the surface of the Stage 1 media. The Stage 2 biofilters can contain single or dual media, such as lignocellulosic/sand mixture. This configuration demonstrated a total nitrogen removal of 85 to 95 percent.

IDEAL APPLICATION

- Installation location is greater than 50 feet from inland or coastal waters.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps.
- Groundwater table depth is greater than 3 feet below the disposal system.
- Where nitrogen removal is required.

BENEFITS

- Total nitrogen removal depends on the configuration and is expected to be either 50 to 95 percent prior to discharge to the soil absorption system.
- Local materials may be used for biofilter media.

CHALLENGES / RESTRICTIONS

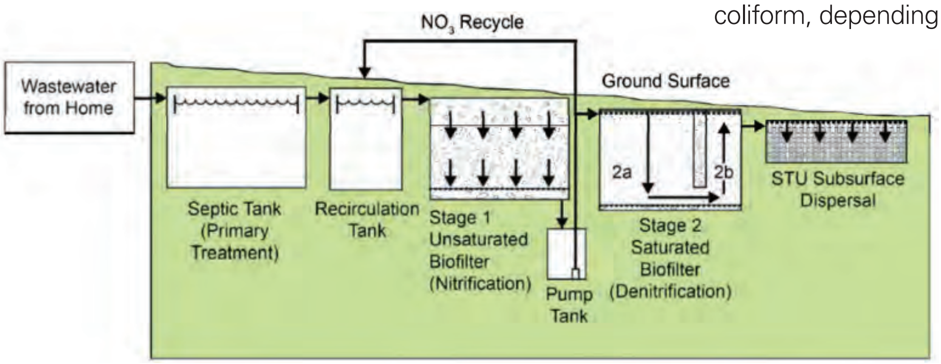
- Pump operation and electricity will be needed if a recirculation system is included.

OPERATIONS AND MAINTENANCE

- Routine inspections (twice a year is required by Florida code) include pump operation and electrical connections, hydraulic inspection, flushing and cleaning of distribution lines, biofilter media life, and the recirculation system.
- The septic tank must be maintained to prevent clogging and failure of the subsequent treatment and disposal steps.

EFFLUENT QUALITY

- Meeting NSF245 criteria for total nitrogen removal is a goal, but certification has not yet been granted.
- Meeting NSF40 criteria for CBOD5, TSS, and pH is a goal, but certification has not yet been granted.
- Can effectively remove a high percentage of fecal coliform, depending on soil type.



Treatment by Recirculating Unsaturated Biofilter and Saturated Biofilter and Disposal by Soil Treatment Unit (Hazen and Sawyer, 2015).

Nitrification / Denitrification Biofilter

EMERGING EFFLUENT DISPOSAL TECHNOLOGY – APPROVAL REQUIRED

Several configurations of biofilter disposal technologies have been researched in New York. Septic tank effluent is transferred through a low pressure distribution system comprised of a pump and parallel, low pressure dosing pipes with drilled orifices. As the wastewater percolates down, it infiltrates the lined nitrification/denitrification biofilter underlying the pipes. Nitrification and denitrification occur in the sand and sand/lignocellulose layers, respectively.

One configuration of the biofilter consists of 6 to 8 inches of soil cover, followed by a 12- to 18-inch nitrifying sand layer, and then a 12- to 18-inch denitrifying sand/sawdust layer. The system is lined to maintain saturation conditions and to allow effluent discharge to a dispersal system.

IDEAL APPLICATION

- Installation location is greater than 50 feet from inland or coastal waters.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps.
- Groundwater table depth is greater than 3 feet, below the effluent disposal system.
- Where nitrogen removal is required.

BENEFITS

- Total nitrogen removal is expected to be up to 90 percent.
- Processes are primarily driven by gravity and capillary forces.
- Saturated nature of sand and sawdust layer should minimize oxidation and degradation of the wood source over time.
- Local materials can be used for the biofilter media.
- Woodchip biofilter tank allows for convenient replacement of woodchips.

CHALLENGES / RESTRICTIONS

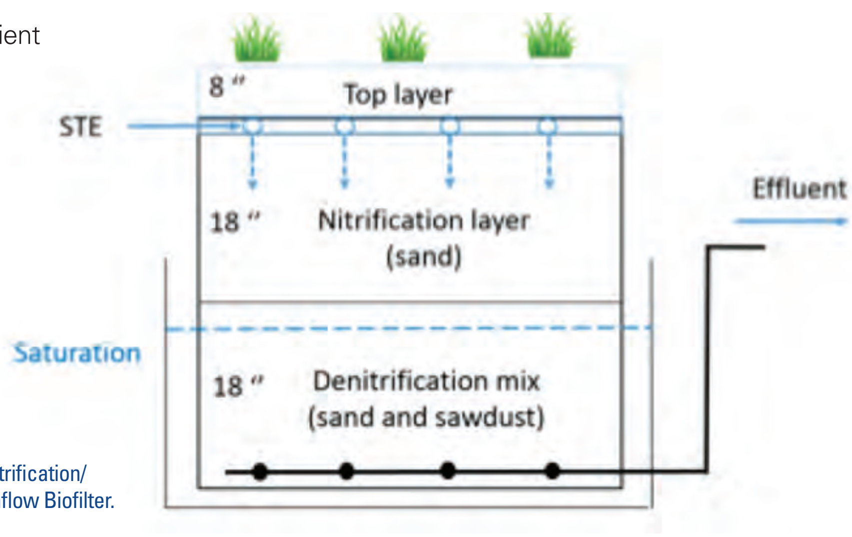
- Pump operation and electricity needed for sending wastewater to the woodchip biofilter tank.

OPERATIONS AND MAINTENANCE

- The septic tank, its effluent filter, and pump, if included, must be routinely inspected and maintained for proper functioning and to prevent clogging and failure of downstream biofilters.

EFFLUENT QUALITY

- Meeting NSF245 criteria for total nitrogen removal is a goal, but certification has not yet been granted.
- Meeting NSF40 criteria for CBOD5, TSS, and pH is a goal, but certification has not yet been granted.
- Can effectively remove a high percentage of fecal coliform, depending on soil type.



Disposal by Lined Nitrification/
Denitrification Downflow Biofilter.

Appendix D

Alternative Toilet Technologies

Composting Toilet

ALTERNATIVE TOILET TECHNOLOGY – APPROVAL REQUIRED

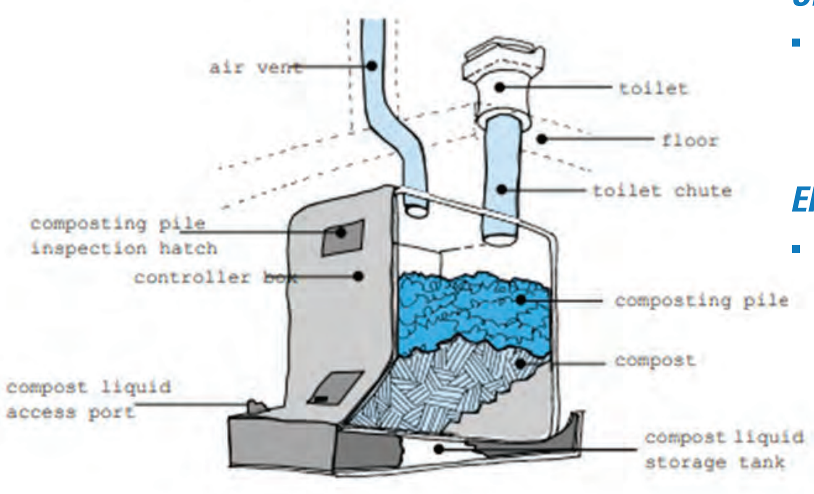
A typical composting toilet includes a composting reactor tank connected to one or more waterless toilets in the house. There are self-contained units with the compositing bin under the toilet seat. The reactor tank controls the decomposition of excrement, toilet paper, and carbon-based bulking agents such as wood chips, straw, hay, or grain hulls. Bulking agent materials break down quickly to prevent buildup of aerobic bacteria and fungi. The owner must remove and dispose of aged compost frequently, turn the composting waste with every use, and replenish bulking agents and odor control fluid. An exhaust system driven by a fan vents odor, carbon dioxide, and moisture from the reactor bin to the outdoors. The decomposing material needs to be turned frequently to break up the mass and to keep the pile porous and aerated. The final material is about 10 to 30 percent of its original volume and must be properly disposed as municipal solid waste (recycling/reuse on the property is not allowed in Hawai'i).

IDEAL APPLICATION

- This may be an option for homeowners who are willing to perform the maintenance required.

BENEFITS

- As a zero-discharge system, nitrogen will not be released into the groundwater.
- Since water is not needed for flushing, household water consumption is reduced.
- System consumes very little power (only the small fan).
- Residents may be able to install a reduced-size wastewater treatment and disposal system, minimizing costs and disruption to the parcel.



Composting Toilet (National Small Flows Clearinghouse, 2000).

CHALLENGES / RESTRICTIONS

- A high level of maintenance is required by the owner, such as periodic turning of the compost, daily addition of bulking agents, handling and disposal of compost, and preventing too much liquid in the composter.
- A power source is generally needed.
- Composting excrement may be visible in some systems.
- There can be objectionable odors emitted from these systems.
- If more than one toilet is desired within the household or property, costs are multiplied accordingly with the number of toilets installed.
- Additional approved treatment/disposal system required for household grey water and kitchen blackwater.

OPERATIONS AND MAINTENANCE

- The decomposing material needs to be turned frequently to break up the mass and to keep the pile porous and aerated.

EFFLUENT QUALITY

- There is no discharge from composting toilets, thus this would help to mitigate nitrogen release.

Incinerating Toilet

ALTERNATIVE TOILET TECHNOLOGY – APPROVAL REQUIRED

These types of toilets use electricity, oil, natural gas, or propane to burn waste to a sterile ash. A paper-lined upper bowl holds newly deposited waste. The paper liner is replaced after each use. Flushing using a foot pedal causes an insulated chamber cover to lift and swing to the side while the bowl halves separate. The paper liner and its contents deposit into the incinerating chamber. When the foot pedal is released, the chamber cover reseals and the bowl halves close (National Small Flows Clearinghouse, 2000).

A "start" button on the toilet begins the burning process, which occurs after each individual deposit. An electric heating unit cycles on and off for about an hour while a blower motor draws air from the incinerating chamber over a heat-activated catalyst to remove odors. A fan then distributes the air through a vent pipe to the outdoors. The fan is also used to cool the incinerating unit. The entire cycle takes from about 1.5 to 1.75 hours per "flush" or use (National Small Flows Clearinghouse, 2000).

IDEAL APPLICATION

- This may be an option for homeowners who are willing to complete the maintenance required.

BENEFITS

- As a zero-discharge system, nitrogen will not be released into the groundwater.
- Since water is not needed for flushing, household water consumption is reduced.
- Residents may be able to install a reduced-size wastewater treatment and disposal system, minimizing costs and disruption to the parcel.

CHALLENGES / RESTRICTIONS

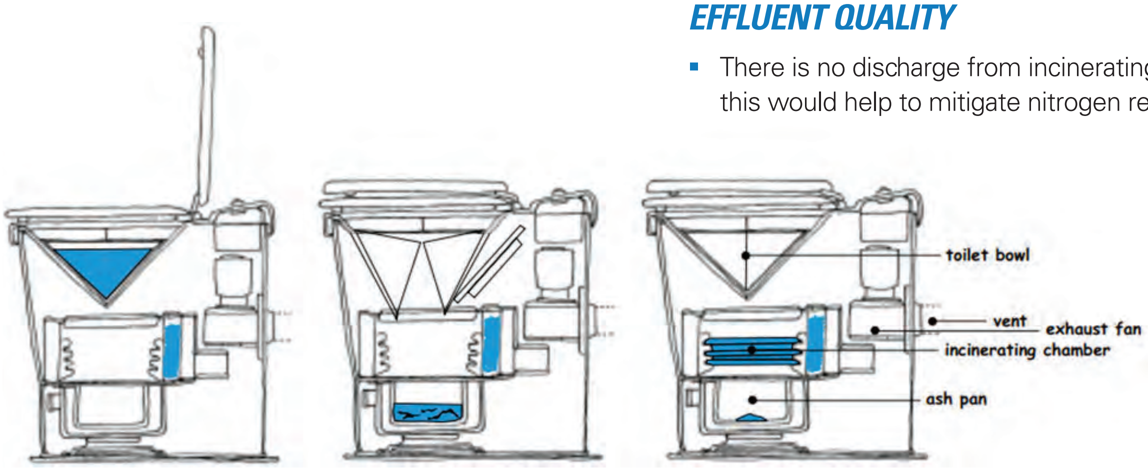
- Care must be taken to minimize electrical hazards.
- A power source is needed.
- The toilet cannot be used during the incinerating cycle.
- If more than one toilet is desired within the household or property, costs are multiplied accordingly with the number of toilets installed.
- Additional approved treatment/disposal system required for household grey water and kitchen blackwater.

OPERATIONS AND MAINTENANCE

- Regular cleaning of the toilet seat and bowl as needed.
- Disposal of generated ash in a sealed bag with regular municipal solid waste.
- Mechanical/electrical inspection, maintenance, and repair requirement are unknown currently.

EFFLUENT QUALITY

- There is no discharge from incinerating toilets, thus this would help to mitigate nitrogen release.



Incinerating Toilet Shown with Seat Cover Up, Seat Cover Down and Incinerating Chamber Opened, and Seat Cover Down and Incinerating Chamber Closed (Left to Right) (National Small Flows Clearinghouse, 2000).

Appendix E

Decentralized Cluster Wastewater Collection Technologies

Gravity Sewers

COLLECTION SYSTEM TECHNOLOGY

Gravity sewers are a network of underground pipes that convey wastewater from individual households to a treatment facility. Gravity sewers are the standard, conventional type of system for centralized wastewater systems that connect numerous homes, businesses, and industries to a regional treatment plant. The sewers utilize gravitational energy resulting from a difference in elevation to cause flow.

IDEAL APPLICATION

- Where ground conditions allow for gravity flow and relatively easy excavation.

BENEFITS

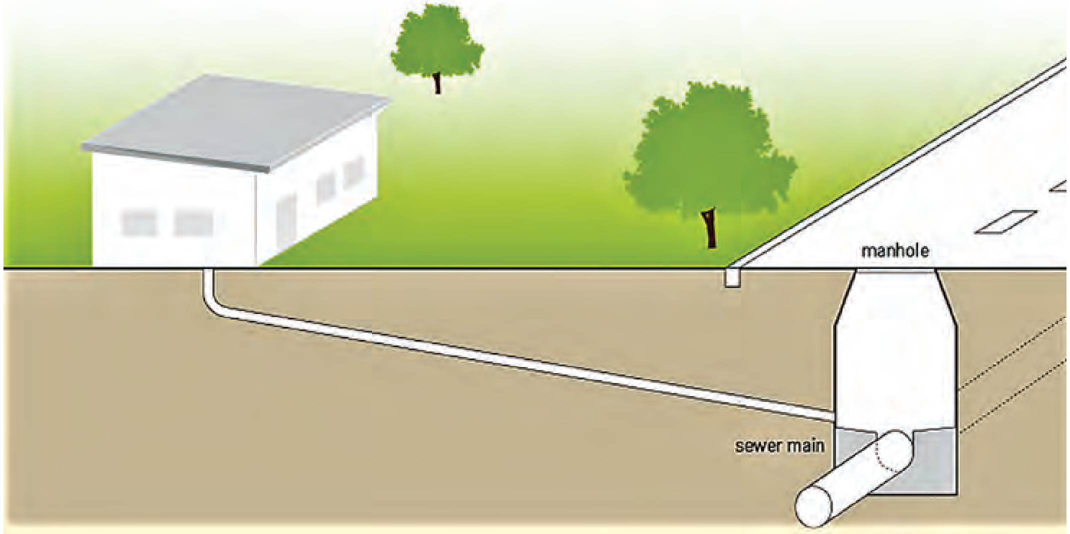
- Can handle grit and other solids, as well as large volumes of flow.
- Does not require onsite treatment or storage of the household wastewater before it is discharged.
- Little impact to homeowners and their properties.
- Presents a viable option if there is an appropriate difference in elevation.
- No electricity for pumping and no pump maintenance.

CHALLENGES / RESTRICTIONS

- Flat or large variations in terrain or difficult excavation conditions can increase costs.
- Larger pipes compared to other collection system options.
- Prone to clogging.
- Manholes associated with gravity sewers are a potential source of inflow and infiltration.
- Must be designed to maintain a self-cleansing velocity, generally 2 feet per second, at a minimum, during most flow conditions.

OPERATIONS AND MAINTENANCE

- Inspect on a regular schedule, this can be accomplished via surface inspections of manholes, lowering hand-held camera or robotic closed-circuit TV.
- Proactively flush accumulated debris, fats, oil, and grease.
- Remove blockages and tree roots as required.



Typical Gravity Sewer System (Tiley et al., 2014).

Liquid-Only Pressure Sewers

COLLECTION SYSTEM TECHNOLOGY

A liquid-only sewer system is a network of pipes that convey pre-treated wastewater pumped under pressure to the treatment facility. A precondition for these sewers is that efficient preliminary treatment is available at the household level, typically achieved using a septic tank. This system is also known as a septic tank effluent pumping (STEP) sewer system and is practical in areas with a limited number of homes and relatively short distances to the neighborhood treatment facility.

IDEAL APPLICATION

- Where a septic tank already exists at each property.
- Where appropriate differences in elevation do not exist for gravity flow, or where shallow construction is preferred.

BENEFITS

- Independent from land topography restrictions.
- The septic tank retains most of the fats, oils, grease, and solids reducing clogging problems.
- Septic tanks have storage capacity to operate during power outages.
- Smaller pipes compared to conventional gravity sewers.
- Can be installed at a shallow depth.

CHALLENGES / RESTRICTIONS

- Requires power for the pumps located at each property.
- Requires a septic tank at each property.
- Grease and sludge must be periodically pumped from each individual septic tank.
- Pumps and filters must be maintained on each property.

OPERATIONS AND MAINTENANCE

- Provide/maintain power to the pump at each property.
- Inspect and clean filter on pump monthly.
- Periodically remove accumulated sludge and scum from septic tank.
- Remove any blockages in pressure pipe network.

Liquid-Only Pressure Sewer System (Orenco Systems, Inc.).

Low Pressure Sewers

COLLECTION SYSTEM TECHNOLOGY

Low pressure sewers utilize grinder pumps located in a small receiving station/vault on each property to transport finely ground raw wastewater from the home through a network of pressurized sewer pipes to the treatment facility.

Raw wastewater from the home enters an onsite tank that is much smaller than a septic tank which houses the grinder pump where the sewage is shredded by cutting blades in the pump intake. The pumps contribute flow to the pressurized network of pipes which convey the chopped raw sewage to the treatment facility.

IDEAL APPLICATION

- Where appropriate differences in elevation do not exist for gravity flow, or where shallow construction is preferred.

BENEFITS

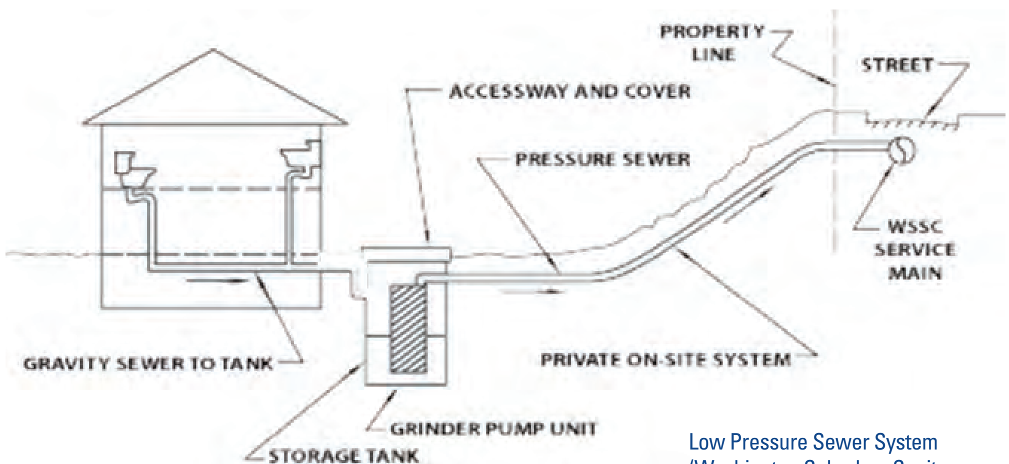
- Independent from land topography restrictions.
- Smaller pipes compared to conventional gravity sewers.
- Can be installed at a shallow depth.

CHALLENGES / RESTRICTIONS

- Requires power for the grinder pumps at each property.
- Pumps must be maintained on each property.

OPERATIONS AND MAINTENANCE

- Provide/maintain power to each pump.
- Inspect pump and chamber on a regular basis, remove any accumulated materials.
- Inspect and maintain backflow preventers.
- Remove any blockages in pressure pipe network.



Low Pressure Sewer System (Washington Suburban Sanitary Commission [WSSC] Water, 2019)

Vacuum Sewers

COLLECTION SYSTEM TECHNOLOGY

Vacuum sewers use negative pressure to transport raw sewage from homes to the treatment facility. This system maintains a partial vacuum with an air pressure below atmospheric inside the pipe network and vacuum station's collection vessel. A vacuum sewer system consists of valve vaults at each home, valves that regulate the entry of wastewater and air, collection system piping, and one or more vacuum stations. The system requires a normally closed valve at each entry point to seal the lines, so that the vacuum is maintained. The valves open when a specific amount of sewage accumulates in the collection chamber, upon which the resulting pressure difference drives the sewage towards the vacuum station and then to the treatment facility. Such a system works best in flat or gently rolling terrain because it has limited capabilities to transport wastewater uphill (a maximum of about 20 feet). The pipes of vacuum sewers have relatively small diameters and can be installed at shallow depths.

IDEAL APPLICATION

- Where there is flat or low slope terrain.
- Where shallow construction is preferred.

BENEFITS

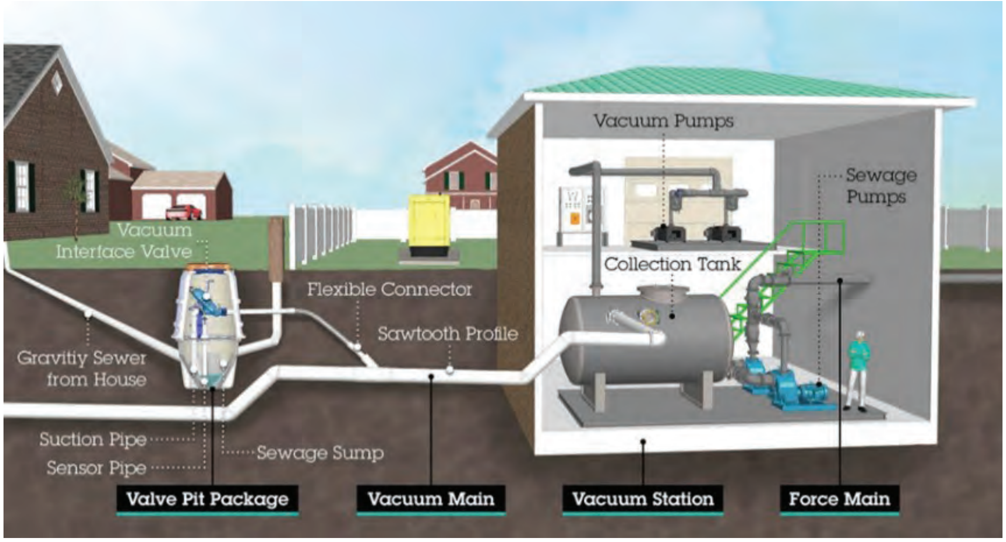
- Smaller diameter pipes compared to conventional gravity sewers.
- Can be installed at a shallow depth.
- Closed system with no exfiltration or odors.

CHALLENGES / RESTRICTIONS

- Economic feasibility depends on the number of homes served by the system (the more the better).
- Requires energy to create the permanent vacuum.
- Vacuum stations require regular maintenance checks, typically higher maintenance than gravity systems.
- Limited application where there are significant changes in elevation.

OPERATIONS AND MAINTENANCE

- Provide/maintain power to each unit and vacuum station.
- Regular pressure/vacuum testing.
- Vacuum stations require regular checks.
- Remove any blockages in pressure pipe network.



Vacuum Sewer System (Airvac® Vacuum Sewer Systems, QSM, 2020).

Appendix F

Decentralized Cluster Wastewater Treatment Technologies

Conventional Activated Sludge

TREATMENT TECHNOLOGY

The term activated sludge refers to biological treatment via suspended-growth, aerobic mixed liquor consisting of flocs of active bacteria. These bacteria consume and remove aerobically biodegradable organic substances from screened or screened and pre-settled raw wastewater.

A conventional activated sludge system consists of an aeration tank, which is used for biological degradation, and a secondary clarifier, where the sludge is separated from the treated wastewater. Screens, de-gritters, and primary settling tanks are often used prior to the aeration tanks to remove large and heavy solids. In the aeration tank, air is transferred to the wastewater to facilitate biological treatment and biodegradation of organics and nutrients. Additional settling and pollutant removal occur in the secondary clarifier prior to disinfection (if needed) and disposal.

IDEAL APPLICATION

- Where a high level of treatment is required.

BENEFITS

- High BOD and nitrogen removal, high effluent quality, self-sustaining system.
- Small land area requirement.
- Free from fly and odor nuisance.
- Can be modified to meet specific discharge limits.
- Available in a modular package plant configuration.

CHALLENGES / RESTRICTIONS

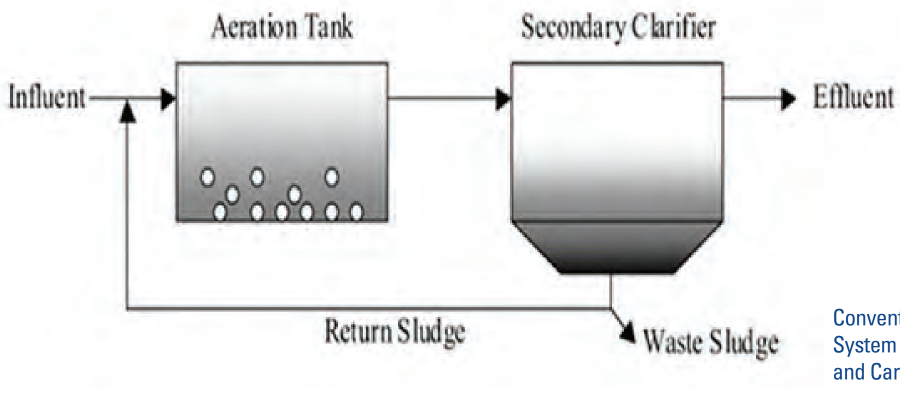
- High electricity consumption.
- Requires skilled operation and maintenance.
- Requires expert design and construction.
- Bulking and biological surface foaming.

OPERATIONS AND MAINTENANCE

- Monitoring of dissolved oxygen, pH, and mixed liquor suspended solids.
- Influent and effluent must be monitored, changing the parameters accordingly.
- Regular cleaning of influent screens.
- Regular sludge wasting and disposal.
- Control of concentrations of sludge and oxygen levels in the aeration tanks.
- Maintenance includes inspecting the aeration system and following manufacturer recommendations for maintenance of all equipment.

EFFLUENT QUALITY

- Produces high quality effluent with low concentrations of BOD and TSS.
- Capability to provide nitrification and denitrification.



Conventional Activated Sludge System (Water Research Foundation and Carollo Engineers, Inc., 2008).

Extended Aeration Activated Sludge

TREATMENT TECHNOLOGY

The term activated sludge refers to biological treatment via suspended-growth, aerobic mixed liquor consisting of flocs of active bacteria. These bacteria consume and remove aerobically biodegradable organic substances from screened or screened and pre-settled raw wastewater.

Extended aeration activated sludge is a variation of the activated process which provides removal of biodegradable organic wastes under aerobic conditions without primary settling and with a longer aeration time, and a longer sludge age. The long aeration time means a larger aeration tank than the conventional activated sludge process. The process has a high BOD removal efficiency and generates less sludge than conventional activated sludge.

In a typical extended aeration package plant, raw wastewater is screened or goes through a grinder to reduce large suspended, settleable, or floating solids. It is then conveyed to the aeration tank where it is mixed with return activated sludge and oxygen is provided to microorganisms. The resulting mixed liquor is settled in the clarifier. Solids are generally allowed to accumulate in the aeration tank for long periods allowing digestion in the same tank and periodic wasting for disposal. If needed, the clarified effluent is then disinfected via chlorine or ultraviolet light.

IDEAL APPLICATION

- Where a high level of treatment is required.

BENEFITS

- Systems consistently provide high quality effluent in terms of TSS, BOD, and ammonia levels.
- Long HRT and complete mixing, minimal impact of a shock load or hydraulic surge.
- Produces less sludge due to extended retention of biological solids in the aeration tank.
- Available in a modular package plant configuration.

CHALLENGES / RESTRICTIONS

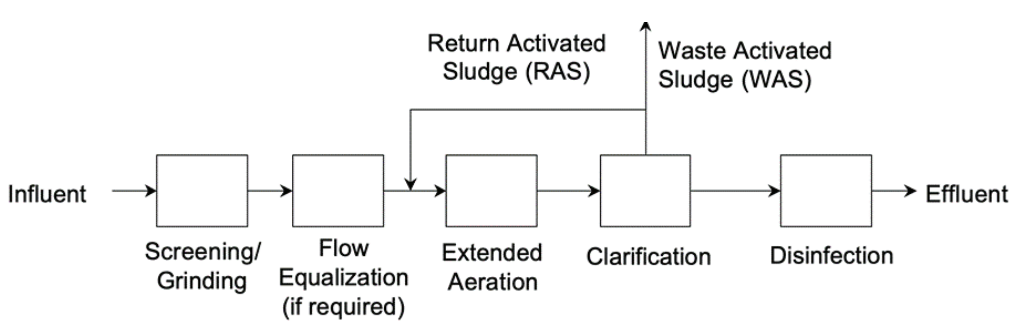
- Higher energy use due to longer aeration time.
- Larger footprint than conventional activated sludge.

OPERATIONS AND MAINTENANCE

- Monitoring of dissolved oxygen, pH, and mixed liquor suspended solids.
- Influent and effluent must be monitored, changing the parameters accordingly.
- Regular cleaning of influent screens.
- Regular sludge wasting and disposal.
- Control of concentrations of sludge and oxygen levels in the aeration tanks.
- Maintenance includes inspecting the aeration system and following manufacturer recommendations for maintenance of all equipment.

EFFLUENT QUALITY

- Produces high quality effluent with low concentrations of BOD, TSS, and ammonia.
- Capability to provide denitrification.



Extended Aeration Activated Sludge System (Water Research Foundation and Carollo, Engineers, Inc., 2008).

Membrane Bioreactor Activated Sludge

TREATMENT TECHNOLOGY

A membrane bioreactor (MBR) is an activated sludge process which uses membrane filtration instead of a secondary clarifier to separate mixed liquor from treated effluent. Fine screening is an essential pre-treatment step to protect the membranes from damaging debris and particles, extend the membrane life, reduce operating costs, and guarantee a higher sludge quality. MBR systems nearly always have an anoxic tank and internal pumping of mixed liquor to facilitate nitrogen removal via denitrification. An MBR is an ideal process for water reuse applications since the membranes provide a barrier to many pathogens. Better effluent quality comes with a higher capital, operation, and energy costs which present a hurdle to implementing MBR systems for cluster systems.

A typical MBR package plant will consist of a preliminary coarse screen, followed by a fine screen, an anoxic tank/zone, an aeration tank with an integral membrane module, a permeate pump to create effluent, and a blower to provide coarse aeration of the membrane cassette and fine bubble aeration for the remainder of the aeration tank. It will usually include an aerobic digester to treat, thicken, and store WAS prior to periodic pump-out and disposal. The package plant may also contain a disinfection system which most commonly would utilize ultraviolet light.

IDEAL APPLICATION

- Where a very high level of treatment is required in a small footprint.

BENEFITS

- Systems consistently provide high quality effluent in terms of TSS, BOD, and ammonia levels.
- Long HRT and complete mixing, minimal impact of a shock load or hydraulic surge.
- Produces less sludge due to extended retention of biological solids in the aeration tank.
- Available in a modular package plant configuration.

CHALLENGES / RESTRICTIONS

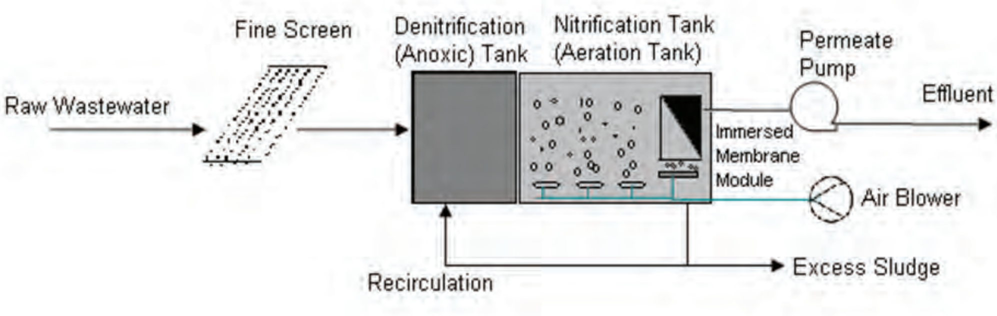
- Higher energy use due to longer aeration time.
- Larger footprint than conventional activated sludge.

OPERATIONS AND MAINTENANCE

- Monitoring of dissolved oxygen, pH, and mixed liquor suspended solids.
- Influent and effluent must be monitored, changing the parameters accordingly.
- Regular cleaning of influent screens.
- Regular sludge wasting and disposal.
- Control of concentrations of sludge and oxygen levels in the aeration tanks.
- Maintenance includes inspecting the aeration system and following manufacturer recommendations for maintenance of all equipment.

EFFLUENT QUALITY

- Produces very high quality effluent with low concentrations of BOD, TSS, and ammonia.
- Capability to provide denitrification.



Membrane Bioreactor Activated Sludge System (Wastewater Engineering Group, 2007).

Attached Growth Bioreactors - Textile Filter

TREATMENT TECHNOLOGY

Like the suspended growth activated sludge processes, attached growth bioreactors take advantage of biological treatment. The biological mass in this case grows as a biofilm on the surface of a media or disk as opposed to suspended flocculated biomass in activated sludge processes. The media should have a large surface area to volume ratio to support the microbial growth and form biofilms. Some versions of the process eliminate secondary clarifiers and associated cost and space requirements.

A textile filter is a variation of an attached growth bioreactor. It is a fixed-bed, biological reactor that operates under (mostly) aerobic conditions. Textile filter systems are available in modular package plant configurations specifically for cluster treatment applications. The system uses fixed spray nozzles and hanging textile media sheets. The sheets are suspended on racks at the top of a tank that is mostly open, and water can accumulate below for recirculation. These systems are designed to treat pre-settled wastewater, most often from a large septic tank.

IDEAL APPLICATION

- Modular package plant that can be used for treating wastewater flows from clusters of homes.

BENEFITS

- Can operate at a range of organic and hydraulic loads.
- Lower energy input than conventional activated sludge.
- Low sludge production.

CHALLENGES / RESTRICTIONS

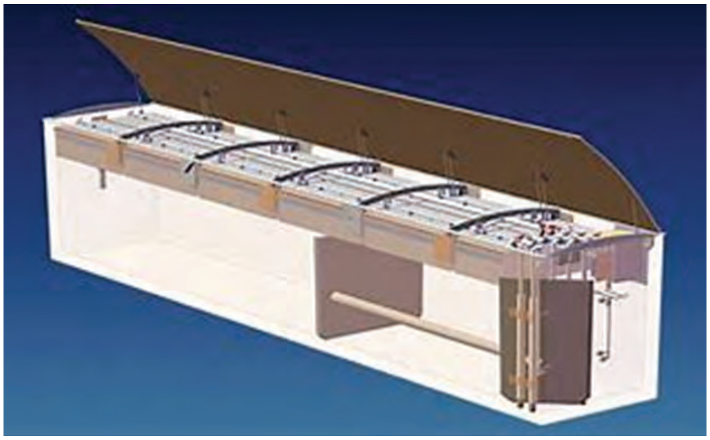
- Requires expert design, construction, operation and maintenance.
- Some variations have larger footprints.
- Risk of clogging, depending on pre and primary treatment.

OPERATIONS AND MAINTENANCE

- Monitoring of influent and effluent.
- Maintenance of all equipment following manufacturer's recommendations.
- Optimum dosing rates and flushing frequency are determined from the field operation.
- The packing should also be kept moist which can be problematic at night or during power failures.
- Regular cleaning of influent screens.
- Regular sludge wasting and disposal.
- The sludge that accumulates on the filter must be periodically washed away to prevent clogging and to keep the biofilm thin and aerobic.

EFFLUENT QUALITY

- Produces high quality effluent with low concentration of BOD and TSS
- Capability to provide nitrification, and nitrogen reduction.



Textile Trickling Filter System (Orenco Systems, Inc.).

Moving Bed Biofilm Reactor

TREATMENT TECHNOLOGY

The moving bed bioreactor (MBBR) process is a combination of activated sludge (suspended growth) and attached growth processes. It uses plastic floating media within an aeration basin which are carriers of attached growth of biofilm. Pre-treated (settled) influent enters the aeration basin for treatment and may enter a second basin for further treatment (full nitrification). Fine-bubble aeration with high oxygen transfer efficiency is commonly used for mixing/suspension. Thousands of small plastic chips, called media or carriers, occupy as much as 50 to 70 percent of the tank volume. In order to keep the carrier media in the tank, there is a strainer attached to the aeration basin effluent pipe. The aeration effluent which contains sloughed biofilm and suspended solids is conveyed either to a secondary settling tank or, more commonly, to a dissolved air flotation separator.

A typical MBBR package plant has a screen, a primary sedimentation tank, one or two MBBR aeration tanks, a blower, a dissolved flotation separator unit, and an aerobic digestion tank to stabilize, thicken, and store the sloughed solids for eventual offsite disposal. If needed, the clarified effluent is then disinfected via chlorine or ultraviolet in a disinfection tank. As with other treatment options, waste sludge requires stabilization and disposal.

IDEAL APPLICATION

- Where a high level of treatment is required in a relatively small footprint.

BENEFITS

- Efficient treatment, low HRT, flexibility to adapt to fluctuating hydraulic and organic loads.
- Low Maintenance.
- Very compact, due to the maximized surface area the media provide for biofilm growth.
- Available in a modular package plant configuration.

CHALLENGES / RESTRICTIONS

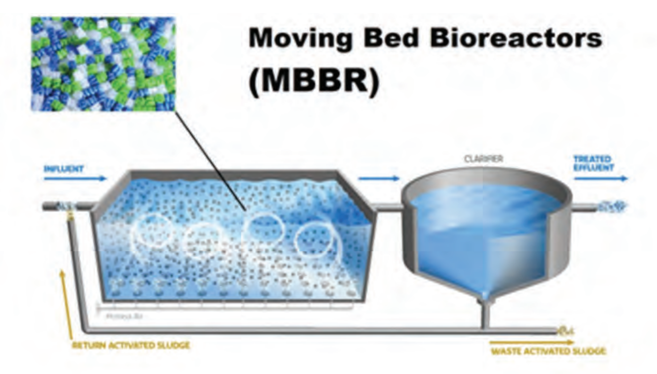
- High-tech system.
- Higher capital and operating costs.
- Carriers can wash out of the system, necessitating supplemental additions.

OPERATIONS AND MAINTENANCE

- Monitoring of influent and effluent.
- Maintenance of all equipment following manufacturer's recommendations.
- Observation of media color and adjustment of air.
- Monitoring and adjustment of dissolved air flotation units.
- Regular cleaning of influent screens.
- Regular sludge wasting and disposal.
- Operators must take samples periodically and analyze them to ensure the bacteria on the carriers are still thriving.

EFFLUENT QUALITY

- Produces high quality effluent with low concentrations of BOD and TSS.
- Capability to provide nitrification and denitrification.



Moving Bed Bioreactor System (Lanyu Gustawater Treatment, 2020).

Constructed Wetland

TREATMENT TECHNOLOGY

Constructed wetlands are a "green" technology designed to re-create the processes that naturally treat wastewater in the environment. Influent wastewater to the wetlands is usually pre-treated using a septic tank or similar process. After pre-treatment, the wastewater flows to a lined earthen basin or cell containing microorganisms, porous media and plants. A perforated pipe runs along the length of the cell just below the plants to evenly distribute the influent. A second pipe runs along the length of the cell to collect the effluent after it travels through the porous media, where it then flows through a distribution box and into a drain field.

IDEAL APPLICATION

- Where a natural treatment system is desired.
- Where there are no significant land area constraints.

BENEFITS

- Simple, easily operated natural system.
- Inexpensive compared to other treatment options.
- Requires little energy when the system operates with gravity flow.

CHALLENGES / RESTRICTIONS

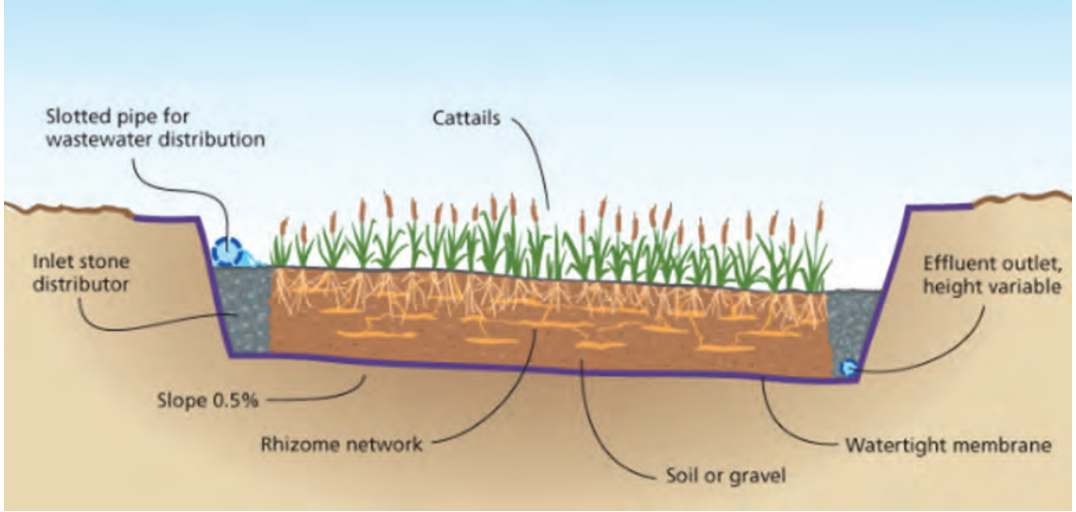
- Large land requirement.
- Not available as a package facility.
- Vector and odor nuisances.
- Requires some level or pre-treatment, usually by use of a septic tank.

OPERATIONS AND MAINTENANCE

- Vector control to prevent population growth of insects and odor control.
- Occasional maintenance of the vegetation promotes growth of desired vegetation and maintains hydraulic capacity.
- Monitoring of influent and effluent.

EFFLUENT QUALITY

- Produces high quality effluent with low concentrations of BOD and TSS.
- Nitrification and denitrification are possible.



Constructed Wetland Treatment System (Grismer and Shepherd, 2011).

Appendix G

Decentralized Cluster Wastewater Disposal Technologies

Absorption Trench / Bed

EFFLUENT DISPOSAL TECHNOLOGY

Absorption systems are a subsurface disposal technology that allows treated effluent to percolate into the soil. These systems are installed with a mild slope to allow effluent to flow by gravity through perforated pipes laid in either a trench or bed. The disposal surface area which on the hydraulic properties of the native soil.

Absorption systems generally range in depth from 1.5 to 3 feet below grade. Trench widths range from 18 to 36 inches, while bed widths are at least 3 feet. The major distinction between the two is that in an absorption bed, the entire disposal area is excavated and backfilled with gravel, whereas absorption trenches have distinct areas of undisturbed soil. Gravelless trench and bed absorption systems utilize plastic dome-shaped segmented chambers buried in the trench/bed with large open spaces instead of perforated pipes surrounded by gravel. Current DOH regulations include detailed guidance for the design of these systems.

IDEAL APPLICATION

- Soil percolation rate is less than 60 min/in.
- Installation location is greater than 50 feet from inland or coastal waters.
- Maximum ground slope is 8 percent for absorption beds, and 12 percent for absorption trenches.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps.
- Cannot be used if groundwater is too close to the surface, minimum vertical separation of three feet from the bottom of the trench/bed.

Gravelless Absorption Bed Disposal System.

BENEFITS

- Common type of disposal system so there are many products available and experience with installation.
- No power is required, and maintenance is generally not necessary.
- Gravelless dome systems require less gravel backfill and provide significant additional water storage volume.

CHALLENGES / RESTRICTIONS

- Large land requirement.
- Overloading, rainfall, or unsuitable soils may cause contaminants to spill out into the surroundings.
- Root intrusion can adversely impact performance.

OPERATIONS AND MAINTENANCE

- Normally none. Some systems use a dosing pump - if present, it must be checked and cleaned.
- Observation ports can be installed within the disposal area to check whether the water is percolating into the ground as expected.

EFFLUENT QUALITY

- Provides some additional treatment for BOD, TSS, nutrients, and fecal coliform.

High Pressure Drip

EFFLUENT DISPOSAL TECHNOLOGY

Drip disposal systems (also called drip irrigation systems) are a disposal technology that uses a network of pipes containing emitters commonly spaced 12 inches apart and installed in excavations like but shallower than absorption beds. Rather than working by gravity, these systems receive treated effluent in pumped doses from a dosing tank, which allows for controlled loading rates to the shallow root zone of the surrounding soil. While some of the treated wastewater percolates into the soil, drip disposal systems act partially as an evapotranspiration system since some of the effluent is taken up by the plants at the ground surface.

IDEAL APPLICATION

- Installation location is greater than 50 feet from inland or coastal waters.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps.
- Groundwater table depth is greater than 3 feet below the drip system.

BENEFITS

- Reliable alternative for areas with low permeability, seasonal high-water tables, or severe slopes.
- Ability to control dose/rest cycles allows for even spacing or dosing of effluent. This facilitates wastewater infiltration by spreading it spatially and over time.
- Significant evapotranspiration is possible.

CHALLENGES / RESTRICTIONS

- Large dose tank may be needed to accommodate timed dose delivery to the drip absorption area.
- Power is required to run pumps, sensors, and controls. Some minimal regular maintenance is required.
- Clogging of emitters can occur.

OPERATIONS AND MAINTENANCE

- Provide continuous electricity to small dosing pumps.
- Typical inspections may include observing and reporting of the general condition of the system, water level in tanks, ponding around the system, clogging at pumps and filters, pump cycles, and readings of any meters.
- Regular monitoring and maintenance of pump, filter and piping shall be performed.

EFFLUENT QUALITY

- Provides some additional treatment of BOD, TSS, nutrients, and fecal coliform.

High-Pressure Drip Disposal System.

Low Pressure Pipe

EFFLUENT DISPOSAL TECHNOLOGY

A low pressure pipe disposal system is a shallow, pressure-dosed soil absorption system that includes a network of small diameter perforated pipes placed in narrow trenches or beds. Pressure distribution is used to uniformly feed the pipes. Lower pressure is used because the pipes have orifices rather than emitters associated with high pressure systems. Alternating the dosing and resting cycles helps improve disposal efficiency and promote aeration. Low pressure systems can be either time-dosed or demand-dosed.

The main components of a low pressure pipe disposal system include:

- Submersible effluent pump in a pumping (dosing) chamber with a high-water alarm, level controls and a supply manifold.
- Small diameter perforated distribution laterals.
- Drain field media (gravel or sand).

IDEAL APPLICATION

- Areas with low permeability, seasonal high-water tables, or severe slopes.
- Groundwater table is greater than 3 feet below the disposal system.

BENEFITS

- Reliable alternative for areas with low permeability, seasonal high-water tables, and/or severe slopes.
- Shallow and narrow trenches reduce site disturbance and land area requirement.
- Ability to control dose/rest cycles allows for even spacing or dosing of effluent. This facilitates wastewater infiltration by spreading it spatially and over time.

CHALLENGES / RESTRICTIONS

- Limited storage capacity around laterals.
- Possibility of wastewater accumulation in the trenches.
- Potential for clogging and infiltration problems.

OPERATIONS AND MAINTENANCE

- Monitoring ponding at the bottom of trenches, readjusting operating pressure, and reducing flow to overloaded trenches.
- Flushing manifold and lateral lines periodically.

EFFLUENT QUALITY

- Provides some additional treatment of BOD, TSS, nutrients, and fecal coliform.

Low Pressure Pipe Disposal System Demonstration (North Carolina State University).

Seepage Pit

EFFLUENT DISPOSAL TECHNOLOGY

A seepage pit is constructed the same as a cesspool, but it receives treated wastewater. These systems are generally constructed from reinforced concrete rings, with a diameter of 8 or 10 feet and a height of 2 feet, that are stacked in order to achieve the depth required (usually 15-30 feet) to meet percolation requirements. Each ring has large openings in the sides. A concrete lid with a 12-inch inspection port is placed on top. Water percolates out from the sides and the bottom of the unit into the surrounding soil. The effective percolation area is measured as the pit sidewall area. These systems are unlikely to be approved by DOH.

IDEAL APPLICATION

- Soil percolation rate is less than 60min/in.
- Installation location is greater than 50 feet from inland or coastal waters.
- Maximum ground slope is 12 percent and an absorption system is not feasible.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps.
- Groundwater table depth is greater than 3 feet from the bottom of the seepage pit.

BENEFITS

- Seepage pits are the simplest and most compact method to percolate water into the ground.
- They are possible options when the available land area is insufficient for absorption beds or trenches, the terrain is steep, or when an impermeable layer overlies more suitable soil.
- These units can be maintained (accumulated solids from poorly functioning upstream treatment units can be accessed and pumped out) unlike absorption trenches/beds.

CHALLENGES / RESTRICTIONS

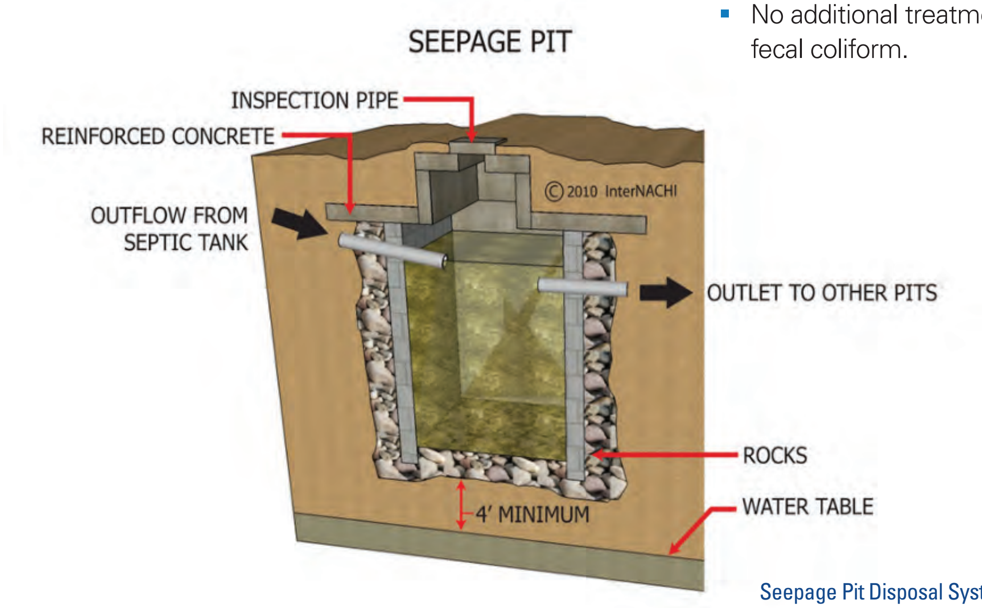
- Unlikely to be approved by DOH.

OPERATIONS AND MAINTENANCE

- Proper functioning of a seepage pit relies heavily on maintenance of the upstream treatment process. This prevents clogging of the seepage pit. Otherwise, periodic pumping of any accumulated sludge will be required.

EFFLUENT QUALITY

- No additional treatment of BOD, TSS, nutrients, or fecal coliform.



Seepage Pit Disposal System (InterNACHI, 2020).

Water Reuse

EFFLUENT DISPOSAL TECHNOLOGY

If an effluent from a treatment system meets criteria set by the DOH, then the recycled water can be utilized in landscaping, agricultural irrigation, and even toilet flushing.

The highest quality of recycled water defined by DOH is R-1 and is the only level of recycled water that can be used above the underground injection control (UIC) line. The requirements for R-1 water include tertiary filtration, daily monitoring for fecal bacteria, continuous turbidity monitoring, automatic diversion of off-spec water, 100 percent back-up disposal, and a reuse site with an approved management plan, signage, and a named responsible manager. The requirements for R-2 recycled water are less stringent, making recycling of effluent less difficult. However, the acceptable uses of R-2 water are also more limited (generally subsurface use only to prevent human contact). Also, a reuse site is still required as well as an approved management plan/manager.

Systems should be designed such that there are no crossings of recycled water lines and potable water lines. Clear markings should be used to identify recycled water pipelines. Strict and specific monitoring and record keeping are required, depending on the level of effluent quality and the method of application of the recycled water.

IDEAL APPLICATION

- Where appropriate, reliable reuse sites are near the wastewater treatment facility.
- Where the appropriate level of treatment is provided.

BENEFITS

- Helps reduce overall demand on potable water supply.

Water Reuse as an Emerging Solution.

CHALLENGES / RESTRICTIONS

- Often more expensive treatment is required to reach water quality requirements.
- Strict rules and regulations to prevent potential environmental or health consequences.

OPERATIONS AND MAINTENANCE

- Extensive monitoring at the treatment facility is required.
- A water reuse plan is required for the reuse site, with monitoring and reporting. Signage is required at the site.

EFFLUENT QUALITY

- Effluent limits and monitoring requirements are regulated by DOH.

Evapotranspiration

EFFLUENT DISPOSAL TECHNOLOGY

Evapotranspiration is a disposal technology that combines direct evaporation and plant transpiration. Treated effluent is conveyed to a porous bed containing water-tolerant plants. Wicking, or capillary action, draws water to the surface, where it is either taken up by the plants and transpired, or evaporated from the surface. Effluent that is not transpired or evaporated will percolate from the bottom of the bed. This type of system is known as evapotranspiration-infiltration.

These systems can also be designed with an underlying impermeable liner for a "zero-discharge" system. In this case, disposal is strictly dependent on evaporation and plant transpiration. Additionally, the liner allows the system to be placed above an Underground Injection Control (UIC) line or where there is shallow groundwater or proximate surface water such as a stream, lake or the ocean. Other components that are typically included are drip or distribution lines, flushing or filtering mechanism, controller to automate dosing cycles, distribution pump, and alternating evapotranspiration beds.

IDEAL APPLICATION

- Where zero discharge is desirable and there is adequate land area.
- Installation location is greater than 50 feet from inland or coastal waters.
- Maximum ground slope is 12 percent.
- Cannot be installed within the 100-year flood zones as defined by flood insurance rate maps.

BENEFITS

- If an impermeable liner is included for a "zero-discharge" system, then 100 percent nitrogen removal is achieved.

CHALLENGES / RESTRICTIONS

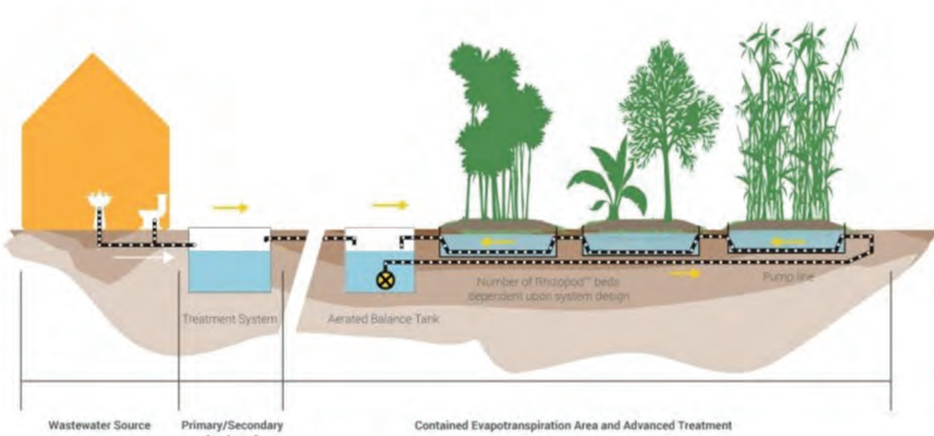
- Large surface areas are needed for year-round disposal. The size is controlled by a water balance based on rainfall and pan evaporation rates.
- These systems are more effective in arid climates where evaporation rates are much higher than precipitation rates.
- Recordkeeping of lysimeter (soil pore water sampler) data is required to ensure proper functioning.

OPERATIONS AND MAINTENANCE

- O&M tasks will include simple inspection of observation wells, electrical costs for pumping, as needed, minor landscaping, and maintaining upstream processes to avoid overflow of solids into the evapotranspiration bed.

EFFLUENT QUALITY

- Provides some additional treatment of BOD, TSS, nutrients, and fecal coliform.



Evapotranspiration Disposal System.

Injection Well

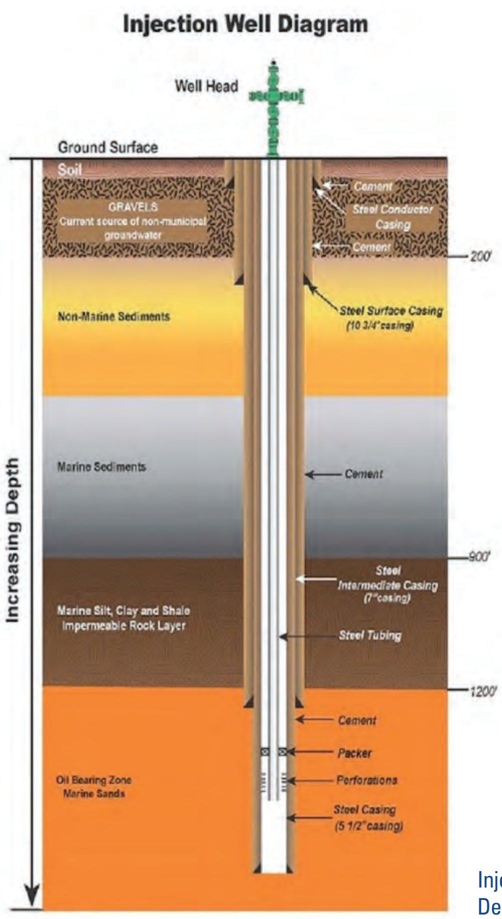
EFFLUENT DISPOSAL TECHNOLOGY

In this system, subsurface disposal of wastewater occurs by injection via a well (Hawai'i Administrative Rules 11-23). The current regulations are designed to prohibit the contamination of US drinking waters. Wastewater cannot be injected into current sources or potential future sources of drinking water. Injection can only occur into "exempted" aquifers which are already highly contaminated or have total dissolved solids (TDS) greater than 5,000 mg/L, making them brackish. In Hawai'i, there is an underground injection control (UIC) line, which is a boundary for each island which designates brackish groundwater near the coast. Makai of the UIC line, wastewater injection could potentially be granted a UIC permit. These types of permits are difficult to obtain and contain restrictions on flow, numerical contaminant limitations, and monitoring and reporting requirements.

For some cesspool replacement areas close to the coast, where decentralized cluster systems could be viable, an injection well could be considered as a possible disposal alternative. However, the DOH would generally consider it to be a "last resort" type option only applicable if other options are not viable. Currently, due to the 2019 Supreme Court ruling on the Maui County injection wells at the Lahaina WWTP, it is unlikely that any new UIC permits for wastewater will be issued in the foreseeable future.

IDEAL APPLICATION

- In areas of brackish groundwater and a permit is feasible.



Injection Well Diagram (California Department of Conservation).

BENEFITS

- Very simple system.
- Little to no maintenance required.

CHALLENGES / RESTRICTIONS

- Limited applicable locations/siting.
- Very difficult, if not impossible, to obtain a permit.

OPERATIONS AND MAINTENANCE

- Sampling and reporting requirements are extensive.

EFFLUENT QUALITY

- Discharge limits would be regulated by DOH.

Surface Water Discharge

EFFLUENT DISPOSAL TECHNOLOGY

Discharge of treated wastewater to surface water requires a National Pollution Discharge Elimination System (NPDES) permit. Permit requirements are found in Hawai'i Administrative Rules 11-62 Wastewater Systems and in the EPA's Clean Water Act. Obtaining a new NPDES permit for wastewater discharges in Hawai'i is generally avoided due to cost, complexity, monitoring requirements, 5-year duration/renewal requirements, etc.

For decentralized cluster systems near a stream or inland lake, a surface discharge permit is technically an option, and these permits are handled by the Hawai'i Department of Health (DOH). However, similar to an injection well, the DOH would generally consider it to be a "last resort" type option only applicable if other options are not viable. In addition, there are very few permitted discharges to inland lakes and streams and high levels of treatment are generally required.

IDEAL APPLICATION

- Following a high level of treatment where the treatment facility is near a stream or inland lake.
- Where an NPDES permit can be secured.

BENEFITS

- Simple system.
- Effectively recycles water back into the environment.
- Can augment stream flow.

CHALLENGES / RESTRICTIONS

- Potential negative impacts on natural bodies of water or drinking water.
- NPDES permit required. Expensive monitoring and reporting required.
- Very difficult to obtain a permit.
- Very limited applicable locations/siting.

OPERATIONS AND MAINTENANCE

- Sampling and reporting requirements are extensive.

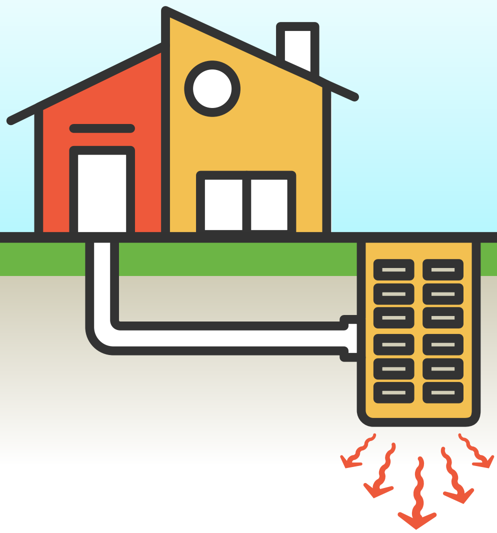
EFFLUENT QUALITY

- Effluent limits are included in NPDES permits and regulated by DOH.

Surface Water Discharge (IECE).

Appendix H

Example Homeowner's Information Packet



RULES ARE CHANGING FOR YOUR

HOME CESSPOOL

CESSPOOLS NEED TO GO!

Cesspools are underground wells used to dispose of household wastewater into the groundwater table. In 2017, the Hawaii State Legislature passed Act 125 requiring the replacement of all cesspools by 2050 to prevent environmental contamination. Cesspools pose a high risk to drinking water sources and coastal ecosystems. Even if you don't plan on being in your house in 2050, having a cesspool will negatively effect the resale value of your home.

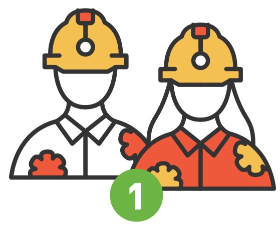
HOW DO I KNOW IF I HAVE A CESSPOOL?

You probably **don't** have a cesspool if:

- You pay a sewer bill or sewer charge on your water bill.
- Your home was built recently.
- An alternative wastewater system other than a cesspool is shown at your residence on the "OSDS" map found here: **geoportal.hawaii.gov**

Inquire with the Department of Health if you're unsure of whether or not you have a cesspool!

OK, SO HOW DO I FIX IT?



Hire a licensed civil engineer to help you make a plan

Submit your plan to the Department of Health for approval

Hire a licensed contractor to build new system

Engineer submits inspection report for approval

CAN I AFFORD THIS?

Check out our local financing options.

Typical replacement costs range from $9,000 to more than $60,000. For current financing opportunities, contact the Department of Health or visit their website listed below.

State or County Support
(if available)

Home Refinancing

Federal Grants and Loans
(if available)

For additional information contact the Department of Health at 808-586-4294 or visit their website at **health.hawaii.gov/wastewater**

CESSPOOL ALTERNATIVES

Different locations will require different levels of treatment! Follow this guide for an idea of what system you may need and then get in touch with a local engineer for a personalized estimate as prices may vary.

Is your property near an existing sewer system?

Recommendation: A

Is your property small[1], sloped[2], upcountry[3], in a floodzone, or near a body of water[4]?

Recommendation: B + C + D

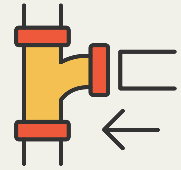
None of the above?

Recommendation: B + D

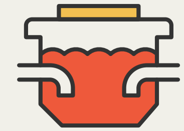
1 *Less than 10,000 sf*
2 *Slope greater than 8%*
3 *Mauka of the UIC line (a boundary protecting drinking water aquifers)*
4 *Within 1,000 ft of a drinking water source, 50 ft of a waterbody, or 3 ft of water table*

SEWER CONNECTION OR BASIC TREATMENT

Every property will need to either connect to an existing sewer system or install a septic tank to treat wastewater onsite! Septic tanks need annual maintenance while a sewer connection means you'll get a monthly sewer bill!



OR



A Existing Sewer System

This is the lowest maintenance option but there is a connection fee and a monthly sewer bill!

B Septic Tank

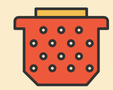
This tank settles out and breaks down solids, which then need to be pumped out every few years by a licensed contractor.

C ADDITIONAL TREATMENT

Homes using onsite treatment near a vulnerable water resource need additional treatment with their septic tank to reduce the amount of nutrients discharged into the environment.

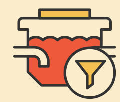
Alternative Toilets
These waterless toilets don't produce wastewater! The septic tank handles the rest of the water from your house.

OR



Aerobic Treatment
In this case, the septic tank is smaller and an aerated zone is added for additional treatment.

OR

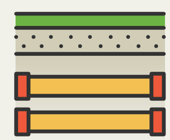


Biofilter
A media like sand or gravel is used to polish the water leaving your septic tank.

D DISPOSAL

Treated water needs to be fed back into the ground.

OR



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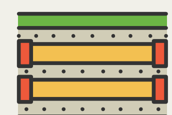
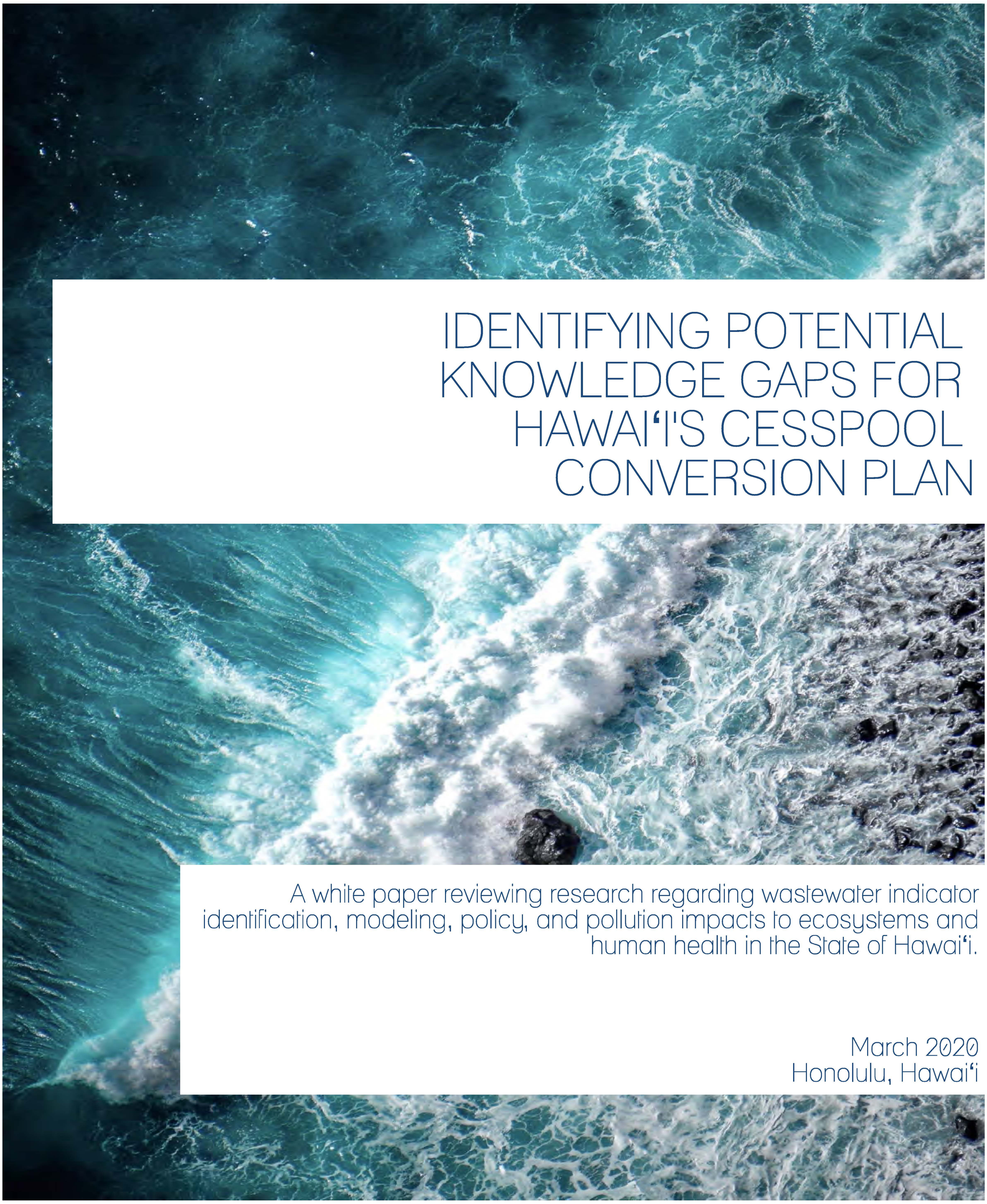


Seepage Pit
Converting your cesspool into a seepage pit is the cheapest option but it's not always allowed.

Absorption Field
Tubes with tiny holes spread wastewater out underground so it can filter through the soil.

Evapotranspiration
This option is the same as the absorption field except it's shallow so the water feeds your plants then evaporates.

Appendix C. Identifying Potential Knowledge Gaps for Hawai'i's Cesspool Conversion Plan.



IDENTIFYING POTENTIAL KNOWLEDGE GAPS FOR HAWAI‘I'S CESSPOOL CONVERSION PLAN

A white paper reviewing research regarding wastewater indicator identification, modeling, policy, and pollution impacts to ecosystems and human health in the State of Hawai‘i.

March 2020
Honolulu, Hawai‘i

University of Hawai‘i
Water Resources Research Center Hawai‘i
Sea Grant University of Hawai‘i

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Michael Mezzacapo

March 2020

SPECIAL REPORT WRRC-SR-2020-03
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Principal Investigator: Darren T. Lerner, Ph.D.

WATER RESOURCES RESEARCH CENTER
HAWAIʻI SEA GRANT COLLEGE PROGRAM
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Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the Water Resources Research Center or the University of Hawaiʻi Sea Grant College Program.

Acronyms/Abbreviations

AOC	Area of Concern
ARB	Antibiotic-resistant bacteria
ARG	Antibiotic-resistant genes
AS	Artificial sweetener
BUI	Beneficial Use Impairment
CCWG	Cesspool Conversion Working Group
CEC	Contaminants of emerging concern
DON	Dissolved organic nitrogen
DIN	Dissolved inorganic nitrogen
fDOM	Fluorescent dissolved organic matter
FIB	Fecal indicator bacteria
INVEST	Integrated Valuation of Ecosystem Services and Tradeoffs
MCL	Maximum contaminate levels
MRSA	Methicillin-resistant *Staphylococcus aureus*
NRCS	United States Department of Agriculture, Natural Resources Conservation Service
OWTS	Onsite wastewater treatment systems
PCP	Personal care products
N	Nitrogen
NDR	Nutrient Delivery Ratio
NOAA	National Oceanic and Atmospheric Administration
P	Phosphorus
RAM	Robust Analytical Model
RAP	Remedial Action Plan
SDM	Structured decision-making
SGD	Submarine groundwater discharge
SWAT	Soil and Water Assessment Tool
UH	University of Hawai‘i
USEPA	United States Environmental Protection Agency

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Introduction

Authorization and goals

This white paper was requested by the Cesspool Conversion Working Group (CCWG) under the authorization of Act 132, passed by the Twenty-Ninth Hawaiʻi State Legislature. Section two, objective three, of Act 132 which tasks the CCWG with identifying areas "where data is insufficient to determine a priority classification of cesspools for conversion and determine methods and resources needed to collect that data and conduct analysis of those areas" (Hawaiʻi Senate Bill 2567, p.2). The goal of this white paper is to provide the CCWG with a resource to evaluate current and past research, evidence, and information relating to the impacts of cesspool and wastewater pollution, as well as highlight any knowledge gaps for future study. It is beyond the scope of the white paper and proposal for the author to recommend specific actions for prioritization, rather the information is provided to inform members about available data to construct a prioritization and upgrade scheme. The author has surveyed, summarized, and analyzed academic research, theses, and relevant published works relating to wastewater indicator identification, policy, modeling, human health, and potential impacts to ecosystems in Hawaiʻi. In addition to reviewing research, many scientists and experts were consulted and interviewed to provide technical feedback on their subject matter and assist with distillation of scientific concepts. The scope of the white paper is limited to the main Hawaiian Islands and will not address research or case studies from other islands in the Pacific region.

Analysis and scope

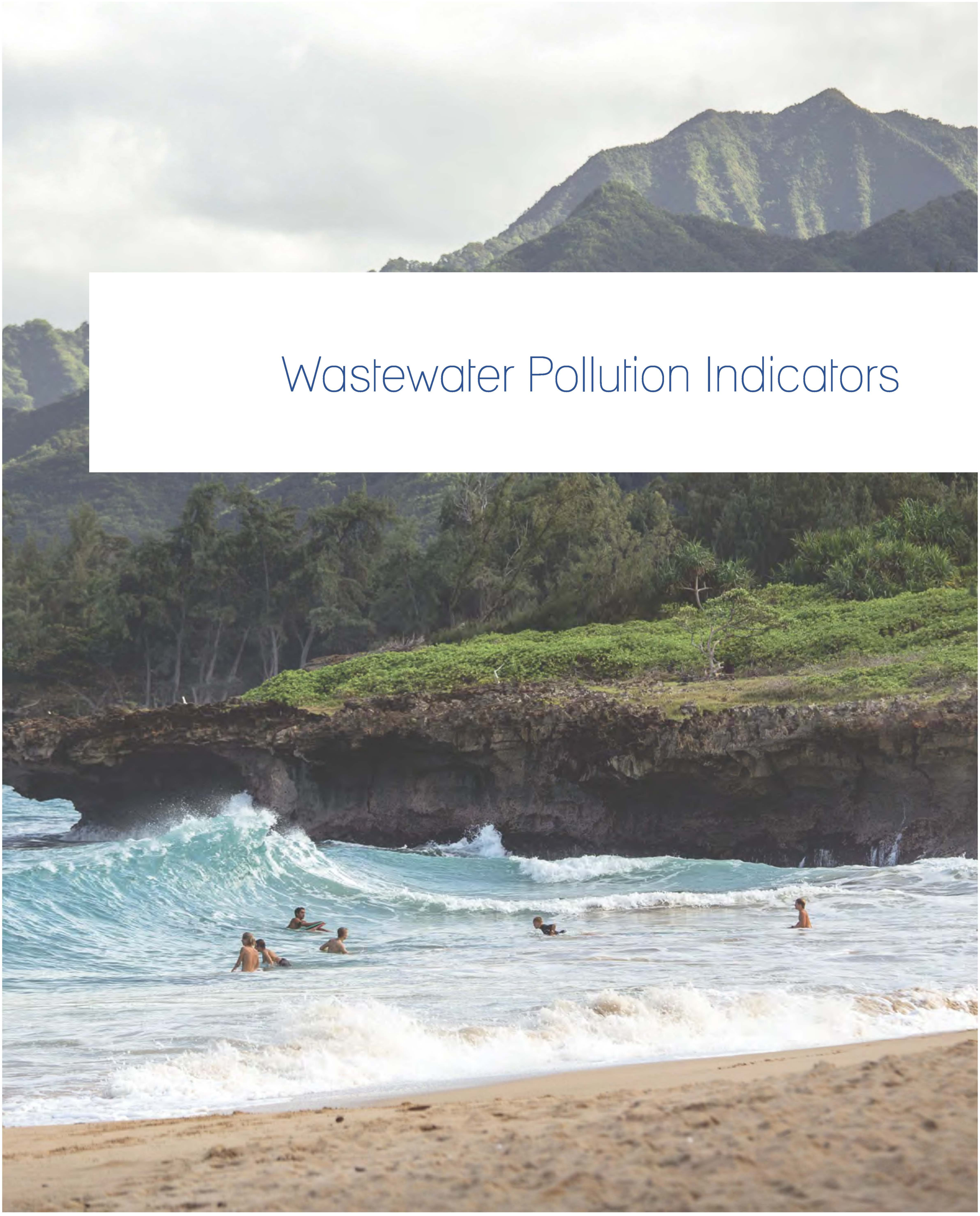
The analysis and science translation portion of this report is divided into four topics: *Wastewater Pollution Indicators; Ocean/Coastal/Groundwater Impairment and Human Health Concerns; Water Resource Modeling/Monitoring/Risk Analysis; and Policy and Community Engagement*. Before each section are key concepts and identified knowledge gaps on the preceding topic. Onsite wastewater technology is not evaluated in this white paper. Carollo Engineers was awarded a contract by the Hawaiʻi Department of Health (DOH) to investigate onsite wastewater treatment system (OWTS) technology options for upgrading cesspools. The evaluation will create a technology matrix to describe the benefits and challenges of implementing various OWTS technology, including operations and maintenance considerations, life-cycle, installation cost, availability, and level of treatment provided. The Carollo report will also consider site constraints and Hawaiʻi's unique geology and topography, such as the occurrence of a high-water table, variations in soil permeability, slope of terrain, and proximity to flood zones and other water resources.

Methods

Searches were performed using Google Scholar, PubMed, Science Direct, Web of Science and Google. Results included academic studies, scholarly publications, general journal articles, theses, websites, and reports using the keywords such as: cesspool; Hawaiʻi; wastewater; nutrient pollution; bacterial pollution; water quality; septic pollution; algae; pathogens; micropollutants; tracer injections; contaminants of emerging concern and wastewater management. One hundred and twenty-four primary documents were discovered. The conclusion section in this report summarizes strategies the CCWG may wish to pursue and challenges that surfaced within the topics researched. Every attempt has been made to accurately summarize and represent the materials reviewed. Chapters have been reviewed by subject experts where appropriate. Finally, a reference list is provided in in Appendix I to inform the reader of available sources relating to wastewater pollution research in Hawaiʻi.

Summary

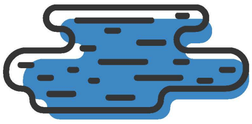
Assembling a comprehensive list of research studies regarding wastewater pollution and associated impacts has identified a significant body of work and data within Hawaiʻi. Many of the studies within this white paper provide valid scientific evidence to support the creation of a long-range cesspool conversion plan. There are gaps that exist in certain topics, including hydraulic and hydrologic modeling, and methods with limitations, including identifying specific wastewater sources. However, many of these limitations can be overcome. For example, limitations in identifying specific sources from wastewater indicators using % N and $\delta^{15}N$ can be overcome with the assistance of available land-use information and potential pollution sources to clarify the isotopic data. Resource management presents many challenges, especially in areas that include competing views and values. To overcome discrepancies in available data, and varying societal values, the use of a transparent and adaptable frameworks can be a key approach for problem solving. A holistic OWTS management approach that addresses scientific and social needs is the ideal solution to overcoming any identified hurdles.



Wastewater Pollution Indicators

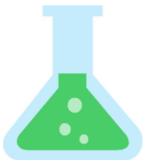
How can we measure if wastewater pollution is entering the environment, and where is it coming from?

5 Key Concepts

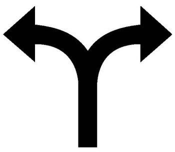


Regarding Water Pollution Indicators

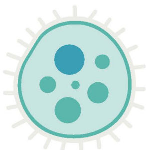
Many of the wastewater indicators identified have limitations and are best combined with a suite of other indicators to evaluate pollution sources. Pollution scoring tools have been developed that combine evidence from multiple pollution tracers.



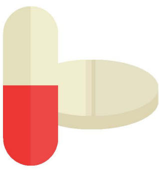
Several studies used nitrogen isotope values ($\delta^{15}N$) and % N algal tissue analysis to map locations and potential sources of nutrients, such as cesspools. $\delta^{15}N$ values and % N in algal tissues are a good, initial screening method, for source pollution investigation. However, isotope values and % N values may possibly result from a combination of multiple nitrogen sources, depending on the features of each field site.



Wastewater derived pollution has multiple pathways to enter the ocean, including surface water and submarine groundwater discharge (SGD). Researchers can track the pathways and discharge points of wastewater derived contaminants into the ocean.



Bacterial community studies can complement microbial source tracking studies, assist with tracking environmental impacts, and may be useful for long-term monitoring programs concerned with the change (climate, land-use, etc.) and degradation of our environment.



Preliminary studies have discovered compounds such as carbamazepine, caffeine, ibuprofen, sulfamethoxazole, and ethynylestradiol in streams and coastal waters of Hawaiʻi, which are likely entering the waters from cesspools. The advantage of using these tracers is their uniqueness to wastewater. To date, there are no publications showing their application or ability to distinguish between municipal injection well or cesspool sources, however, research is underway.

7

Knowledge Gaps

Regarding Water Pollution Indicators

Epidemiological studies are needed to determine where certain pathogens, such as *Staphylococcus aureus* are entering the water from wastewater sources and if they are causing health issues to recreational water users or drinking water.

Large scale state-wide sampling of multiple indicators may help inform a decision-making framework process and improve existing model accuracy. Future studies should include long-term sampling to capture temporal patterns of sewage pollution as well as capture patterns as N-loading diminishes in regions where cesspool conversions have taken place.

Ecosystem level impacts of wastewater pollution are difficult to quantify and predict, especially in the face of global threats like rising temperatures and ocean acidification, but benthic communities of plants and sessile invertebrates have already shown change.

More studies are needed to elaborate on relationships between water-borne nutrients and % N in algal tissues. There is abundant information on the measurements of stable isotopes of nitrate in water. However, the use of mixing models may be helpful to examine specific contributions of different nitrogen sources to coastal waters and works well at large scales

More human health risk assessment studies are critically needed to understand if there is appreciable risk to human health from potential pharmaceutical exposure and the long-term effects of consuming low-levels of certain anthropogenic compounds

Methods that investigate the applicability of $\delta^{15}N$ in other forms of nitrogen, such as ammonium and dissolved organic nitrogen, along with isotopes of other biogeochemically important elements should be tested for use in Hawaiʻi as wastewater indicators. These could be done in water and dissolved or on particulate organic matter, rather than marine plants which may not acquire these isotopes without fractionation.

Little is known about natural background bacteria levels such as *Enterococcus* in tropical soils and waters, or their transport dynamics in wet tropical regions where recreational water use occurs year-round.

Non-point pollution is difficult to trace

Drawing a linear connection to explicit non-point pollution sources and ecosystem degradation is extremely difficult. Non-point pollution remains the greatest source of water quality declines across the United States (Lewis, 1999). The Clean Water Act of 1972 addresses point source and non-point source pollution, however, mandatory federal regulations only exist for point-source pollution (Brown and Froemke, 2012). Hawaiʻi's cesspools (generally regarded as a non-point pollution source), on average, release an estimated fifty-five million gallons of human waste into the ground each day (Hawaiʻi Department of Health, 2016). Upgrading cesspools are a tangible first step to reduce the many sources of nutrients getting to the coast from human development (Yoshioka et al., 2016). Understanding how to best measure where non-point pollution originates, both human and environmental, is difficult. Researchers have developed and tested various indicators that can be used to track pollution sources. Many of the indicators identified in the next several sections have some limitations. To have the most accurate representation of pollution sources, it is best to combine a suite of pollution indicators. Such an effort was made by Abaya et al. (2018b), using dye tracer studies, sewage indicator bacteria measurements, nitrogen isotopes in macroalgae, and a unique pollution scoring tool. However, it can be difficult to quantify many of the processes occurring in the subsurface such as biological and chemical degradation rates, mixing of various sources (e.g., cesspools and wastewater effluent injection), dispersion, and groundwater flow lines, making it challenging to have complete certainty when identifying the exact location and magnitude of pollution sources. Yet, this does not mean that the current science and identified indicators should not be used for decision-making or resource management. By properly analyzing the merits of the research and its limitations, a comprehensive process can be developed by combining the best site-specific or regional indicators, alongside other data, to thoroughly examine and measure the presence of pollution and its impacts on humans and the ecosystem.

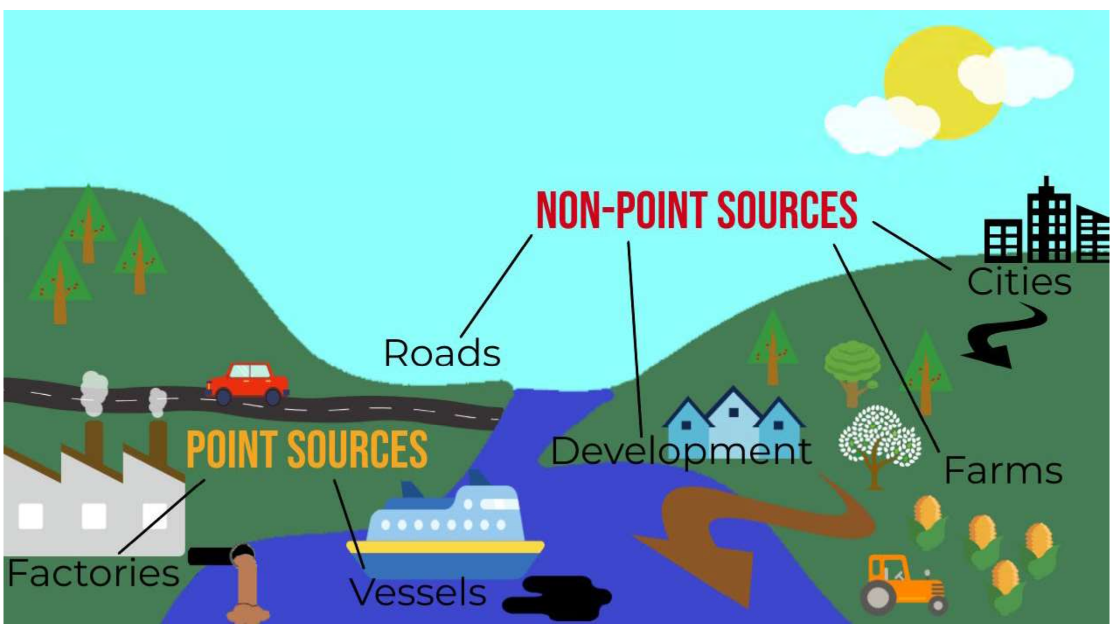


Figure 1. Examples of various origins of point and non-point pollution. Source: Michael Mezzacapo.

What are some recognized indicators available to detect wastewater pollution?

Chemical Indicators

The primary signs of wastewater influx into the coastal ocean are excess nutrient levels, usually nitrogen and phosphorus. The signs of eutrophication (excess nutrients) in these waters, however, may not be obvious if dilution, coastal currents, or nutrient uptake are significant, such as in the waters around Hawaiʻi (C. Smith, personal communication, December 20, 2019). Other areas in the continental United States facing significant nutrient pollution from OWTS, such as Suffolk County in the State of New York, have already experienced aquatic ecosystem impacts from eutrophication, including harmful algal blooms and the reduction of native seagrasses (government of Suffolk County, New York, 2015). Many of these impacts have negative consequences to ecosystems, economies, infrastructure, or human health, which have spurred regulatory actions.

Humans have different ways of responding to environmental changes (National Research Council, 1992). Changes that a direct, visual, or highly impactful to our behaviors are often the most noticed. With the advancement of scientific knowledge and our understanding of our influence on the environment, there is now a rational basis for acting to prevent such degradation (National Research Council, 1992). In the case of Hawaiʻi's OWTS challenges, policymakers and stakeholders face two options. The first option is one that involves anticipatory action, which addresses the nutrient loading problem before severe consequences are noticed, such as algal blooms or coral die-off. The second is delayed action, which depends on resource users awaiting the experience of environmental change or degradation in order to justify actions taken. The latter methodology may carry higher risks to ecosystems and economies reliant on such resources.

In an effort to understand sources of nutrient pollution, the use of nitrate stable isotopes ($\delta^{15}N$) was developed as a wastewater tracer and is well established within the scientific community (Valiela et al., 1997; Kendal et al., 2015; Cole et al., 2004; Wiegner, 2016). Isotopes are variants of chemical elements with the same number of protons and electrons, but different number of neutrons, which vary its mass. Nitrate stable isotopes have been used since the 1970's to identify nitrate sources (Yang et al., 2019). The $\delta^{15}N$ of nitrate in coastal water has been used as a wastewater indicator in numerous studies in Hawaiʻi and provides evidence of wastewater pollution. Many of these studies were carefully timed to capture the strongest submarine groundwater discharge (SGD) signature, which is understood to deliver nutrients from land-based sources (Richardson et al., 2016; H. Dulai, personal communication, November 18, 2019; Wiegner et al., 2016). However, because SGD varies over tidal cycles and daily and seasonal time scales, it is often more useful to get an integrated nitrate isotope signature via sampling of certain coastal organisms (such as algae), which efficiently capture nitrogen, to more accurately assess wastewater pollution.

Although phosphorus is an essential factor in plant growth and another nutrient in wastewater pollution, there are no phosphorus isotope signatures (phosphorus is mono-isotopic and only the oxygen isotopes in phosphate can be used as tracers) available for use as a wastewater tracer (Paytan and McLaughlin, 2011). However, Brown (2019) documented increased community diversity of the types of cyanobacteria, which bloom when there is excess phosphorus, in wastewater plumes off the western shores of Maui.

Using phosphate in combination with other wastewater indicators may prove to be a useful linkage in a system to detect wastewater pollution and cyanobacterial blooms (C. Smith, personal communication, January 24, 2020).

Several studies identified for this white paper focused on using $\delta^{15}N$ values in algal tissue to map locations and potential sources of nutrients. Dailer et al. (2010), identified certain macroalgae in Hawai‘i to be suitable as an indicator of human sources of nitrogen due to the algae’s ability to acquire high nutrient amounts. The macroalgae also acquire and integrate all sources of water column nutrients over short to long periods and are present in the coastal benthic (ocean bottom) community. The algae may represent nutrients deposited through SGD (especially if the algae grow on top of the seep) and are easily collected and analyzed for a relatively minimal cost (Dailer et al., 2010). Some limitations do exist, including the ability to identify a single nutrient source when multiple nitrogen sources are present (cesspools, fertilizers, wastewater effluent injection). Some of these limitations can be overcome by using multi-tracer methods and land-based data to analyze sources. Overall, the possibility of identifying the specific sources of nitrogen pollution by using $\delta^{15}N$ values coupled with %N data is realistic in Hawai‘i with the assistance of available land-use information and potential pollution sources to clarify the isotopic data (C. Smith, personal communication, November 25, 2019). Because nitrogen undergoes biochemical reactions moving from the pollution source to water body, and is influenced by land-use, climate, and hydrogeological conditions, there is a need for additional data to categorically identify specific sources of pollution. More research may wish to focus on the influencing factors for identifying the pollution sources and tracing the migration and transformation of nitrogen (Yang et al., 2019).

Despite any potential limitations, such as an overlap of various nitrogen sources (natural denitrification, wastewater effluent, cesspool leachate), $\delta^{15}N$ values are used globally to detect human sources of nitrogen (Kendall, 1998; Gartner et al., 2002, cited in Dailer et al., 2010). The $\delta^{15}N$ values can, and have, provided a useful means of tracing sewage under the right conditions. Professor Celia Smith and the students and staff in her laboratory are analyzing data of $\delta^{15}N$ and %N values (along with other water quality parameters such as pH, salinity, and temperature) in algal and water samples from the 2019 Water Resources Research Center sewage contamination study across the main islands of Hawai‘i, building on contributions by Smith and Smith (2006); Dailer et al. (2010; 2012); Cox et al. (2013); Amato, et al. (2016; 2020); and Shuler et al. (2018). Only a couple of taxa are considered for $\delta^{15}N$ tissue analysis in the most recent Water Resources Research Center sewage contamination study. The two algae species under evaluation are *Acanthophora spicifera* and *Ulva lactuca.* By limiting the number and type of algae analyzed, scientists have more control for variables, and more direct measurements of nitrogen concentrations versus averaging values community-wide (Derse et al. 2007; LaPointe, 1987). Research performed between 2012-2014 has confirmed previous modeling efforts to connect OWTS pollution and marine ecosystems on the island of O‘ahu, as shown in Fig. 2. Amato et al. (2020) compared algal tissue data ($\delta^{15}N$ and %N) and nitrogen transport from wastewater models, concluding that a strong relationship exists between modeled estimates of coastal groundwater nitrogen and measured *Ulva* $\delta^{15}N$ values. “These results indicate that both algal bioassays and groundwater N models are effective indicators of wastewater in the nearshore environment” (Amato et al., 2020, p. 9). The results also signal the value of this approach and its use at a moderate scale to identify areas in need of OWTS upgrades to improve water quality and ecosystem health.

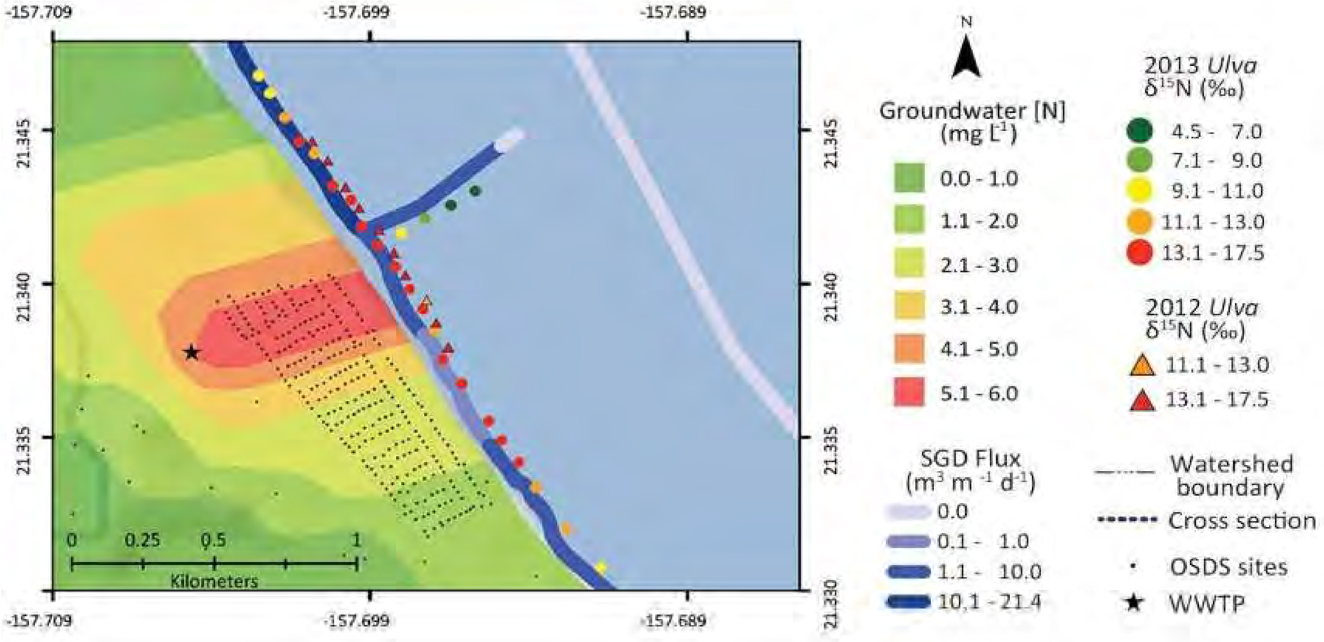


Figure 2. Zoomed view of Waimānalo study area. *Ulva lactuca* tissue $\delta^{15}N$ values are shown as triangles for the 2012 sampling and as circles for the 2013 sampling. SGD flux estimates are shown as blue bands. Scale for $\delta^{15}N$ and SGD flux is nonlinear. Estimated groundwater nitrogen is shown as colored polygons. The location of OSDS sites are noted as small back dots and the Waimānalo WWTP is represented by a black star. Source: Amato et al., 2020; *Marine Pollution Bulletin*. Used with permission.

Methods that investigate the applicability of $\delta^{15}N$ in other forms of nitrogen, such as ammonium and dissolved organic nitrogen, along with isotopes of other biogeochemically important elements (S,C,D,O, B (Boron)) may be promising for use as indicators and should be considered for testing in Hawai‘i to measure and track wastewater pollution sources (Aravena and Robertson, 1998; H. Dulai, personal communication, November 19, 2019; Young et al., 2009; Victoria et al., 2008).

Biological Indicators

Measuring a specific type and quantity of bacteria in water is a common method that can be used to identify if wastewater pollution may be present, however, current technology does not accurately permit the ability to identify the source through a single test. These bacteria are known as fecal indicator bacteria (FIB). Fecal indicator bacteria are normal inhabitants of the gastrointestinal tract of humans and many mammals. The presence of FIB is used to estimate the potential for pathogenic bacteria to cause human health illness. However, many epidemiological studies have failed to find correlation between human health outcomes and FIB levels in subtropical waters (Harwood et al., 2014; Fleming et al., 2006). Typical FIB are *Enterococcus* or *Escherichia coli*.

Using typical and alternative FIB, along with molecular marker tests (tests to examine molecules contained within a sample to reveal specific characteristics about the source) may assist in more accurately identifying the presence of wastewater pollution (Kirs et al., 2017). Enterococci are commonly found in the guts of mammals and birds, shed in the feces, and historically were used to estimate human health risks (Byappanahalli et al., 2012a). However, these bacteria are often found in high natural concentrations in Hawaiian soils, making it difficult to discern the appropriate reference levels of the bacteria (Byappanahalli et al., 2012b). During heavy rainfall events, large amounts of sediment and other materials are suspended in the water, rendering concentrations of *Enterococcus* in nearshore waters less indicative of only wastewater pollution (Fujioka et al., 2015). State water quality monitoring programs and related water management decisions should not rely solely on enterococci levels (Kirs et. al., 2017). Furthermore, FIB presence does not correlate with pathogen presence, meaning that the pathogens associated with FIB may or may not be present to cause illness (Lund, 1996; Bonadonna et al., 2002; Lemarchand and Lebaron, 2003; Anderson et al., 2005; Harwood et al., 2005, cited in Harwood et al., 2014).

Alternative bacterial indicators can include *Clostridium perfringens* and F+-specific coliphage, which have both been suggested for use as water quality indicators in Hawaiʻi (Fujioka and Byappanahalli, 2003; Kirs et al., 2017; Luther and Fujioka, 2004; Viau et al., 2011). However, more research needs to be done in this area of alternative wastewater pollution indicators to accurately predict human health risks. Because bacteria are readily found in the environment, distinguishing between the origination of different sources (soils or animals) at an appropriate location can be difficult (M. Kirs, personal communication, November 19, 2019). Additionally, relying on certain indicator bacteria to detect and identify pollution sources in Hawaiian marine environments is not recommended due to naturally low concentration levels (Kirs, 2015).

A newer method that may be able to trace microbes and identify specific sources of pollution is microbial source tracking (MST). Microbial source tracking is a complex method with analytical protocols and a decision-making process that can be used to identify specific fecal contamination sources (Stoeckel, 2005). Identification of contamination sources such as leaching cesspools or farming activities is important, as it enables the establishment of meaningful management practices and remediation strategies. Several molecular tools targeting source-specific microorganisms have been developed to discriminate between contamination sources and are summarized by Boehm et al. (2013). Some of the most promising source-specific markers identified were evaluated for use in Hawaiʻi based upon their sensitivity and specificity as well as die-off characteristics. Research is ongoing, but MST may provide scientists, public health experts, and land managers with better tools to identify and track pollution sources; further research should be continually monitored and evaluated for applicability and accuracy.

Certain types of *Bacteroides* can also be used as microbial markers to identify the presence of wastewater pollution (Betancourt and Fujioka, 2006; Boehm, 2010). *Bacteroides* are gram-negative, non-spore forming, anaerobic bacteria found in the gut of warm-blooded mammals (Wexler, 2007). Host specific identification is possible and can help track specific pollution sources such as cesspools or natural sources of animal waste. A 2010 study by Boehm et al. found traces of human-associated *Bacteroides* in Hanalei Bay with the likely sources being pollution from nearby cesspools. Other studies have also found certain *Bacteroides* in the Waiʻ Ōpae Tide Pools following Tropical Storm Iselle and in Hilo Bay (Wiegner, 2017; Wiegner, 2009; T. Wiegner, personal communication, November 19, 2019). However, human-associated *Bacteroides* and human viruses are not perfect indicators and can be difficult to detect, even in waters with known wastewater pollution (T. Wiegner, personal communication, November 19, 2019). Sensitivity (only a certain percentage of humans carry certain markers) and specificity (source can come from different types of animals) are significant limitations to this type of molecular marker being readily used to identify wastewater pollution sources. Therefore, it may be helpful to combine these types of indicators with other indicators to more accurately detect wastewater pollution and attempt to identify sources (M. Kirs, personal communication, December 2, 2019).

An example of combining biologic methods for detecting and tracing wastewater pollution in Hawaiʻi was performed by Kirs et al. (2017). The study used human-associated *Bacteroides*, human polyomaviruses, and bacterial community analyses to identify wastewater-related impairment in the Mānoa watershed. The conclusions from the study are as follows. 1) Using both enterococci and *Clostridium perfringens* (typical and alternative indicator bacteria) simultaneously is well suited for Hawaiʻi as an initial, cost-effective method to screen for the presence of wastewater pollution. However, molecular tests for source-specific markers are needed to confirm wastewater sources. 2) Bacterial community studies improve MST evaluations (by adding to databases of marker identification) and may be useful for long-term monitoring programs concerned with change (climate, land-use, etc.) and degradation of the environment.

What are some emerging wastewater pollution indicators?

One clear indicator of anthropogenic pollution is non-natural chemicals or compounds like personal care products (PCP), artificial sweeteners (AS), such as sucralose, and pharmaceuticals or hormones. Research by Tran et al. (2014), cited in Lim et al. (2016) found that pharmaceuticals, PCPs, and AS might be promising markers for detecting and identifying wastewater sources. These markers are persistent, not naturally produced in the environment, not entirely removed by wastewater treatment plants or OWTS, and tend to be relatively stable during transport (Lim et al., 2016).

> It remains highly challenging to accurately predict the extent of wastewater contamination using the methods developed using these chemical markers. Currently, there is no single chemical that could serve as a marker for wastewater contamination for all sites accurately. Understanding of land-use patterns, types and levels of contaminants in wastewater, and fate and transport of chemicals are needed in order to select suitable markers (Lim et al., 2016, p. 2).

Knee et al. (2009) were able to study caffeine as a wastewater tracer in SGD on the island of Kauaʻi. Hunt (2014) has also identified multiple pharmaceuticals and other wastewater tracers such as fabric brighteners in groundwater discharge to Honokohau Harbor, which may possibly be linked to nearby wastewater effluent wells or pits. Recent advancements in the testing of chemicals of emerging concern (CEC) allows broader, more effective screening for various CECs in the environment. This advancement has prompted multiple studies underway in Hawaiʻi focused on streams and coastal springs along the shoreline to study human-made indicators of wastewater pollution (Dulai et al., in prep; McKenzie et al., 2017).

Preliminary studies by Professor Henrietta Dulai and her laboratory at UH Mānoa targeted high-density cesspool areas and confirmed the presence of, and analyzed trends of compounds such as carbamazepine, caffeine, ibuprofen, sulphamethoxazole, fluoroquinolones, and ethynylestradiol in streams and coastal springs of Oʻahu and the Kona coast of Hawaiʻi Island. These substances have been shown to have potential negative effects on ecosystems and the organisms that inhabit them (Qiang, 2016; Lange, 2001; Shved, 2008; Jobling, 1998; Pollack, 2009).

Although not specifically studied in Hawaiʻi, recent studies have attempted to determine if there is significant evidence linking antibiotic resistance to human pathogens when humans are exposed to antibiotic-resistant bacteria (ARB) and antibiotic resistant genes (ARGs) in drinking water. Economy et al. (2019) identified *Staphylococcus aureus* and Methicillin-resistant *S. aureus* (MRSA) in wastewater effluent and showed relationships with other FIB in nearshore waters of Hilo, Hawaiʻi. There is limited information on how OWTS process certain ARBs or ARGs, though antibiotics undergo some natural degradation in the environment through photo, chemical, and biological processes. However, these processes are dependent on temperature, moisture, and chemical composition of the effluent treatment mechanisms (Helt, 2012). Sanganyado and Gwenzi (2019) conclude that human health risks from low-dose exposure to PCPs and pharmaceuticals remain weak, however, consuming drinking water contaminated with ARBs and ARGs may contribute to the development of antibiotic resistance in humans. In order to have an accurate risk assessment of ARBs or ARGS in groundwater, scientists and healthcare providers need to integrate disease outbreak analysis, human exposure modeling, and clinical data to estimate the dose-response relationships of pathogenic ARB in drinking water (Sanganyado and Gwenzi, 2019). However, using human made chemicals as a pollution indicator looks promising and future studies will reveal more about its application and use in Hawaiʻi.

Distinguishing between the origin sources of a sewage indicator is important, however, it still an incomplete process. To date, there are no single test methods to identify if a microorganism or chemical marker is from human or animal waste (Sinton et al., 1998). Combinations of indicators, along with proper additional information such as land-use patterns and uses, along with hydrologic and hydraulic modeling, may be the most appropriate method to help distinguish between sources. Sinton et al. (1998) recommend a multivariate statistical approach, using the most appropriate chemical or microbial options for the site. Newer DNA-based methods and more information regarding natural concentrations of microorganisms in different environments will help advance our ability to be more confident when studying fecal contamination in the future.

How are wastewater pollution indicators reaching water resources?

Wastewater pollution has multiple pathways to enter the ocean, including non-point sources such as surface water, SGD, and point sources like pipes. One method of tracking and tracing groundwater flow into coastal waters from SGD is to use dye tracer tests, such as that performed in Abaya et al. (2018b) and shown in Fig. 3.

Figure 3. Dye tracer test used to measure travel time of wastewater to ocean environments. Source: University of Hawaiʻi, N.D.

In an effort to track and estimate SGD parameters more comprehensively, researchers have used multi-tracer approaches by measuring salinity, silica, radon, radium isotopes, and temperature (Dulai et al., 2016; Taniguchi et al., 2019; Kelly et al., 2019). Using anthropogenic indicators and methods such as those researched by Dulai et al. (2016) may provide the ability to track the pathway of nutrients to understand how and what waters are being impacted by pollution. Other SGD tracking methods include tracking fluorescent dissolved organic matter (fDOM) solutes. The solutes may provide a cost-effective and efficient monitoring tool to measure and map groundwater dispersal along coastal environments and coral reefs. The fDOM solutes of SGD can be analyzed and visualized with geospatial software to create maps of potential areas of SGD, as shown in Fig. 4. According to recent research, fDOM has the potential to differentiate groundwater sources according to land-use, hydrology, or other factors, in combination with other biogeochemical parameters (Nelson et al., 2015).

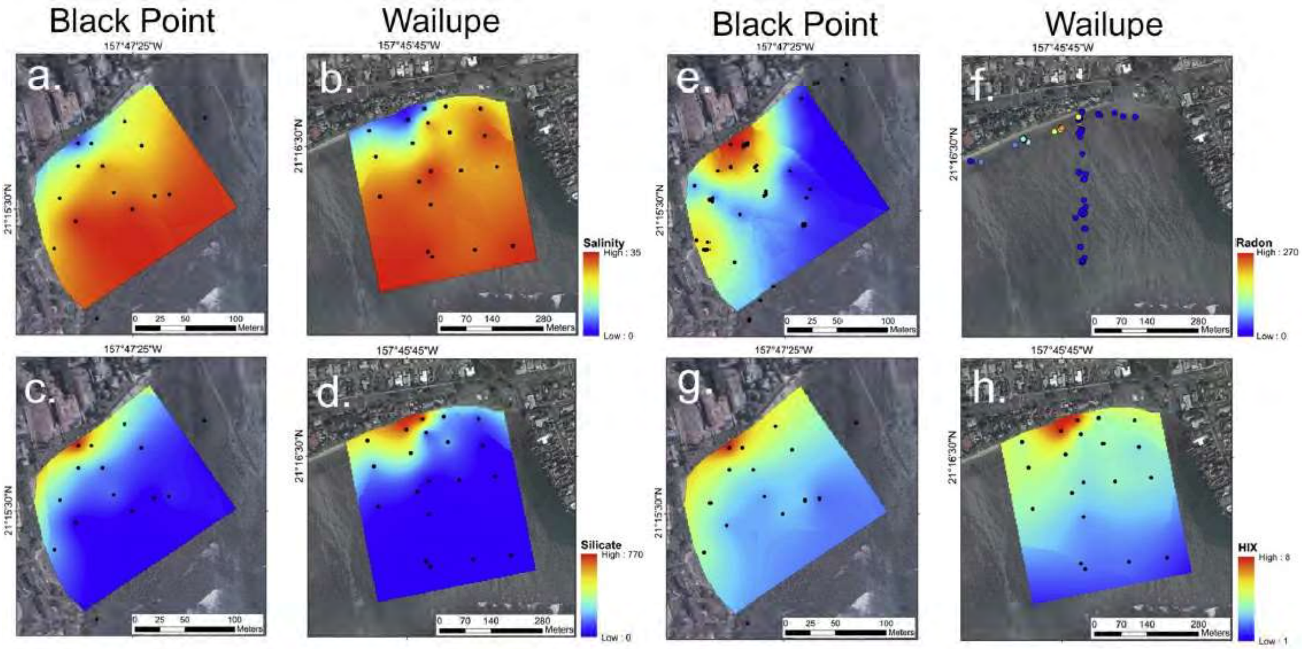


Figure 4. Fluorescent dissolved organic matter (fDOM) in the spatial context of submarine groundwater discharge (SGD) in Maunalua Bay. Contour plots of conservative solutes and fDOM solutes at Black Point (a, c, e, g) and Wailupe (b, d, f, h) 28–29 May 2014, including salinity (a, b), silicate concentrations (c, d) (log10 μmol L−1), radon concentrations (e, f) (dpm L−1) and the fDOM humification index (g, h) (HIX). Source: Nelson et al., 2015; *Marine Chemistry*. Used with permission.

Having better information around elements of and within SGD is important when attempting to understand water quality and coastal nutrient balance and fluxes. Studies by Richardson et al. (2015), Bishop et al. (2017), and Amato et al. (2016) measured parameters of SGD, marine and groundwater quality, and compared land-use characteristics to understand how nutrients can be moved by SGD. By understanding nutrient levels and nitrate isotopes within fluxes of SGD, land-use patterns, and recharge data, researchers can examine the potential for nutrient loading within the local aquifers, which may be useful for risk evaluation and prioritization of practices to reduce pollution.

Groundwater has the ability to deliver significant quantities of new and recycled terrestrial nutrients from various sources. Via natural or human sources, nutrient and chemical pollution can enter surface waters through groundwater connections (Dulai et al., 2016). Several studies investigated wastewater indicators and connectivity between pollution sources and adjacent waters in Hawaiʻi. Professor Craig Glenn and his team at UH Mānoa are currently investigating hydraulic, geochemical, and stable isotopic connections between wastewater and other land-uses to ocean waters. Groundwater flow into coastal zones on the islands of Oʻahu, Maui and Hawaiʻi Island have been mapped and measured by Glenn's group using aerial infrared imaging from both aircraft and drones, such as shown in Fig. 5 (Johnson, et al., 2008; Glenn et al. 2012, 2013; Kennedy, 2011, 2016; Kelly et al., 2013, 2019; Mathioudakis, 2017, 2018). This type of combined information can inform models or resource managers. The overall goal is to understand how contaminants and nutrient loading can move from OWTS (by using remote sensing techniques like thermal imaging combined with field and laboratory studies of SGD to surface waters. By measuring nitrogen stable isotopes within algal tissues, measuring SGD discharge, and using microbial genomic fingerprinting, this data can be incorporated into advanced watershed and groundwater transport models, enabling watershed management and policy to be based on field-tested parameters for specific sites. There are clear hydraulic connections between groundwater, SGD, and streams, which signal the need for broad watershed management practices, including stricter control and inventory of non-point source pollution sources (Bishop et al. 2017; Dores, 2017; Mathioudakis, 2018).

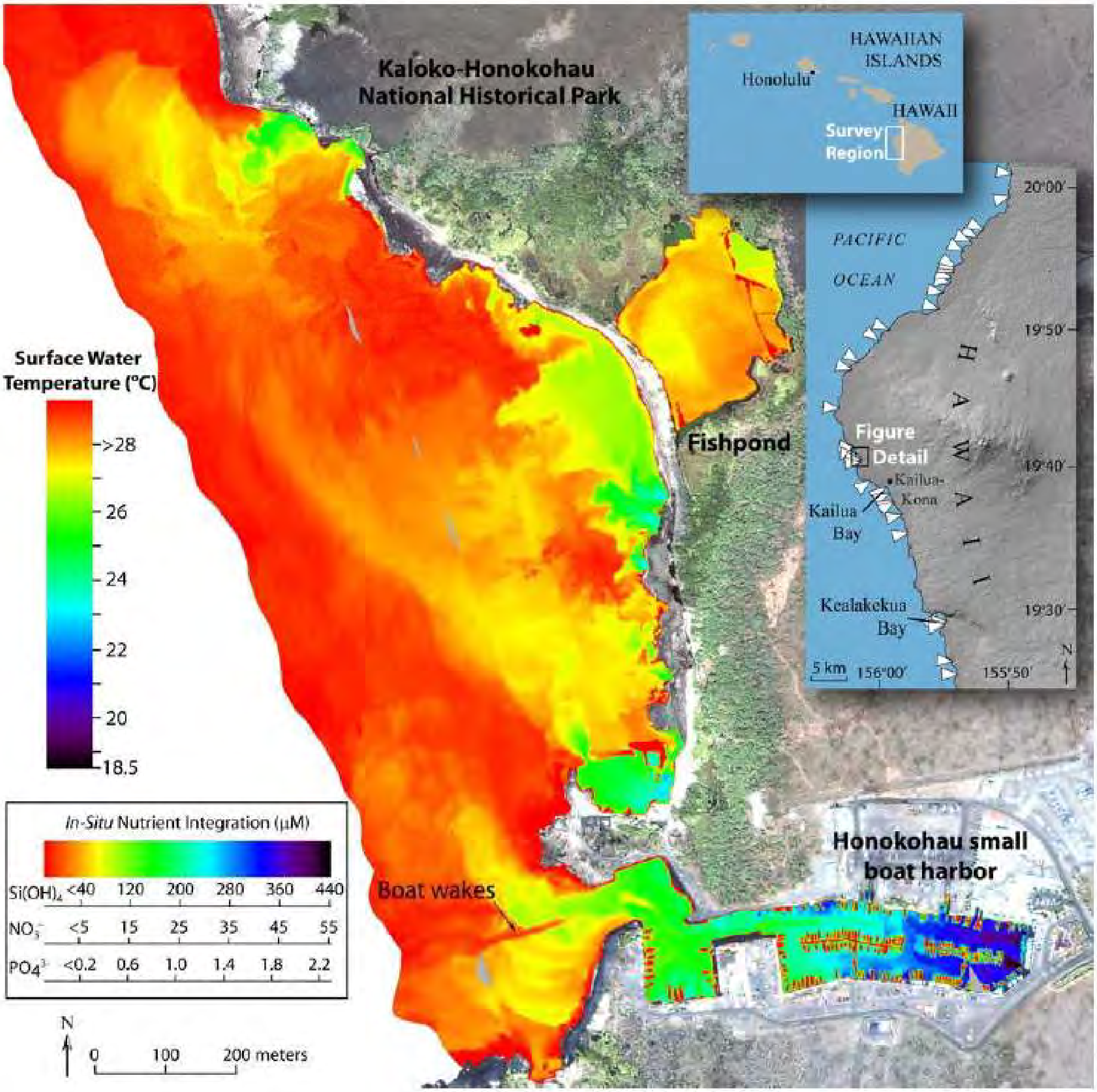
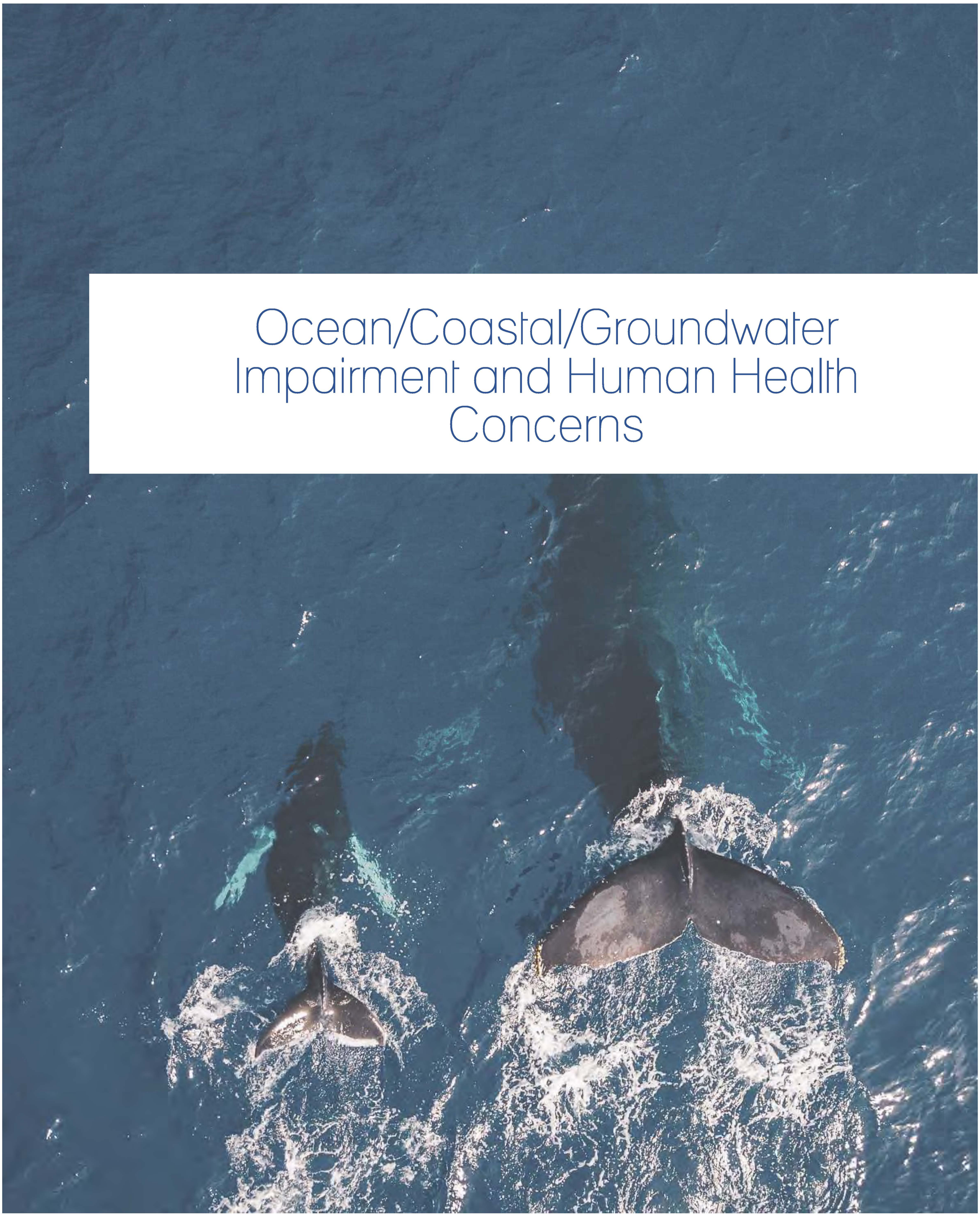


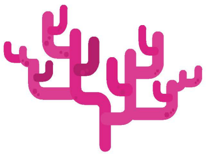
Figure 5. 2005 sea surface temperature map using low altitude thermal infrared aerial imaging over waters near the Kaloko-Honokohau National Historical Park, western Island of Hawaiʻi. Red indicated sea water temperature while other colors indicate SGD. White triangles in the inset indicate the positions of thirty-one major point-sourced SGD plumes identified by the imagery. Source: Johnson et al., 2008. Used with permission.

Ocean/Coastal/Groundwater Impairment and Human Health Concerns

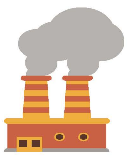


What are some of the impacts to water resources and human health from wastewater pollution?

5 Key Concepts



Regarding Ocean/Coastal/Groundwater Impairment and Human Health Concerns



Excessive nutrient pollution is associated with high nitrogen levels in algae tissues, the presence of invasive algae, high invasive macroalgal cover and low biodiversity on coastal reefs.

Many studies have connected sewage effluent discharge with decreased species diversity, increased eutrophication, and substantially altered ecosystem structure.

Coral cover was negatively correlated with the presence of FIB, high macroalgal $\delta^{15}N$ levels, and overall nutrient concentrations. Tidal pulses are likely to be delivering wastewater pollution to reefs offshore.

There are several examples of areas in Hawai‘i that have seen decreases in coral cover adjacent to areas with high cesspool densities and dissolved nitrogen levels.

In Hawai‘i, recreational bathers are four times more likely to develop *S. aureus* infections. Hawai‘i has two times more MRSA infections than the national average.

6 Knowledge Gaps

Regarding Ocean/Coastal/Groundwater Impairment and Human Health Concerns

Gathering more field data to enhance our understanding of the relationships between groundwater pollution, connected hydrologic systems and the ecological impacts can inform models to improve our understanding of these processes and pollution sources.

Understanding coastal water flow regimes may be vital to understanding which areas may receive the greatest impacts from land-based pollution sources.

More studies need to be performed to evaluate any impacts from the interactions of multiple pollution compounds and the environment.

Although not required by state or federal regulations, testing private drinking water wells where large numbers of cesspools are in use may provide the state with vital data on groundwater quality and improve human health risk assessments.

Though there are examples in Hawaiʻi of improvements to water quality and ecosystem health after point source wastewater pollution discharges were eliminated, more research is needed to evaluate the impacts to ecosystems after the replacement of cesspools.

Research needs to be performed to evaluate if legacy nutrients will negatively impact the amount and speed of the recovery of ecosystems after replacing cesspools and outdated OWTS.

What are the types of impacts to various ecosystems in Hawai‘i?

Because no point of land is beyond thirty miles from the shore, all of the State of Hawai‘i is considered part of the “coastal zone”, meaning activities on land have an impact on inland water quality and coastal water quality (Department of Health, 2015). There are numerous research studies listed in the primary reference list that evaluate the impacts to water resources and various ecosystems across the Hawaiian islands. Several of these studies focused on the impacts to coral reef communities, which are vitally important to Hawai‘i and beyond. The following section will attempt to answer questions about potential impacts to water resources, associated natural communities and human health concerns from OWTS pollution. One conclusion, however, that isn’t in question is that land-use practices can and do directly impact surface and groundwater quality as well as adjacent reef communities (Amato et al., 2016; C. Smith, personal communication, December 3, 2019). Figure 6 below demonstrates that extensive human land-use practices have impacts to offshore environments, one being increased nutrient amounts in algal tissues. Groundwater adjacent to these areas enters the ocean through SGD and surface waters, which can carry nutrients and harmful pathogens (McKenzie et al., 2019). Our understanding of the relationships between groundwater pollution, connected hydrologic systems, and ecological impacts is extensive but not complete (Amato et al., 2016). By gathering more field data and using it to inform models and frameworks currently in use, we can improve our understanding of these processes.

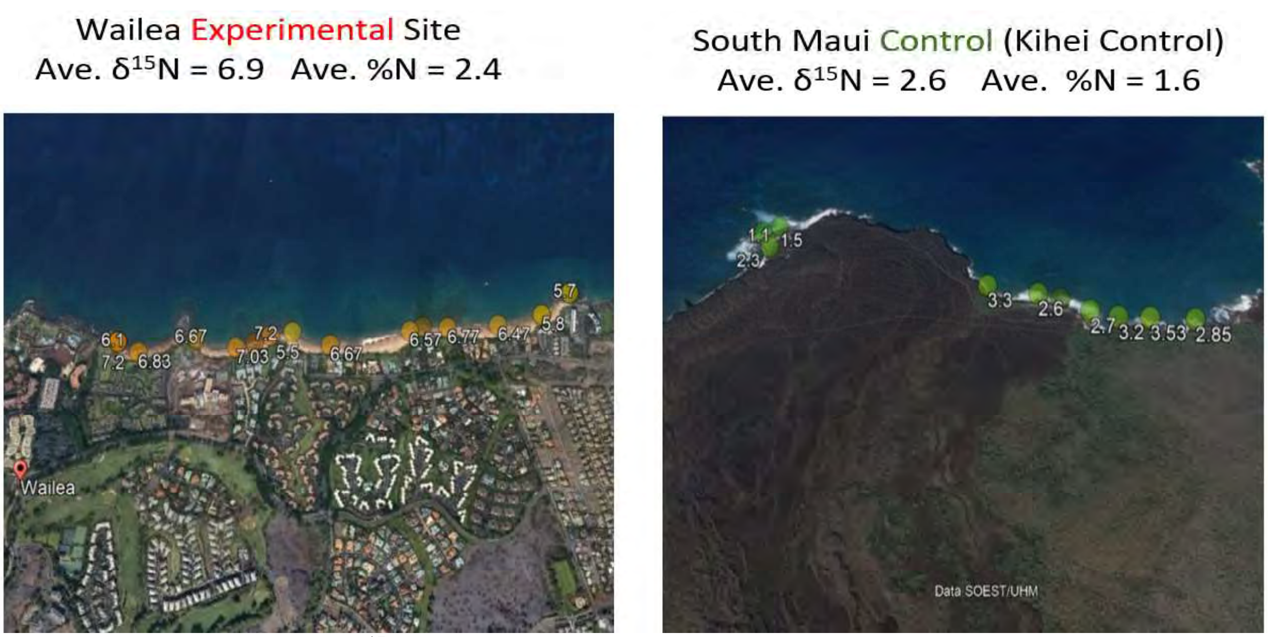


Figure 6. Maui algal tissue $\delta^{15}N$ values comparing a highly developed area to a non-developed area. Source: 2019 Water Resources Research Center Sewage Contamination Study, (unpublished). Used with permission.

Excessive amount of nutrients from OWTS pollution or other land sources such as stormwater runoff or agricultural fertilizer are associated with high nitrogen levels in algae tissues, the presence of invasive algae, and high macroalgal cover and low benthic biodiversity (Amato et al., 2016). These impacts can be damaging to coral reefs and the various supported local economies, landscape, fisheries, and cultural practices. The most common impact to coral reefs from nutrient pollution is algal overgrowth (Dailer et al., 2010; Abaya et al., 2018a). Corals can become stressed under high nutrient loadings with coral reef mortality being linked to excessive nutrient concentrations (Abaya, 2018). Couch et al. (2014) has also linked high nitrate concentrations to coral growth anomalies.

Damage to and loss of coral reefs can have widespread consequences, including severe economic losses. It is estimated that intact coral reefs provide $835.4 million dollars in protection to buildings on the islands of Maui, Oʻahu, Kauaʻi and Hawaiʻi (Gutierrez, 2019; Storlazzi et al., 2019). Intact and healthy reefs can increase food security, promote tourism, provide protection to infrastructure and improve community resiliency from major storms (Gutierrez, 2019; Storlazzi et al., 2019). According to Cesar and van Beukering (2004), the net benefits provided by coral reefs to Hawaiʻi's economy are estimated to be $360 million a year. The value provided by the State's 1660 km^2 (410,000 acres) of potential reef area in the main Hawaiian islands is estimated at nearly $10 billion (Cesar and van Beukering, 2004).

Direct and indirect losses to corals and human communities can be attributed to wastewater pollution. Maui residents in the North Kihei area have experienced severe algae growth problems, likely from nutrient pollution, due to a high number of cesspools and OWTS in the area (Smith and Smith, 2006). Cesar et al. (2002) measured annual impacts to condominium property values from excessive algal biomass piling on beaches and estimate annual losses in property values were over $9 million dollars. By combining losses of property values, loss in rental income, and money spent for algae cleanup costs, the total estimated losses jump to over $20 million dollars per year. The CCWG may wish to identify certain communities where holistic research studies could be performed to evaluate wastewater management schemes, recovery mechanisms, bacterial counts, $\delta^{15}N$ values, and economic assessments to evaluate the successes of post cesspool conversion program outcomes.

Frameworks to track, monitor and evaluate progress are important. One such framework used to track and evaluate environmental degradation and restoration efforts are Areas of Concern (AOC), used by the U.S. and Canada in the Great Lakes Water Quality Agreement. An AOC identifies an area that has experienced environmental degradation through beneficial use impairments (BUI). A BUI is defined as a change in the chemical, physical, or biological integrity of an ecological system that causes significant environmental degradation (USEPA, 2019a). Remedial action plans (RAPs) are then developed to restore BUIs and remove an AOC designation. A RAP is a plan that includes: identifying which BUIs exist and their causes; criteria for restoring the listed BUIs; remedial methods and actions to be taken; and a method to track progress toward delisting (USEPA, 2019a). More information on the AOC framework can be found at https://www.epa.gov/great-lakes-aocs.

Amato et al. (2016) highlighted that coastal and reef areas adjacent to less anthropogenic disturbance typically have lower nitrogen concentrations in SGD and algae cover than areas adjacent to more disturbance. Researchers observed low nutrient levels in coastal surface waters, high species richness, an abundance of corals, and little benthic macroalgae compared to locations adjacent to higher human disturbance. Scientists studying the complex dynamics of marine ecosystems have highlighted the potential for rapid, dramatic changes in ocean conditions, called tipping points (Ocean Tipping Points, 2019).

Even seemingly small pressures from human influence can cause rapid and large-scale changes in a system. Projects such as the Ocean Tipping Points Project (http://oceantippingpoints.org/) seek to understand these tipping points in our region and develop management tools to avoid ecosystem damages, monitor indicators, prioritize management actions, and evaluate progress toward ecosystem objectives (Ocean Tipping Points, 2019). Hawaiʻi's 30 by 30 initiative to manage thirty-percent of its nearshore waters acknowledges the need to manage local stressors, including sediment and nutrient runoff, to have sustainable and resilient coastal ecosystems. The CCWG may wish to incorporate management tools or monitoring information provided by the Ocean Tipping Points project or the 30 by 30 project into its long-range plan. As noted previously, it may be difficult to draw a direct correlation to OWTS pollution as declines in ecosystem health have many factors involved, such as globally influenced climate change, or local land-use changes. Concretely identifying correlation between specific OWTS and environmental degradation has not restricted other states' efforts to upgrade outdated or failing OWTS as part of plans to improve ecosystems an create healthier communities (Mezzacapo, 2019).

In an effort to overcome some the difficulties of studying reef impacts, Abaya et al. (2018b) attempted to use a multi-technique approach to document reef impacts and indicators from various sources of nutrients associated with water column mixing and SGD in Hilo Bay. The study used FIB as a wastewater indicator, measurements of ocean bottom cover, macroalgal bioassays (bioassays are analytical measures of a concentration or potency of a substance and its effect on living cells or tissues), and a pollution scoring tool. Coral cover was negatively correlated with FIB, macroalgal $\delta^{15}N$ levels, and overall nutrient concentrations (Abaya et al., 2018a). Although wastewater concentrations were most detectable close to the shoreline, results did show that tidal pulses might be delivering pollution to the reef offshore. Therefore, understanding flow patterns in waterbodies may be vital to understanding which areas may receive the greatest impacts from pollution sources. Other studies, including one by Delevaux et. al. (2018) sought to also use a multi-technique approach by developing a linked land-sea modeling framework. The study researched Hāʻena on the windward side of Kauaʻi and Kaʻūpūlehu on the leeward side of Hawaiʻi Island. By using by using local data, coupled groundwater and coral reef models, researchers sought to determine the impacts of land-based processes influenced by human activities and marine drivers on coral reefs.

Hawaiian ecosystems are already experiencing impacts

There are several examples of areas in Hawaiʻi that have seen decreases in coral cover adjacent to areas with high cesspool densities and high dissolved nitrogen levels. Minton et al. (2012), cited in Abaya (2018), found coral coverage decreased nearly fifty percent at various sites around Puakō, an area with high levels of nitrogen, short groundwater travel time, and high levels of *Enterococcus* in nearby waters. Many other studies have connected wastewater effluent discharge with decreased species diversity, increased eutrophication, and substantially altered ecosystem structure (Pastorok and Bilyard, 1985; Jokiel, 1991; Stimson et al., 2001, cited in Bahr et al., 2015). Figure 7 highlights common threats to coral and human health from a literature review and a data visualization comparing tool. The figure illustrates the overlap between nine common threats to coral and humans. Connecting the various factors that impact coral and human health is important because of overlapping interdependency on resources.

Delevaux et al. (2018) developed a unique land-sea modeling framework to connect many factors that play a role in impacting coral. The framework uses local data and fine scale groundwater and coral reef models. They incorporate impacts from groundwater and nutrients, human activities, and marine variables like waves, geography, and habitat in a reef to ridge system to evaluate vulnerable areas and potentially inform place-based ridge-to-reef management.

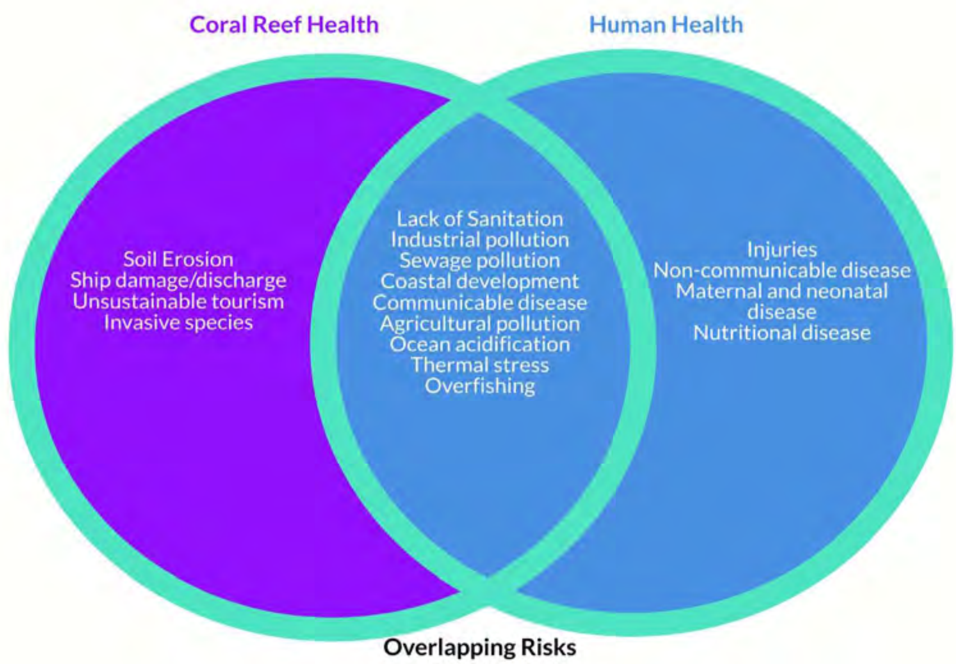


Figure 7. Diagram used to visualize the evidence of common threats overlapping for coral reefs and human health. Wear (2019) surveyed literature and used the GBD Compare Data Visualization tool from the Institute for Health Metrics and Evaluation to identify common threats to human health and Reefs at Risk Revisited (Burke et al. 2011, cited in Wear, 2019) to identify common threats to coral reef health. Adapted from Wear, 2019.

There have been limited studies around Hawaiʻi evaluating the toxicity and persistence of various environmental contaminants in wastewater on marine biota from certain sources of pollution (Hunter et al., 1995). Human health concerns in seafood are typically focused on heavy metals, pesticides, and organics, which tend to concentrate in sediment and fish, and are often attributed to industrial activity. Examination of research for this white paper did not discover any studies in Hawaiʻi that tested septic tank or cesspool sludge and effluent for different types of contaminates, compounds, or bacteria and viruses. Additionally, little is understood how many types of CECs or organic wastewater contaminates (OWCs) move and interact with other chemicals or treatment system characteristics and subsurface variables, and how or what impacts to local water resources may occur (Conn et al., 2006). More testing of human waste for specific chemicals, genetic markers, or expanded pathogens might yield future wastewater pollution indicators and generate studies to evaluate their associated impacts, human, or ecosystem based.

Wastewater pollution is thought to impact physical ocean characteristics as well, which can indirectly and directly impact ocean organisms and systems. According to studies by Richardson et al. (2018); Prouty et al. (2017); Silbiger and Sorte (2018) wastewater discharge has been associated with effects on coastal water pH through increased dissolved inorganic carbon flux. Decreased pH can impact coral growth and overall resiliency (Bennett, J., Ocean Portal Team, and NOAA, 2019). Coastal ocean acidification is happening at a faster rate than acidification in the open ocean, which can more directly impact human settlements (Strong et al., 2014). Other studies outside Hawaiʻi demonstrate that corals exposed to caffeine are less resistant to coral bleaching (Pollack et al., 2009). Pharmaceuticals have also been linked to lower male to female ratios in stream fish exposed to ethynylestradiol (Nash et al., 2004). These various impacts indicate that many more studies need to be undertaken to completely understand future risks to ecosystems, especially from wastewater pollution. As these studies demonstrate, impacts are already happening and may have serious and costly repercussions.

In the Florida Keys, high human density and associated wastewater loadings were linked to elevated $\delta^{15}N$ values and harmful algal blooms, which can impact recreational water activities and drinking water supplies (USEPA, 2018). According to Lapointe et al. (2005), cited in Dailer et al. (2010) freshwater effluent from SGD, originating from injection wells, are likely impacting Florida coral reefs by providing excess amounts of nutrients. It is important to note that effects from reducing pollution through the elimination of diffuse sources such as OWTS, may still impact the environment through redistribution via point sources, such as injection wells. A similar example is evident in Hawaiʻi through the Lahaina wastewater treatment plant case (Fackrell et al., 2016; Glenn et al., 2013; Hunt and Rosa, 2009). And may also be applicable for injection wells at Keehi, Kahului, and the Waimanālo wastewater treatment plan (Amato et al., 2016; Amato et al., 2020).

Finally, a 2016 study by Yoshioka et al. investigated the potential of increased rates of disease on coral reefs from wastewater pollution. The 2016 paper examined whether enterococci concentrations along the shoreline waters and $\delta^{15}N$ values had any relation to coral reef disease offshore. The study had limitations, however, and could not conclusively draw causation as many variables existed and data was limited. The authors did highlight the importance and need for long-term sampling to capture temporal patterns of wastewater pollution (Yoshioka et al., 2016). Future studies may also wish to continue to explore alternative metrics to link wastewater pollution and ecosystem impacts, such as MST, and develop better data or models to understand water movement, especially in embayments where reefs may be particularly affected by decreased water quality (Yoshioka et al., 2016).

What are the effects of wastewater pollution to human health?

Protecting human health and the environment is an important role for governments and other institutions (USEPA, N.D). Ensuring the proper processing and disposing of human waste presents many challenges to achieving the goal of a healthy environment (Andrzejewski, 2019). Waste disposal challenges aren’t unique to Hawaiʻi. Other locations in the United States also have a significant amount of antiquated waste disposal systems such as cesspools (Suffolk County Health Department, 2019). Dangerous pathogens such as *Vibrio cholerae* were once widespread across the United States in the 1800’s, but because of upgrades in water treatment technology, many dangerous pathogens aren't of major concern anymore (WebMD, 2019). Understanding Hawai'i's human health risk from sewage contamination is essential to properly prioritize cesspool upgrades. There are epidemiological studies associating risks with point source pollution, however, limited information regarding risks of non-point pollution in subtropical climates. Cesspools and OWTS that are malfunctioning can provide a reservoir for pathogenic bacteria, which can enter nearshore environments through groundwater, surface water and SGD, potentially causing water quality hazards, illustrated in Fig. 8 (Ground Water Protection Council, 2016).

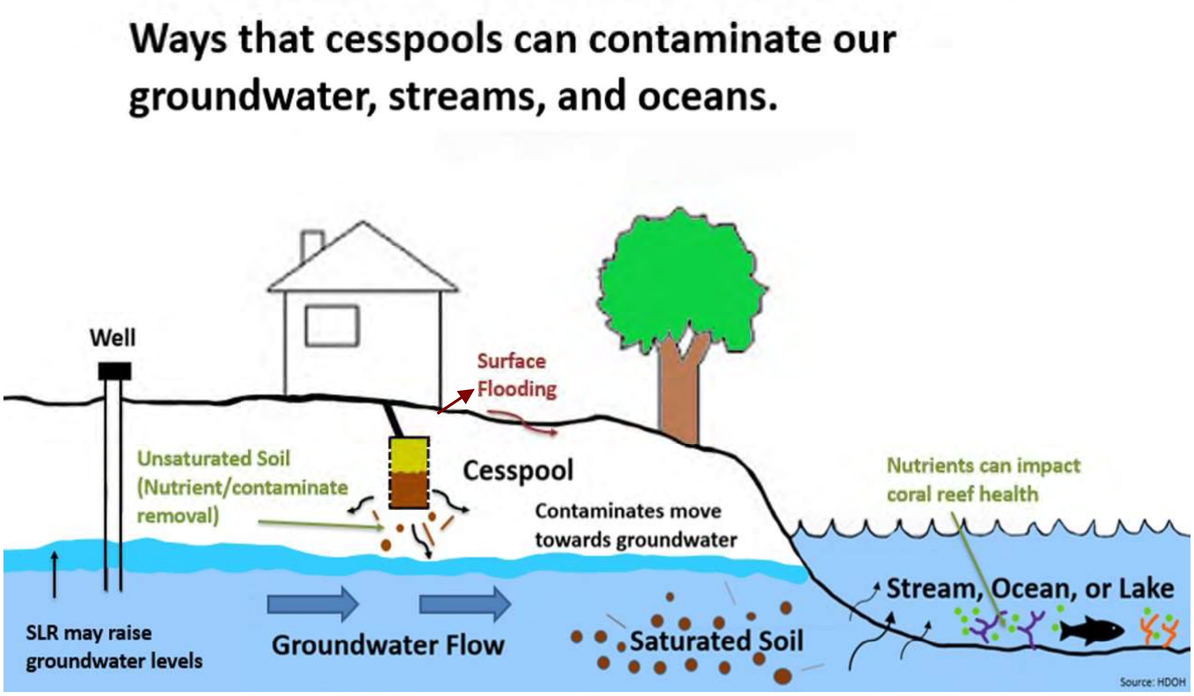


Figure 8. Multiple pathways that cesspool pollution can enter water resources. Source: Adapted from Hawai'i Department of Health (N.D.).

Recreational water quality is important to locals and tourists who use Hawai'i's ocean resources (Kirs, 2018). However, little is known about background bacteria levels and transport dynamics of bacteria and viruses in wet tropical regions where recreational water use occurs year-round (Strauch et al., 2014; Rochelle-Newall et al., 2015; Strauch, 2017, cited in Economy et al., 2019). Pathogens such as *Staphylococcus aureus* are recognized as a potential environmental human health threat, even though *S. aureus* is naturally found in the environment and on the skin and nasal passages of most healthy humans (Zetola et al., 2005, cited in Economy et al., 2019). Recreational bathers in Hawai'i are four times more likely to develop *S. aureus* infections (Charoenca and Fujioka, 1995, cited in Economy et al., 2019; Taylor and Unakal, 2019). And infections of *S. aureus* on the skin can cause boils, impetigo, styes, folliculitis, and furnacles (Minnesota Department of Health, 2010).

More concerning is Hawai'i's rate of methicillin-resistant *S. aureus* (MRSA) infections, which is two-times the national average (Chaiwongkarjohn et al., 2011, cited in Economy et al., 2019). This bacterium is responsible for several difficult-to-treat infections in humans. *Staphylococcus aureus* is being found in many parts of watersheds, even areas where humans typically aren't recreating, and often found in wastewater (Economy et al., 2019). Results from an evaluation and modeling done by Economy et al. (2019) show *S. aureus* and other FIB were common in Hawaiian estuarine waters, rivers, and watershed sources, although it still isn't clear if these are from natural or human sources and what risks, if any, they may pose to humans. Rainfall amounts and changing climate patterns (higher water amounts, higher bacterial counts) may influence the transport of bacteria and pathogens from the watershed to nearshore waters.

By better identifying specific bacterial sources that are threats to human health, appropriate government institutions or local organizations can create more localized watershed management strategies as preventative measures, in an effort to reduce pathogen loads from multiple sources (stormwater, OWTS, agriculture). Models designed for wet tropical regions, like that in Economy et al. (2019), used hydrologic and water quality metrics to predict pathogen loading to nearshore waters and could be used to inform recreational water users or water resource managers of health risks to recreational water users.

Although many human health risk assessment studies have yet to show appreciable risk to human health from potential environmental exposure to pharmaceuticals and personal care products, the problem needs to be viewed in a larger context (Cunningham et al., 2009). The long-term effects to humans or organisms through the consumption of low-levels of certain anthropogenic compounds are still unknown, which does not mean the risk is zero. Pharmaceuticals, for example, are a known and added stressor to aquatic ecosystems. Many aquatic ecosystems have other stressors that include flow regime changes, temperature fluctuations, habitat destruction, overfishing, eutrophication, invasive species, and diseases (Johnson and Sumpter, 2014). Ultimately, adding stressors may reduce the resilience of certain ecosystems and their ability to respond to changing climates or further human development.

Decreasing wastewater inputs can improve water quality

Starting with Smith et al. (1983), who studied changes in Kāneʻohe Bay, Hunter and Evans (1995) followed and detailed one of the best-documented transitions in ecosystem composition within Kāneʻohe Bay. In the past, Kāneʻohe Bay suffered from poor water quality and high nutrient levels from various sources of pollution, including wastewater and sediment from terrestrial runoff. It's unclear the exact percentage of nutrient inputs from each source, however, large amounts of pollution were derived from leaky sewer lines, cesspools and septic tank discharges, commercial tour and recreational boat waste discharges, and periodic sewage diversions from municipal wastewater treatment plants (Hunter and Evans, 1995). In 1977–1978, two municipal wastewater outfalls were diverted from the bay. What followed was a dramatic decrease in nutrients, turbidity, and phytoplankton abundance in areas surrounding the outfalls. Changes in the environment occurred rapidly, from areas dominated by certain algae and filter and deposit feeders, to "coral gardens" which more closely matched the natural evolution of Hawaiian reefs. In less than ten years, the algae *D. cavernosa* had decreased to a quarter of its 1970 era abundance and coral cover more than doubled, as detailed in Fig. 9 (Hunter and Evans, 1995). In recent years, algal blooms have returned, puzzling scientists.

One theory is that legacy nutrients from years of wastewater sources flow into the shallow and slow-moving portions of the bay are attaching to sediment. When storms, currents, or disturbance re-suspend these nutrients, bloom cycles may reoccur (C. Smith, personal communication, December 20, 2019). However, more research needs to be performed to validate this possibility.

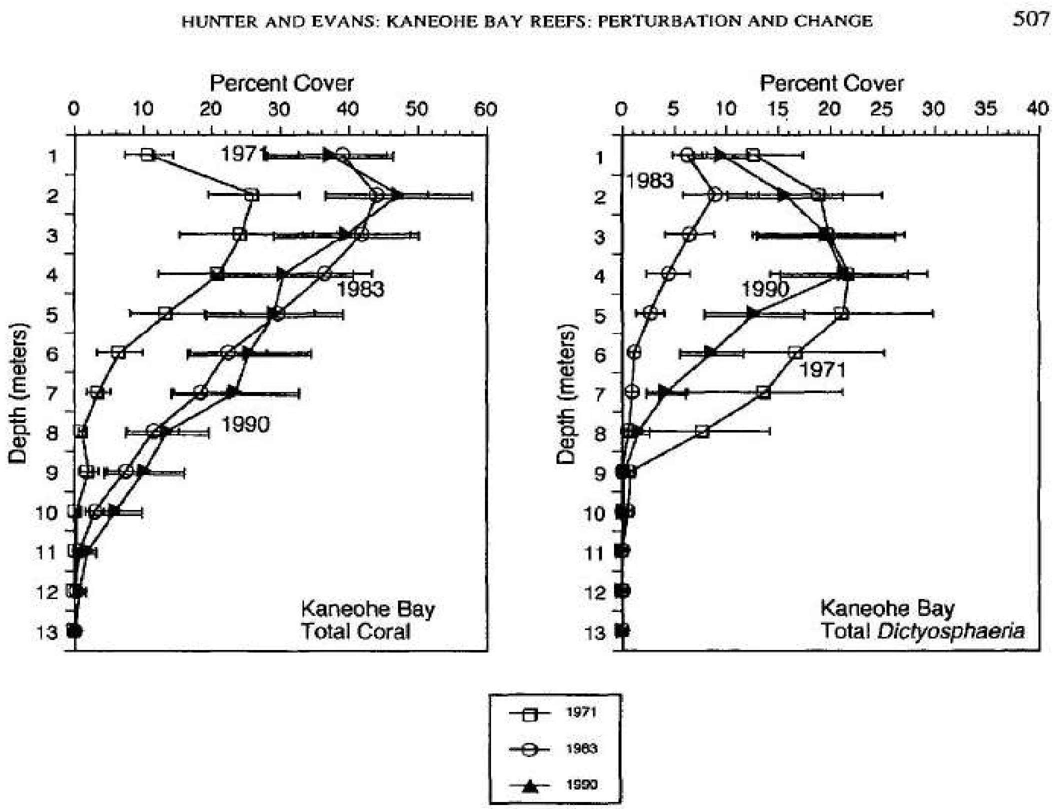
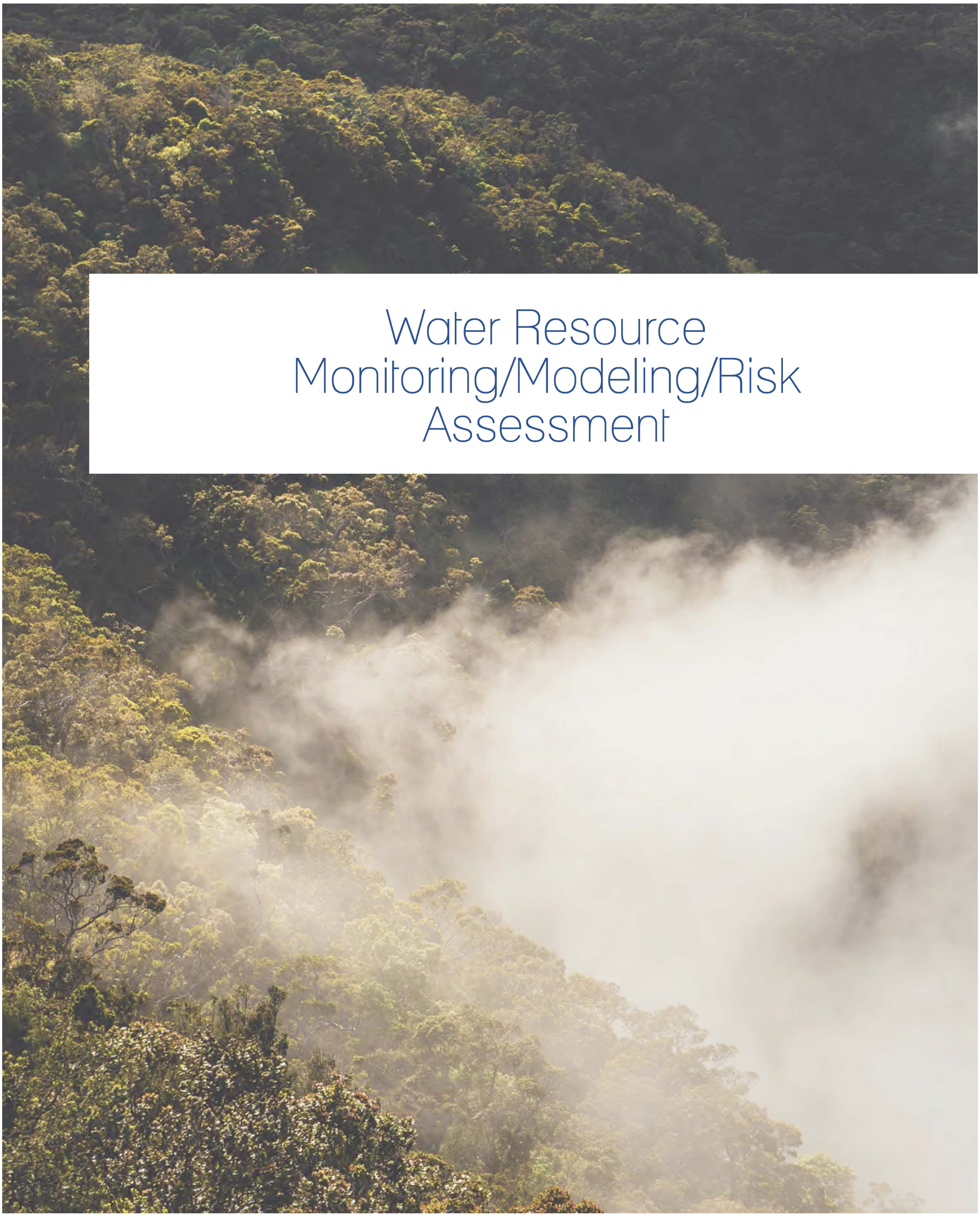


Figure 9. Depth profiles of mean percent cover of a) total coral and b) *Dictyosphaeria cavernosa* averaged over fifteen survey sites in Kāneʻohe Bay censused in 1971, 1983, and 1990. Source: Hunter and Evans, 1995; *Bulletin of Marine Science*. Used with permission.

Other research has been performed to assess impacts of repairing failing OWTS and associated microbial water quality. One study based in North Carolina from Conn et al. (2012) determined that repairing failing OWTS can improve microbial groundwater quality. However, because of land-use patterns and the continued presence of bacteria in surface waters, researchers suggest a multi-tiered monitoring approach, using simple cost-effective methods and microbial tracers, including FIB and phage to track whether upgrades were successful. According to the authors, “The findings are a first step of developing a systematic approach towards selecting the type, number, and locations for pre/post monitoring of OWTS and in the selection of specific microbial tracers to be monitored” (Conn et al., 2012, p.223). Challenges still remain to develop a comprehensive understanding of the connection between human activities (which contribute pollution), marine and freshwater environments, and human health. Increasing levels and distribution of anthropogenic substances into the environment have the potential to significantly impact human health. These risks should not be underestimated and must continue to be studied (Fleming et al., 2006).

Water Resource Monitoring/Modeling/Risk Assessment



What tools do we have to attempt to understand complicated environmental processes?

9 Key Concepts

Regarding Water Resource Monitoring/Modeling/Risk Assessment

Statewide coastal models have been created detailing cesspool impacts.

Monitoring data collected, including radon^{222} and $\delta^{15}N$, are significant resources for understanding nutrient loading from sources to the coastal environment. These and other hydrological data are critically needed for model applications.

Models can be used to evaluate potential impacts to infrastructure and assist with long-term planning efforts.

A study evaluating the human health and environmental risk posed by OWTS on O'ahu estimated that nearly 10 mgd of sewage is released to the environment, much of it reaching the groundwater. Cesspools made up about 77 percent of the total estimated release of untreated effluent and 96 percent of the potential nitrogen release.

Using source-water protection assessments can provide the CCWG with data on source-water susceptibility to contamination, which can be inputted into a decision-making model for determining system upgrade requirements or timetables.

There are available contaminant-specific models that identified groups of drinking-water wells with the lowest/highest reported contaminate detections and the lowest/highest nitrate concentrations.

A vertical distance between ground surface and groundwater of 25 feet was recommended for proper OWTS effluent treatment, many areas in Hawaiʻi cannot meet this condition.

Decreasing wastewater inputs can improve ecosystem and human health.

Recent studies have validated wastewater modeling approaches with algal bioassays, including similar ones by Whittier and El-Kadi in 2009 and 2014.

5 Knowledge Gaps

Regarding
Water Resource
Monitoring/Modeling/Risk Assessment

Further field studies are necessary to collect data used to calibrate and validate models in order to determine the degree groundwater is being degraded by OWTS.

Site specific data are necessary to improve current models regarding density effects and preferential groundwater flow.

Three-dimensional hydrologic models simulating chemical fate, transport processes, and mixing dynamics are needed for various contaminants in coastal areas that have high concentrations of cesspools and sensitive resources.

More studies or models that evaluate variations in site specific conditions may be needed to assist in the OWTS permitting process. By better understanding the capabilities of different soils, and other site conditions, more tailored regulations can be created for OWTS installations.

Having a better understanding of aquifer vulnerability is important for risk analysis and planning. It is unknown if anyone has extended models to include sea-level rise impacts on wastewater plumes.

What can different types of models tell us?

One of the main questions often asked is: can models tell us which cesspools are causing pollution and impacts to water resources? The answer is, unfortunately, probably not. In general, models are simplifications of real-world systems and are good at providing generalized information about that system. Without site-specific data and the ability to track and trace pollution from a specific source, like a cesspool, model results are only as good as their input data. Despite such limitations, models are still very useful tools that can simulate and assess important and often complex processes within a system. Additionally, models can compare different scenarios, for example, nutrient quantities and travel times from different OWTS upgrade schemes.

The first step in the modeling process is to develop a site conceptual model, as shown in Fig. 10, which includes all available hydrogeological information about the site and a list of variables to simulate. An appropriate numerical model is then chosen, simulating the processes controlling water flow and contaminant transport. Example models, often used across Hawai‘i, include several from the USGS, including MODLOW, GSFLOW, and PSLoadEsT. More information about each model is available at https://www.usgs.gov/mission-areas/water-resources/software.

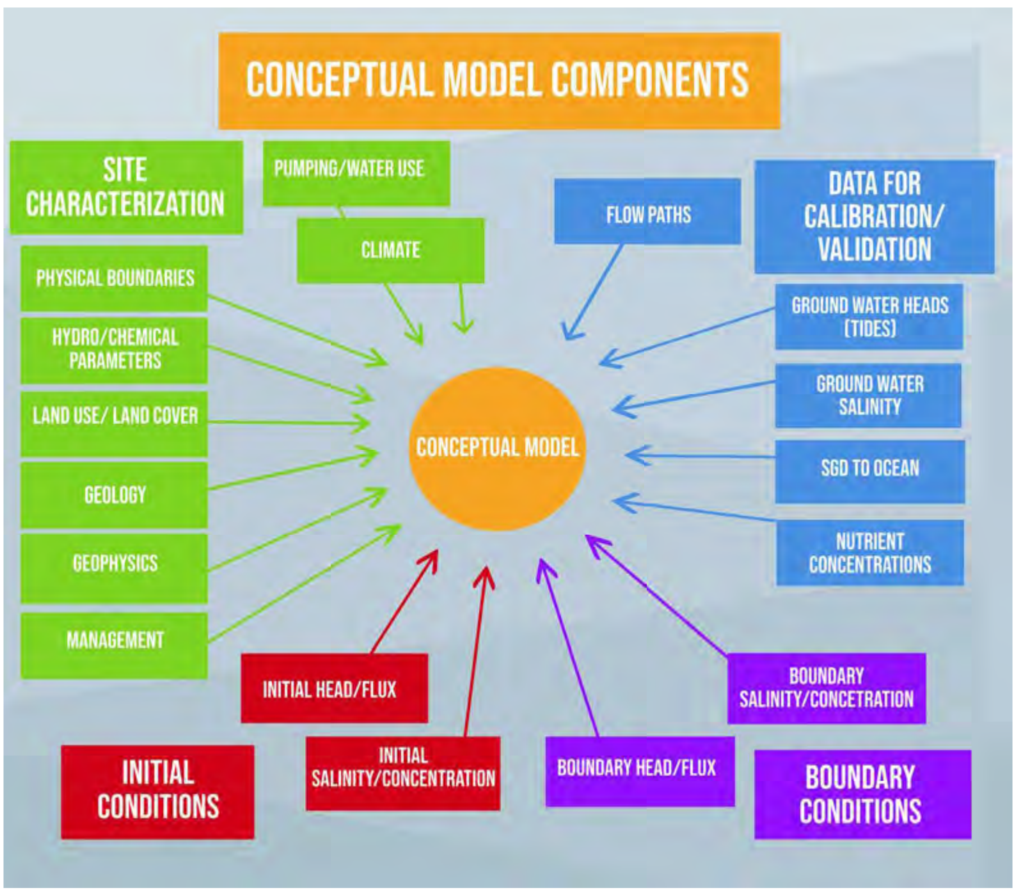


Figure 10. Elements of a groundwater conceptual model. Adapted from El-Kadi, personal communication, December 20, 2019.

Various models, including empirical and physically-based models, can either be deterministic or statistical in nature. The latter models differ by using parameter statistics to predict expected values or the probability of the occurrence of an outcome. For example, a deterministic model would predict a contaminant level at a certain time and location. A statistical model would predict how likely the concentration of a contaminant would exceed a certain value at the same time and location.

Empirical models, which are based on verifiable observations or experiences, rely mainly on calibrations to forecast an outcome. An example of an empirical model is the robust analytical model (RAM), which was originally developed by Mink (1981) for the determination of sustainable yield for Hawaiʻi aquifers by calculating variations of an aquifer head (water level) in response to water pumping.

Physically-based models, such as those developed by Whittier et al. (2010) and El-Kadi et al. (2014), predict outcomes utilizing measured or calibrated parameters. A numerical model is usually used in the analyses, controlling for water flow and chemical transport. The area of interest is divided into individual cells and the variable of interest, for example, water level or a contaminant concentration, is calculated by the numerical model at the center of each cell. Depending on the characteristics of the site, numerical models can be either two or three-dimensional. Three-dimensional models are more appropriate in characterizing the variable nature of complex natural systems.

Input data determines the quality of the model results

Understanding and assessing the transport and fate of contaminates in groundwater and the ocean are critical to assisting the State's water quality goals. Models at different spatial scales—including statewide or aquifer only—may be useful to inform where to prioritize management actions or create science-based OWTS conversion timelines.

Some models can use limited amounts of data, although more data will generally improve model accuracy. Models can be limited by a weak understanding of certain processes, such as groundwater and surface water interaction, preferential flow (uneven and often rapid movement of water and solutes through pores, fractures, and other hydrogeological structures causing significant anomalies in hydraulic conductivity), and contaminant interactions between bedrock, soil, and other compounds (Cornell University, N.D.) For example, hydraulic conductivity, which is a measure of the ease of which water flows through sediments or rocks, is an example of an important parameter needed for subsurface groundwater modeling (Rotzoll and El Kadi, 2008). One way to measure hydraulic conductivity is by performing well pumping tests or using measured water levels. However, many areas in Hawaiʻi have limited wells or are remote and inaccessible to researchers. Many of these limitations are difficult to overcome because of logistical, financial, and time constraints. Newer, less expensive, hydrogeophysical methods are being tested by Professor Niels Grobbe to provide 3D images of the subsurface over large areas, to better understand the distribution, properties, and flow of subsurface fluids. Such information allows for data-driven interpolation between wells, and provides better data for models.

Most models lacking parameterization data can generally be calibrated with other data (Whittier et al., 2010). Limited data can negatively affect the calibration process resulting in non-unique sets of parameters, however, when combined can provide acceptable results. In other words, different combinations of parameters can provide the same answer to overcome limited data in another (A. El-Kadi, personal communication, December 27, 2019). Using field data to constrain or limit parameters in a model based on field measurements can also reduce calibration uncertainties and narrow down the list of non-unique data sets.

More data is needed in Hawaiʻi for certain modeling activities

As stated previously, hydrologic models depend on accurate and thorough data. Limited data has hindered efforts to model OWTS pollution and hydrology in Hawaiʻi. For example, a model developed by Whittier and El-Kadi (2009, 2014) used available OWTS data from the University of Hawaiʻi and Hawaiʻi Department of Health. However, there were limited amounts of data on OWTS location, capacity, and leaching rates. Additionally, hydrogeological parameters, such as hydraulic conductivity and porosity were estimated based on available water-level data, which were scarce, although newer methods of data acquisition are being explored. Due to these limitations, the model's results may need to be carefully interpreted and reevaluated (Barnes et al., 2019; El-Kadi and Whittier, 2009). In fact, Barnes et al. (2019) found that nearly ninety-percent of cesspools in West Maui were converted to sewer or septic between 2007 and 2017. When proceeding with long-term cesspool conversion plans for other areas in the state, it may be beneficial to perform an updated inventory review and confirm wastewater modeling efforts with field data such as algal bioassays and hydrogeophysical methods (Amato et al., 2020). The most comprehensive OWTS inventory review was last performed in 2009 for Oʻahu and 2014 for the remaining main Hawaiian Islands by Whittier and El-Kadi.

Obtaining additional parameters of each of the OTWS, such as leach field size, installation location, depth to groundwater, soil parameters, and tank size may be useful to researchers, modelers, or government and resource managers. Coupling OWTS information with updated census data or a person to bedroom ratio may also yield more information on how OWTS are being used in real world situations (within or outside of permit and design specifications) and potential risks to nearby water resources (Amato et al., 2020; D. Amato, personal communication, December 3, 2019).

Detailed hydrogeologic information, such as hydraulic conductivity, recharge rates, and soil type are critical for accurate site assessment and model prediction accuracy. Numerical models assign surface and subsurface spatial data to area cells, variations in information or data gaps can cause problems, which may become evident in data resolution discrepancies. Typical resolution of area cells is displayed on the scale of hundreds of meters. In some cases, higher resolutions, closer to tens of meters are needed. These include density dependent problems or areas, including nearshore sites where saltwater and freshwater interact. Although the models can allow variations of parameters on the cell scale, limited data only permits the use of the lower resolution regional or aquifer-size values.

Aquifer parameters and surface/subsurface soil properties are other important factors that control water movement and chemical leaching to the underlying aquifer and are useful to modelers. Currently, soil maps and soil type information are maintained by the United States Department of Agriculture Natural Resource Conservation Service. Most maps in Hawai‘i have not been updated since the 1960s and 1970s. The filtering characteristics of the soil are important for OWTS design, function, and estimating water movement (that controls recharge) and the transport of nutrients and pathogens. Model reliability can be reduced by the failure to accurately represent Hawaiian volcanic geology, including distinguishing irregularities (such as lava tubes) under the surface. Figure 11 illustrates simulated results showing the effects of a lava tube on the transport of a time-limited injection in a synthetic hillslope. Rather than the typical transport plume pattern seen in the left figure, a highly variable and fast spreading plume can result as noted in distributed colors of the right figure. These features can carry or disperse pollution in different patterns making it difficult to track.

Improved assessment of contaminant distribution and travel times are also critical for supporting decision-making processes or management of water resources. However, data for characterizing lava tubes and similar subsurface features that cause preferential flow and transport can be difficult and costly to obtain. Alternative approaches to collect data, obtain detailed spatio-temporal images of the subsurface rock formations and pore-fluid distribution and properties, and identify hydrologically relevant geological structures can include the use of geophysical techniques such as active and ambient noise seismics, electrical resistivity tomography, self-potential, gravity, and magnetotellurics. Many of these techniques are currently being investigated at the UH Water Resources Research center by Professor Niels Grobbe.

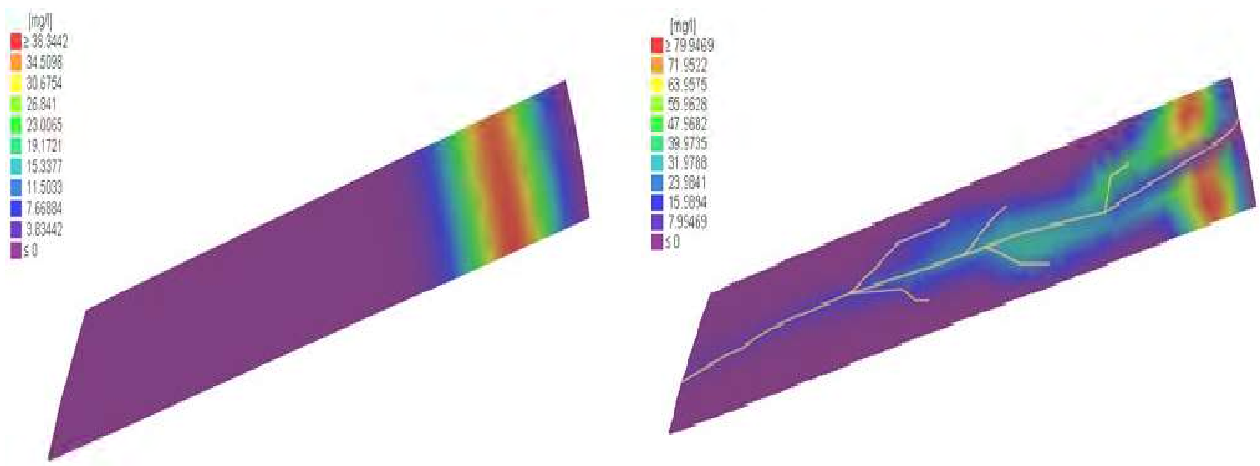


Figure 11: Effect of a lava tube on the transport of a limited time pollutant injection in the right side of a hillslope followed by “clean” injection. (left) Area with no lava tube and (right) with a lava tube. Source: El-Kadi, (unpublished data). Used with permission.

Finally, another important, but sometimes overlooked, input to both hydrologic and oceanographic models is weather data. Hawai‘i has varying topography and a narrow coastal plain, which can aid in quickly flushing water from the mountains to the ocean. Because of topography and geography, rainfall amounts vary widely across the islands. Professor Thomas Giambelluca of the UH Water Resources Research Center and his laboratory are actively improving Hawai'i's rain gauge network, aiming to provide long-term hourly precipitation datasets in multiple locations of a watershed. This type of data can be used to improve model accuracy and predictions, along with monitoring long-term climate trends. Similarly, wind and tidal data are important for oceanographic models, but tide stations are not always located close to where the modeling is being implemented. Instruments and monitoring stations can be deployed in the areas of interest, but it takes a long time to build robust datasets as well as financial resources to monitor and maintain data collection sites (K. Falinski, personal communication, November 25, 2019).

Tracking pollutants and pathogens using models

In general, subsurface OWTS contamination and pollution movement can be simulated through groundwater models. Nutrients and pathogens, which can directly leach into the subsurface through the unsaturated zone (dry soil), can be traced as they continue to undergo various transformation processes in the saturated zone (wet soil). However, significant contamination can occur through surface water via groundwater that reaches streams, also known as base flow. Base flow can infiltrate back to the subsurface at other locations or end up in the ocean. Therefore, ocean contamination can be traced back to both surface water and groundwater origins, with both having the potential to take up or deposit pollutants along the way.

Regional or large-scale models can provide useful information to track OWTS pollution, such as annual rates of sediment load to the ocean, which is important because sediment holds nutrients. Regional results can guide future data collection and possibly prompt more research or analyses in localized areas. Examples of such models include the conceptual statewide model of nutrient inputs to the coastal zone, created in 2016 by Lecky, and published as part of the Ocean Tipping Points Project. The model used input data consisting of estimated nitrogen flux from each Tax Map Key parcel with an OWTS. Total nutrient export to the ocean was then calculated. This model was particularly useful because it covers the entire state of Hawai'i and can show broad inputs/impacts to the coastal zone across all watersheds, as highlighted in Fig. 12 (K. Falinski, personal communication, January 8, 2020). Similarly, on a smaller scale, Falinski (2016) used the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) and Nutrient Delivery Ratio (NDR) model to calculate nutrient flux, including nutrients from agriculture, OWTS, and human-development, using a delivery ratio-based empirical model that was calibrated and customized specifically for Hawai'i. The results were then estimated off the coastal waters of Maui Nui and West Hawai'i, using the same methods as Lecky (2016). Although the input data was similar to Lecky (2016), InVEST NDR was unique because it included all potential sources of nutrients to the coastal zone. The results estimated percentages of nutrients coming from OWTS, wastewater treatment plants, agriculture, and golf courses, which can help managers better understand the proportion of nitrogen input specifically due to OWTS versus other sources (K. Falinski, personal communication, January 8, 2020).

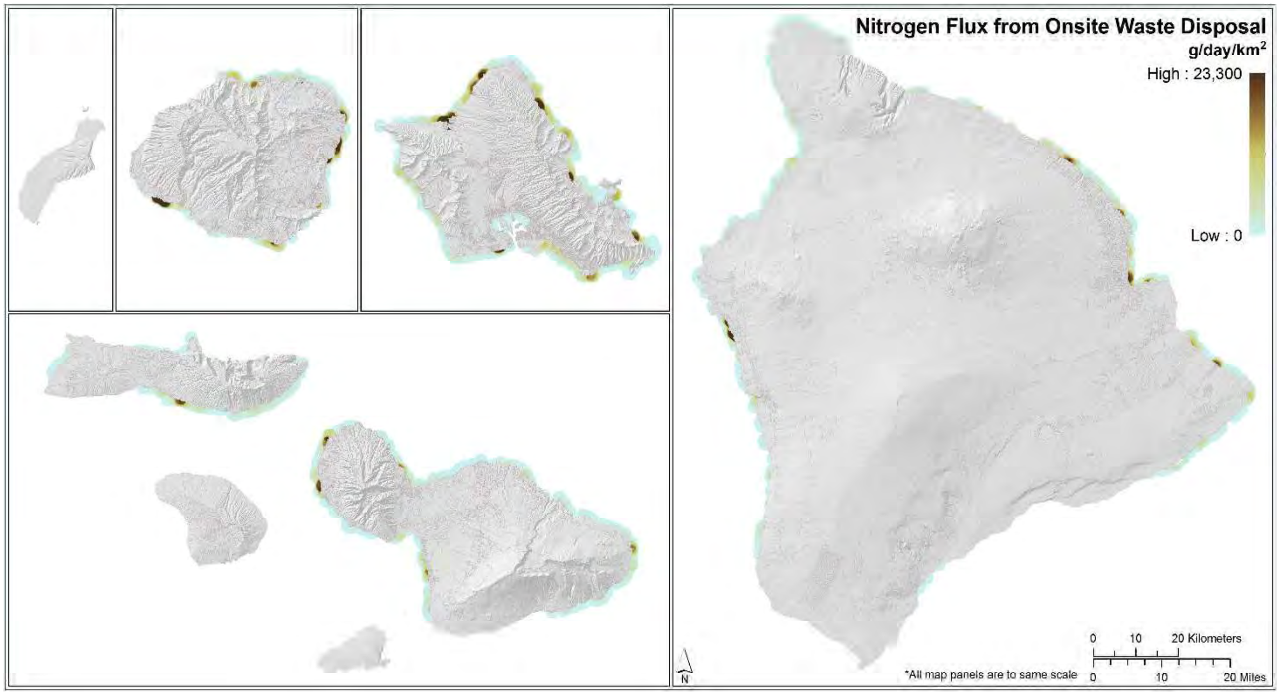


Figure 12: Nutrients from sewage. This map shows the nitrogen flux from onsite waste disposal systems (cesspools and septic tanks) located within 1.5 km inland from the coast. Source: Lecky, 2016. Used with permission.

The USGS suite of models is typically applied when investigating water flow and pollution contamination in Hawai‘i (El-Kadi and Moncur, 2006). With an understanding of water flow, levels, and flow velocities, a solute or chemical transport model can be used to assess chemical pathways and concentrations at various locations and times. The models can also estimate various water and contaminant fluxes reaching drinking water wells or surface water bodies, such as the ocean. A few of these models are discussed below.

The MODFLOW model is widely used to simulate groundwater flow (Harbaugh et al., 2000). The MODFLOW family of models includes MODPATH, which is a particle tracing software that has been applied in Hawai‘i for source water assessment delineations (Pollock, 2016; Whittier et al., 2010). The package also includes MT3DMS, which was combined with MODPATH to assess potential OWTS contamination in studies done in Hawai‘i (Whittier and El-Kadi, 2009, 2014). MT3DMS differs from MODPATH by including transport dynamics caused by the dispersion phenomenon (Zheng, 2010). Meaning MT3DMS can better represent the dispersion of a chemical in the pores or fractures of an aquifer caused by variations in available pathways and velocities, which is important for Hawai‘i’s unique geology. A contaminant will spread, forming a plume as it moves in the direction of the flowing water, and covering a larger area over time. MODFLOW alone has limitations in dealing with density dependent flows by only simulating freshwater, which is less buoyant than saltwater.

Limitations of MODFLOW relevant to OWTS pollution include (A. El-Kadi, personal communication, December 29, 2019):

a. Estimating dynamics and circulation of water and chemicals in the saltwater-freshwater zone.

b. Realistically incorporating dynamic brackish zones of a freshwater aquifer, which can change based upon aquifer condition, from pumping and/or recharge. Future models should incorporate parameters for dynamic aquifer bottoms versus a fixed aquifer bottom.

c. Estimating groundwater sustainability due to saltwater influxes.

d. Properly calculating salinity measurements and water flow to provide accurate parameters for assessing chemical transport.

e. Incorporating the ability to predict the effect of sea level rise and expected increase saltwater intrusion to aquifers.

f. Considering salinity in modeling scenarios where there is a concern about the potential effects of high salinity in leaching wastewater that can affect water quality in the aquifer.

To overcome MODFLOW's limitations, SEAWAT was developed to address water flow and contaminant transport in nearshore environments where saltwater and freshwater interact (Langevin, 2009). The model predicts dynamic zones where freshwater and saltwater mix. Model outputs include water levels, chemical concentrations, and most importantly, salinity distributions. An example application of SEAWAT was introduced by El-Kadi et al. (2014) in a study that dealt with the sustainability of groundwater resources. Management scenarios assessed sustainability of aquifer use, setting limits for decline in water levels and spring flows and an increase in salinity values. More precise and accurate management of nearshore aquifers can be expected when including variables like salinity impacts, especially when moving towards an integrated "one water" approach for water management.

Difficulties of modeling aquifers in the Hawaiian Islands

As stated earlier, surface water transport of contaminants can be a significant contributor to ocean contamination. For example, a recent study by Welch et al. (2019) utilized field measurements and modeling for a watershed in American Samoa to assess the relative contributions of surface and subsurface sources of ocean contamination. An estimated fifty-nine percent of pollution contributions came from surface sources while forty-one percent were from subsurface contributions. An integrated surface-subsurface modeling approach might be necessary in Hawaiʻi. However, the effort can be complicated due to the interactive nature of processes in the two systems and disparity of water travel times (A. El-Kadi, personal communication, December 27, 2019). To overcome such hurdles, a simplified approach is usually adopted. This typically involves simplifying parameters of one of the systems. For example, groundwater modelers can treat streams as drains receiving water from the aquifer without any details regarding surface water flow or transport processes. Another approach would be to utilize a "soft coupling" method, where the two detailed systems are run in sequence utilizing the output from one as an input to the other. A more accurate "fully coupled" approach is utilized in the USGS GSFLOW model (Markstorm et al., 2008), which integrates the USGS Precipitation-Runoff Modeling System (PRMS-V) and MODFLOW. The GSFLOW model, however, can only simulate water flow and is not equipped to assess water quality.

Across Hawai'i, there is concern that there is a lack of efforts to integrate surface and subsurface modeling. There is a real need to initiate a comprehensive plan to compile the required and available data, specifically in low-lying coastal areas where interaction between surface water and groundwater is significant. Examples of models that emphasize a surface water assessment approach include the Soil Water Assessment Tool (SWAT), a watershed-model that can quantify the impact of land management practices in large, complex watersheds (Food and Agriculture Organization, 2019; Gassman, Reyes, Green and Arnold, 2007). However, SWAT does not include a detailed subsurface water flow component, to overcome this limitation, the model can be coupled with MODFLOW (Bailey et al., 2016).

For some parameters and scales, there is a lack of data available for more accurate model calibration and validation. However, models currently exist for a larger, state-wide scale to assist in the prioritization of cesspool upgrades, including those in Lecky (2016) and Falinski (2016). Large-scale models may be all that is needed to prioritize cesspool upgrade zones (K. Falinski, personal communication, January 8, 2020). However, more data is always beneficial to understand complex systems. Possible sources of future data may include local citizen-science organizations and non-traditional initiatives. Recent research by Njue et al. (2019) and Falinski et al. (2019) showed it is possible to successfully engage the public in hydrological monitoring and obtain extensive datasets with broad spatial and temporal coverage. Data collected by citizen scientists have been found to be comparable to professional data (Njue et al., 2019). In Hawai'i, groups like Hui O Ka Wai Ola (https://www.huiokawaiola.com/) on Maui are demonstrating the usefulness of citizen scientists and illustrating the potential of these groups. The group established strict sampling protocols and QA/QC of data, which is provided to DOH. Other citizen science groups include the Surfrider Blue Water Task Force with seventy-plus water quality sampling sites statewide. However, citizen scientists may not have access to groundwater wells or other locations where data collection is needed. They may also struggle to identify which data is important for models and why. Therefore, researchers may wish to incorporate the use of technology, such as smart phones, which can potentially decrease sampling complexity and costs, or partner with students and experts to train volunteers and share resources.

It is important to note that OTWS modeling efforts so far have overlooked salinity effects by only modeling freshwater flow and transport (Whittier and El-Kadi, 2009, 2014). This can be a serious limitation due to the lack of accurate representation of the nearshore conditions, where the majority of OTWS are located. Additionally, none of the evaluated modeling studies in Hawai'i address the issue of preferential flow caused by major fractures, including lava tubes (A. El-Kadi, personal communication, December 27, 2019). Modeling technology that allows for the consideration of discrete fractures within porous material is needed. For example, Fig. 13 illustrates saltwater intrusion in a synthetic hillslope aquifer with and without a lava tube. It is clear that the lava tube causes a significant increase in saltwater intrusion, including additional spread of the brackish zone. A major research effort is needed to build accurate geological models accounting for volcanic formations. The existence of large fractures or openings may invalidate the current approaches usually adopted for fractured rocks. Field reconnaissance, including geophysical investigations, guided by modeling, can help in such an effort. Leaking stormwater/drain pipes and future flooding events from tidal inundation might also need to be studied with respect to preferential flow paths (D. Amato, personal communication, March 9, 2020).

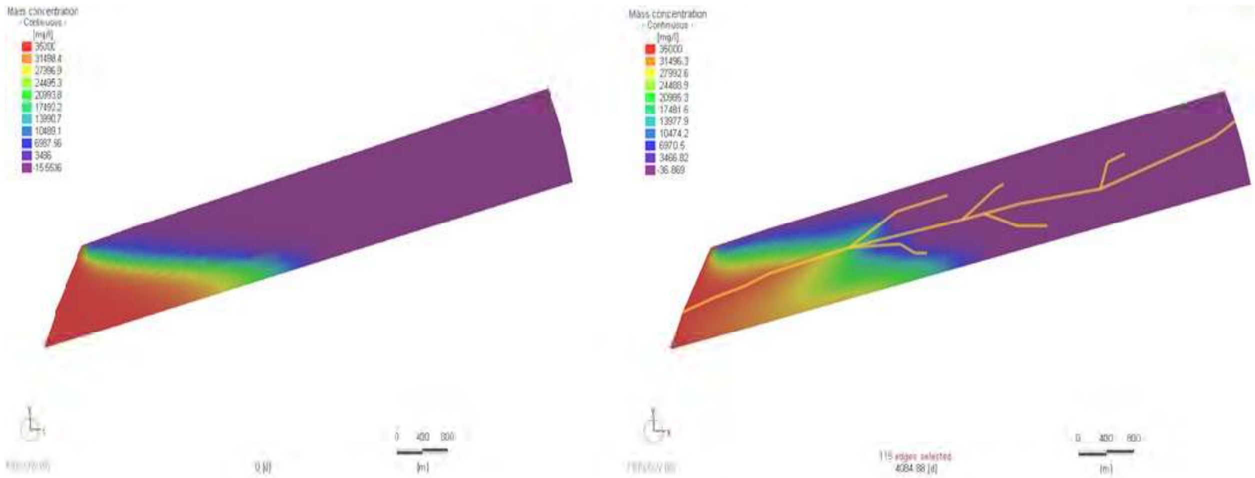


Figure 13: Effect of a lava tube on salinity distribution on a simulated hillslope. (left) Area with no lava tube and (right) with lava tube. Source: El-Kadi (unpublished data). Used with permission.

Understanding how pollution reaches ocean/coastal/groundwater environments

Anthropogenic activities are the main source of groundwater pollution (EPA, 2015). Tracer tests are effective means to understand various physical, chemical, and biological processes to secure valuable data for model calibration and validation. They also can be used to test hypotheses and answer critical questions, such as identifying sources of pollution and assessing expected contaminant levels and travel times. Various information from the land and ocean uses, combined with hydrological, chemical, biological, and weather data, can be used in such an endeavor. Bishop et. al (2017) used water isotopes to track recharge locations and rainwater flow paths to the ocean through land-use types and cesspool areas on Maui. Isotope type testing and water age data can also support these investigations (A. El Kadi, personal communication, December 29, 2019).

The use of multi-tracer tests can provide information and data to more comprehensively understand aquifer characteristics. The ideal groundwater tracer does not react with its environment and is easily detected, non-toxic, and moves with the same velocity as water particles. Example studies include those by Glenn et al. (2013), which used fluorescein dye and sulpho-rhodamine-B dye to assess potential ocean contamination from deep well wastewater injection in Lahaina, Maui. In addition to synthetic tracers, natural tracers such as dissolved radon gas have been successfully used (Dulai et al., 2010). Calibrated and validated models, which are based on data from tracer tests, can be used in a predictive mode to assess future aquifer and ocean conditions or contamination and inform management decisions. However, the accuracy of model predictions depends on the quantity and quality of data, although sensitivity and statistical analyses can address some of the uncertainty in these issues. Examples of successful use of models and tracer data include Amato et al. (2020), which was able to couple Rn with modeling to determine the flux of wastewater N to the coast off Waimanālo.

In addition to the tracer types listed above, agricultural chemicals and nutrients can be analyzed as tracers (see the first section of this report) and used in models. For example, on the island of Maui, Bishop et al. (2017) used modeling as part of a study that included chemical and land-use data to identify potential sources of nutrients. Using a suite of techniques, his team was able to distinguish between agricultural and OWTS pollution sources and identified rates of nitrogen flux into the coastal zone. Another model was developed by Dailer et al. (2012) and used field data from algal bioassays of the nearshore region on Maui to track and document a wastewater plume near the Lahaina Wastewater Reclamation Facility. The algal bioassays used $\delta^{15}N$ values to document movement of wastewater effluent to the surface waters through SGD. From the data, the authors simulated a three-dimensional wastewater plume and observed spatial variability in $\delta^{15}N$ values over time (Dailer et al., 2012). Combining this type of data with other physical studies or models (e.g., Storlazzi and Field, 2008) can inform managers where pollution is traveling or have the most impact on humans or natural resources.

A study in Tutuila, American Samoa, which can be reproduced in Hawai‘i by Shuler et al. (2017), used a water quality analyses to show a link between elevated levels of dissolved total nitrogen in the groundwater and areas on land with a significant number of OWTS. A model framework was created that includes land-use information, hydrological data, and water quality analyses of nitrogen. Results indicated that OWTS contributed significantly more nitrogen to Tutuila’s aquifers than any other source. The above framework demonstrated a way to identify specific sources of non-point pollution across many areas to assist with best management practices. Another study by Welch et al. (2019) used a similar framework and examined SGD and connections between land use and nutrient loading in Faga'alu Bay, American Samoa. Coastal radon^{222} measurements, dissolved nutrient concentrations, and $\delta^{15}N$ values in water and algae can be used to investigate SGD, base flow of nutrients, and determine probable nutrient sources (Shuler et al. 2019). Nutrient loading correlated well with human impact, although differences in location hydrogeology, impact distribution, and wastewater infrastructure also play a role (Shuler et al., 2017). The SGD nutrient fluxes were found to be more prominent than base flow nutrient fluxes (Shuler et al., 2019).

Models for prioritization and upgrade schemes

Environmental models representing various physical processes (e.g., groundwater flow and nutrient transport models) as well as models that incorporate social and economic drivers (e.g., cost-benefit analyses) need to be combined in order to develop a comprehensive prioritization framework and upgrade scheme for the State’s cesspools. An example of one possible component in this framework is the existing nutrient transport/loading model by Shuler and Comeros-Raynal (2019). This model was created for the island of Tutuila, American Samoa to classify coastal areas below each of the island’s watersheds for pollution management. The model is based on levels of dissolved inorganic nitrogen (DIN) loads from surface and groundwater discharge, as shown in Fig. 14. The model was calibrated using measurements of DIN loading rates from all hydrologic pathways in watersheds where samples were available. Three hydrologic pathways were used, including stream base flow from shallow aquifers, surface runoff from rainfall events, and SGD (Shuler and Comeros-Raynal, 2019). Sources of human-derived DIN included OWTS, pigs, and synthetic agricultural fertilizer. Both historical and current stream flow observations were used in the model.

The model then determined DIN loading rates for every watershed on the island via individual nitrogen release rates based on the number of modeled nutrient sources in each watershed (Shuler and Comeros-Raynal, 2019). Further data refinement allowed the ranking and prioritization of impact to each watershed. The CCWG may wish to consider working with researchers to develop a prioritization model that builds upon components similar to the Shuler and Comeros-Raynal (2019) model. Other methods, including those by Barnes et al. (2019) and Babcock et al. (2019) also evaluate multiple objectives, nutrient loading, costs, risks, benefits and tradeoffs of cesspool upgrades, and are discussed in the Policy and Community Engagement section.

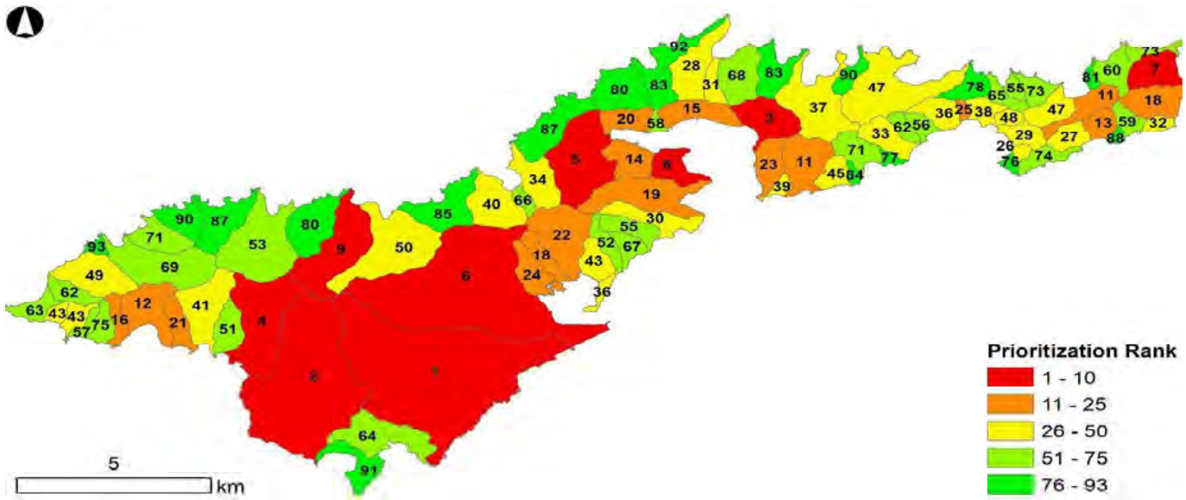


Figure 14. Map highlighting the prioritization ranking of each watershed on Tutuila, American Samoa. The red areas are the most impacted, while the green areas are the least impacted. The study used coastal loading of dissolved inorganic nitrogen (DIN) and indexed the impact in each watershed based on 1) the amount of DIN released by all known human sources in each watershed; 2) the area of each watershed; and 3) the coastline length of each watershed. Source: Shuler, 2019. Used with permission.

Estimating where pollution will end up in ocean environments

Once the groundwater or surface water enters the ocean, different types of models are used to predict where it may end up. Because of the complexity of systems, predictive and empirical models are not often used for these scenarios. Rather, numerical models are more suited to estimate possible pathways for particles and mixing dynamics of substances. Groundwater and oceanographic models are typically run as separate systems and not commonly combined because of the uncertainties in both systems. For example, ocean plume dynamics are poorly understood, and concrete connections between human sources of nutrients and ecosystem health in the ocean need more research. In Hawai‘i, a combination of modeling and monitoring efforts have been used including Wolanski et al. (2009), who created a biophysical model in Maunalua Bay on O‘ahu to connect ocean dynamics with coral reef health. Tomlinson et al. (2011) and Ostrander et al. (2007) focused on using ocean observing data from buoys in Kāne’ohe Bay and water quality sampling to map out plumes. The researchers determined that storm events can lead to plumes of runoff remaining in the bay for up to forty-eight hours.

Finally, Connolly et al. (1999), created mathematical models to understand contributions of wastewater outfalls and shoreline sources of organisms in Mamala Bay. The results were then used by a pathogen fate model to predict the distributions of wastewater contamination indicator organisms and specific pathogens in the Bay (Connolly et al., 1999). Future models, similar to those previously described, may be developed for other coastal areas that have high concentrations of cesspools and sensitive resources that can be negatively impacted by wastewater pollution, such as coral reefs.

Using models to reduce risk

Risk analyses, such as those performed by Whitter and El-Kadi (2009, 2014), evaluated the human health and environmental risk posed by OWTS. One study estimated that nearly 10 mgd of sewage is released into the environment, with much reaching groundwater (Whittier and El-Kadi, 2009). Cesspools made up about seventy-seven percent of the total estimated release of untreated effluent and ninety-six percent of the potential nitrogen release. Groundwater models in certain areas estimated that nitrate concentrations could reach a maximum level of 11 mg/L above background values, which is higher than USEPA maximum contaminate levels of 10 mg/L (USEPA, 2019b). Because soil is the primary treatment mechanism for OWTS, even in areas with low density of OWTS, soil conditions and slope may be a limiting factor determining levels of effluent treatment. Whitter and El-Kadi (2009) recommend a vertical distance between ground surface and groundwater of twenty-five feet for proper treatment of effluent by the soil, however, many areas fail to meet this condition.

Using source-water protection assessments (e.g., Whittier et al., 2010) can provide the CCWG with data on source-water susceptibility to contamination, which can be inputted into a decision-making model to determine system upgrade requirements or timetables. The approach by Whittier et al. (2010) uses groundwater models, aquifer locations, and geographic information system data. A groundwater-flow model used site-specific data, where possible, to provide a numerical score that quantifies susceptibility to contamination. This approach is adaptable and can be updated with new data as it becomes available (Whittier et al., 2010). This assessment, however, isn’t without its caveats. The model did not include flow in the unsaturated zone, chemical reactions, or chemical dispersion data (Whittier et al., 2010). More studies yielding data are needed to improve modeling due to Hawai‘i’s unique geology and hydrology. Many stakeholders can benefit from increased collaboration and the sharing of resources and data by multiple agencies to protect water resources.

Having a greater understanding of groundwater vulnerability is important for risk analysis and planning. Mair and El-Kadi (2013) developed a model that combined well capture zones with multiple-variable logistic regression modeling, where two or more independent variables are used simultaneously to predict a value of a dependent variable. The model was applied to the Pearl Harbor and Honolulu aquifers. The results produced contaminant-specific models that identified groups of wells with the lowest and highest reported detections and the lowest and highest nitrate concentrations (Mair and El-Kadi, 2013). Models like these can help in areas with limited amounts of data and can complement efforts to further develop drinking water protection zones. Reducing risk to natural systems such as coral reefs requires synthesis and processing of data from different disciplines.

A methodology to integrate spatial data on environmental and anthropogenic drivers of coral reefs was developed by Wedding et al. (2018). Their research sought to quantify and analyze spatial drivers of change on coral reefs to understand how reef resilience and diversity might be impacted by human causes (Wedding et al., 2018).

Groundwater models can assist with evaluating infrastructure vulnerabilities

Models can be used to identify infrastructure vulnerabilities and inform long-term planning efforts. One such model by Habel et al. (2019), simulates sea-level rise induced narrowing of the unsaturated space (treatment zone) between OWTS and groundwater. Results of the study revealed that eighty-six percent of the 259 active OWTS in the study area are likely inundated by groundwater at present. Simulations considering nearly one meter of sea-level rise show an increase in the percentage of likely inundated OWTS to ninety-one percent, of which thirty-nine are identified as flooded to the ground surface. Figure 15 details the locations of OWTS and whether they meet minimum requirements under 98 cm of sea-level rise. These results highlight the potential for increasing prevalence of public contact with contaminated waters. Results of this model and similar models may help strengthen infrastructure permitting processes and regulatory requirements when attempting to install OWTS or predict potential failures.

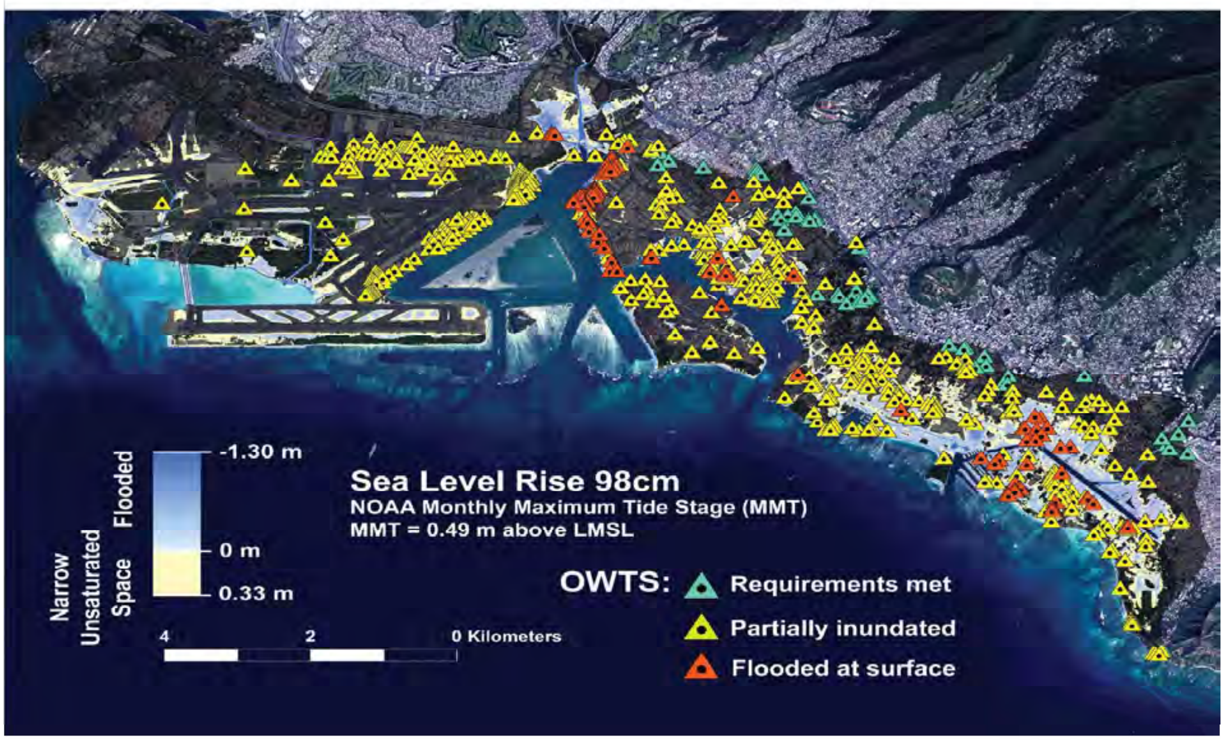


Figure 15: Simulation of groundwater inundation (blue) and narrow unsaturated space (yellow) representing 0.98 m of sea-level rise for a tide height representing the average monthly maximum tide measured at the Honolulu tide gauge. The OWTS data are superimposed upon simulations to identify potential vulnerabilities of the infrastructure. Source: Shellie Habel, 2019. Used with permission.

Improving OWTS nutrient reduction capacity using models and simulations

Some states have a developed university research center regarding OWTS technology and workforce development related to that region (Mezzacapo, 2019). Although no official center exists at the University of Hawaiʻi at Mānoa, there are past and ongoing projects regarding this topic. The CCWG may wish to explore the creation of such a center in Hawaiʻi to develop tailored technologies, test and certify OWTS units, and train a growing wastewater workforce.

It's clear that cesspools have been on the mind of researchers for a number of years, as evidenced by a laboratory experiment performed by Koizumi et al. (1966) to test conditions contributing to cesspool failure and the degree of treatment by cesspools. The results indicated that incomplete degradation of wastewater effluent in test soil lysimeters, which is a container used to determine soil-water drainage or chemical movement within soil, in two basic soil types on Oʻahu make wastewater a definite hazard to groundwater (Koizumi et al., 1966). More studies such as this, which evaluate site specific conditions, may assist the permitting process by understanding the capabilities of different soils or materials, and develop more tailored regulations for OWTS.

Recent research by Professor Roger Babcock and his laboratory at UH Mānoa examines the nutrient removal potential for passive absorption beds for use with a conventional septic tank. The process uses a set of fourteen laboratory columns designed to mimic typical absorption beds. The columns contain various types of locally-available media and layers of sawdust. The different media also included ¾-in gravel, coral sand, basalt sand, and recycled glass to mimic materials used in the construction of absorption beds. The sawdust layer (with fifty percent sand mix) was either four inches or eight inches deep and arranged to allow adequate flow through or saturation to affect anoxic conditions. Different simulated daily loading rates with raw wastewater were evaluated. Researchers are currently measuring parameters including COD, TSS, total-N, ammonia, nitrate, nitrite, total-P and phosphate (R. Babcock, personal communication, January 10, 2020).

The preliminary results show excellent nitrification/denitrification of wastewater effluent (up to eighty or ninety percent) can be achieved in these passive systems. Passive systems may have an advantage over aerobic treatment units due to their less frequent maintenance schedule, lack of required electricity, and minimal additional cost compared to a conventional septic tank and absorption system. Researchers are comparing the different media and the configuration of depth and saturation of the denitrification (sawdust) layer to find an optimal cost benefit scheme. The two main concerns to be investigated in the future are the lifespan of the sawdust layer and how to control clogging in the sawdust layer. Research is ongoing to develop cost effective methods for cesspool replacements in Hawaiʻi (R. Babcock, personal communication, January 10, 2020).

Policy and Community Engagement

How can well crafted policies and community engagement contribute to successful outcomes?

5 Key Concepts

Regarding Policy and Community Engagement

According to one study, one-third of the OWTS in Hawai'i are deficient and in need of immediate repairs or maintenance to address problems.

Homeowner engagement through education, outreach and participation can lead to better OWTS maintenance and reduction in health risks and nutrient pollution.

Survey results show positive attitudes towards human waste recycling in Hawai'i.

A decision analysis process to identify priority areas impacted by wastewater pollution from OWTS may be relevant and advantageous to identify pollution mitigation strategies in a cost-effective manner.

A participatory and structured decision-making process is recommended to help solve "wicked" environmental problems. A "wicked" problem is one with a high level of complexity, uncertainty, and multiple points of stakeholder involvement.

5 Knowledge Gaps

Regarding Policy and Community Engagement

There is a lack of understanding of the community knowledge, values, attitudes, and behaviors in relation to OWTS use, pollution, management, and replacement strategies.

There is a need to match census data, permit requirements, OWTS use and environmental health risk. Understanding the number of residents using systems in relation to permitted bedrooms may help the state ensure systems are functioning properly and protecting environmental health.

The State lacks critical information on OWTS inventory, specifically a georeferenced database of all systems in Hawai‘i – this is needed for diagnosing pollution threats, community outreach/education, watershed planning support, and ensuring proper OWTS maintenance. Updating this information will be crucial to direct meaningful management actions and to inform pollution models.

The state may wish to evaluate actions that can be taken now, such as recommending legislation or streamlining internal processes that permit onsite wastewater technologies such as composting toilets, drip irrigation leachfields, or gray water recycling in homes.

The creation of groundwater quality criteria by the DOH is needed to evaluate, measure, and track pollution, guide decision-makers and inform residents.

What is our capacity to monitor and maintain OWTS?

Failing OWTS may pose a significant threat to the environment. Ensuring the State's capacity—financial, personnel, and regulatory—to monitor OWTS operation will be essential to protecting human health, ground and surface waters. In Hawai‘i, nearly one out of every three OWTS were classified as deficient and in need of immediate repairs or maintenance to address problems, according to a study by Babcock, et al. (2014). Although there were limitations to the previous study, including a small sample size and the survey approaches used, the information provided may represent larger systemic problems, discussed below, regarding Hawai‘i's wastewater challenges. Failing OWTS are not unique to Hawai‘i. The USEPA (2005) estimates at least ten percent of OWTS are not functioning properly across the country due to many factors including poor maintenance and lack of education or financial resources. There may be ways to overcome poor maintenance schedules and perhaps ways to model when failure is likely. Recent model results from Kohler et al. (2015) suggest that mandatory inspections through renewable permits can reduce the life cycle repair, failure frequency, and severity of failure, ultimately lowering OWTS total costs to owners and potentially reducing environmental impacts. The USEPA has identified five OWTS management models (Table 1) and the CCWG may wish to choose one most applicable to implement in Hawai‘i.

A recent policy gap analysis by Spirandelli et al. (2019) reinforces conclusions by Kohler et al. (2015) by detailing several deficiencies when analyzing the State's ability to implement recommendations in the various USEPA models (Table 1). Hawai‘i's current policies and procedures were deficient in the following areas: alignment between land-use and watershed-based planning; performance goals; inventory of systems; public outreach; homeowner education; and mechanisms that ensure regular upkeep and maintenance of OWTS (Spirandelli et al., 2019). Another specific knowledge gap outlined in Spirandelli et al. (2019) is the lack of understanding of community knowledge, attitudes, and behaviors in relation to OWTS, as well as reactions by the public and government offices of various management options at either the state or local level. The OWTS upgrade programs and their success may hinge on addressing the policy gaps identified by Spirandelli et al. (2019). Hawai‘i may benefit by evaluating programs and outreach methods performed by the Cape Cod Commission in its most recent 208 Plan Update to address nutrient pollution. The project used a watershed-based focus on both stakeholder engagement and technical evaluation, seeking to maximize the benefits of local planning, traditional and nontraditional strategies, and allowing local stakeholders to decide which range of options to pursue, instead of mandating a single solution (Cape Cod Commission, 2017). The CCWG may wish to set the parameters for facilitated discussion of solutions with stakeholders on a watershed basis, allowing for a better understanding of community knowledge, attitudes, and behaviors.

To move forward with addressing some of the gaps identified by Spriandelli and others, further research along with legislative updates are needed. It is anticipated that Carollo Engineers will recommend specific technologies for Hawai‘i upon completion of its technology analysis report in 2021. However, the CCWG may wish to evaluate actions that can be taken now, such as recommending legislation or streamlining internal processes that permit technologies used in other states such as composting toilets, drip irrigation leachfields, or gray water recycling in homes (Babcock et al., 2019; Mezzacapo, 2019). Updating plumbing codes may also be useful prior to implementation of the State's long-range cesspool upgrade plan. Furthermore, the creation of groundwater quality/threshold criteria by the State DOH is needed to evaluate and measure pollution, guide decision-makers, and inform residents (Babcock et al., 2019).

Understanding community behaviors and engaging homeowners

Increasing knowledge of OWTS issues among homeowners, regulators, and the public may lead to better maintenance and awareness of the wastewater disposal problems in Hawaiʻi. Babcock et al. (2014) highlights that homeowners were generally interested in how their OWTS function, how to maintain them, and what indicators might lead to future problems or failures. The very first step to addressing concerns regarding OWTS operations, however, is to develop a georeferenced database inventory of all OWTS within the state (Spirandelli et al., 2019). Additionally, Babcock et al. (2014) recommends a statewide OWTS management program to address OWTS failures and the likely future increase in failures of the remaining systems that are being neglected. The USEPA Operating Permit Model in Table 1 would create a framework to improve the current conditions highlighted by Babcock et al. (2014). States like Oregon track OWTS information through an online permitting system simplifying the permitting and tracking process (from creation to maintenance); the CCWG may wish to study other state efforts regarding database creation.

Table 1. USEPA OWTS Management Models Table. Source: Halvorsen and Gorman (2006).

Model	Description
1. Homeowner Awareness Model	Represents minimal level of management; appropriate for areas where most sites without sewer access are suitable for conventional septic systems; relies on construction permits and public awareness
2. Maintenance Contract Model	Represents the level of management desirable where alternative OSS technologies are common; appropriate for areas of moderate environmental sensitivity
3. Operating Permit Model	Represents the level of management necessary to protect areas that are environmentally sensitive, such as wellhead protection zones, shellfish waters, and water contact recreational areas; includes performance monitoring
4. Responsible Management Entity Operations and Maintenance Model	Represents a level of management appropriate for areas where onsite and clustered systems are the main form of sewage treatment; establishes an authority to manage the maintenance of all systems
5. Responsible Management Entity Ownership Model	Represents a level of management appropriate for areas where onsite and clustered systems are the main form of sewage treatment; establishes an authority that owns and manages all systems

Surveys like the one used in Lamichhane and Babcock (2013) may be able inform the State and associated regulators which technologies are accepted by certain consumers and how to improve attitudes. Some citizens in Hawaiʻi had positive attitudes towards urine diverting toilets and human waste recycling. Therefore, additional surveys and obtaining more data may help the State target informational and educational campaigns to those who were or were not favorable to new technologies, with the hopes of ultimately improving environmental behaviors. Updating the inventory of OWTS type, location, and critical system characteristics like maintenance and permitting data will be crucial for diagnosing pollution threats and directing meaningful management actions (Barnes et al., 2019). State and county governments and departments need to share appropriate data, planning documents, capital, and human resources to work together to achieve the overarching goal of Act 125, which is to protect the State's water resources and human and ecosystem health.

Due to limited human and capital resources, large and diverse geographic areas, and diverse stakeholder viewpoints, it may be worthwhile for the CCWG to explore the creation of a watershed management framework, similar to the approach taken by the state of Minnesota to comprehensively assist with land-based pollution reduction, as noted in Fig. 16 (State of Minnesota, 2014). These programs efficiently manage all aspects of nutrient reduction to water resources and clearly spell out roles and responsibilities of stakeholders and other entities.

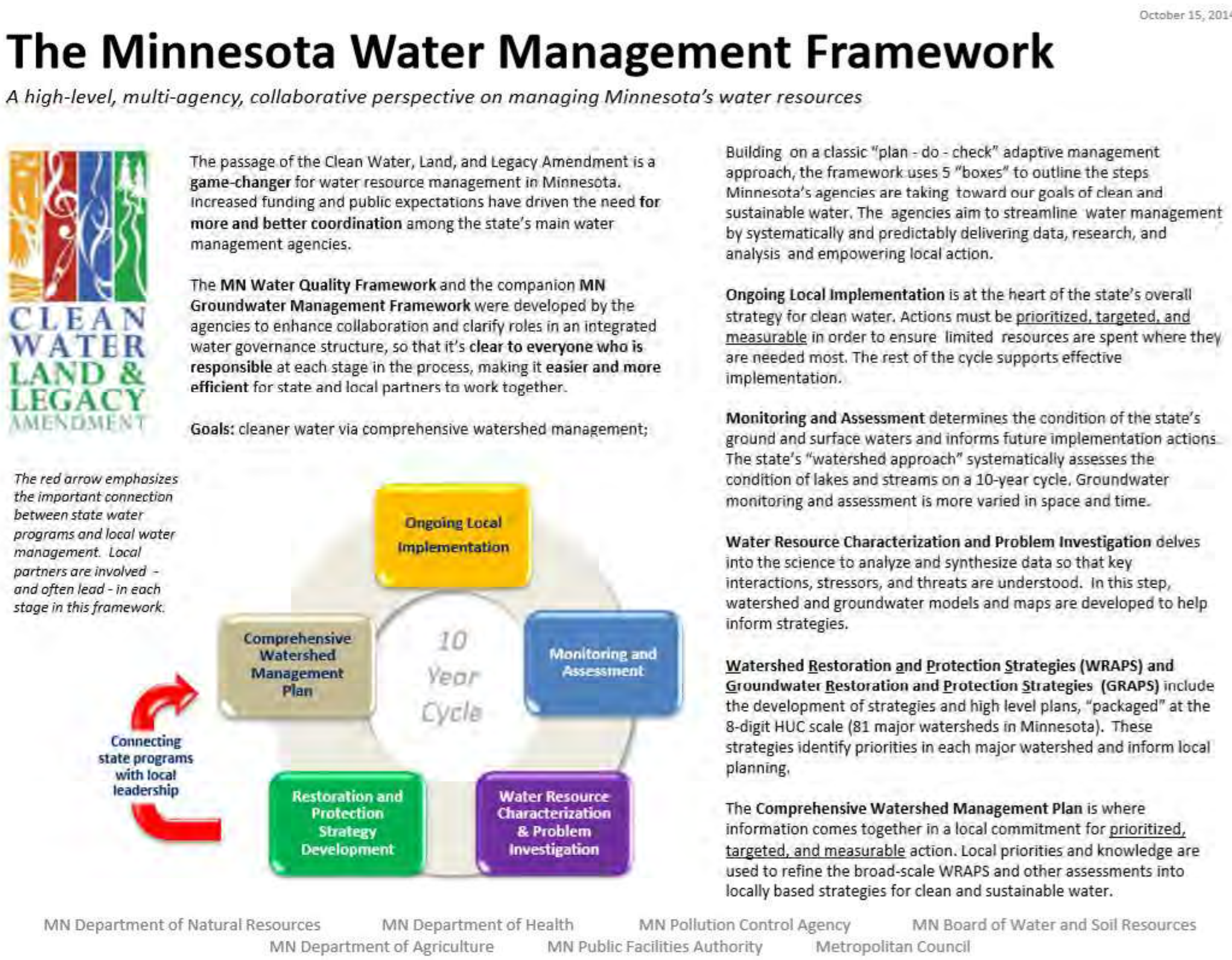


Figure 16. The Minnesota Water Management Framework. Source: State of Minnesota, 2014.

Furthermore, including local organizations in such management programs may benefit the State where there is a lack of understanding of attitudes and behaviors in specific regions and populations. Local organization objectives may also align with needed actions at the state or watershed level such as managing land-based pollution and increasing awareness among citizens about pollution and OWTS challenges. It may be advantageous for the group to explore partnering with such organizations when administering parts of the CCWG long-range plan and conducting outreach activities.

Behavioral change is difficult

Creating pro-environmental behavior is difficult. For this example, pro-environmental behavior is defined as one “that consciously seeks to minimize the negative impact of one’s actions on the natural and built world” (Kollmuss and Agyeman, 2002, p.240). Many factors shape our perceptions, decisions, and ultimately our actions. Previous linear progression models of understanding pro-environmental behavior (Fig. 17) failed to capture the complexity in humans and societies. Older, rationalist models assumed that education of an issue would lead to pro-environmental behavior, however, ultimately these theories proved false (Burgess et al., 1998, cited in Kollmuss and Agyeman, 2002). Many organizations and governments still use this approach, and science has shown there is often a disconnect between attitude and behavior or actions. Research has attempted to explain this disconnect through causes listed below:

- ***Direct versus indirect experience:*** learning about a problem isn’t as effective as seeing it for yourself.
- ***Normative influences:*** social norms and cultural traditions can widen the gap between pro-environmental attitude and behaviors.
- ***Temporal discrepancy:*** actions and people’s attitudes can change overtime.
- ***Attitude-behavior measurement:*** measured attitudes are often broader and do not always correlate with a specific measurable action.

Figure 17. Early pro-environmental behavior models. Adapted from Kollmuss and Agyeman, 2002.

Historically, the ideas and theories regarding environmental behavior often discounted “individual, social, and institutional constraints, and assumed that humans are rational and make systematic use of the information available to them” (Blake, 1999, cited in Kollmuss and Agyeman, 2002, p.247). The power to drive environmental change and make a difference on an issue is often unevenly distributed amongst society. People’s values are “negotiated, transitory, and sometimes contradictory” (Redclift and Benton, 1994, p.7–8, quoted in Blake, 1999, cited in Kollmuss and Agyeman, 2002).

One possible model that can be used to understand or solicit pro-environmental behavior is by Kollmuss and Agyeman (2002) (Fig. 18). The authors understand that the model is not complete and that there is no direct connection between receiving knowledge and performing an action. However, by combining environmental knowledge, values, and attitudes with emotional involvement on a subject, it may contribute to a type of environmental consciousness. Within the model, this consciousness is "embedded in broader personal values and shaped by personality traits and other internal as well as external factors" (Kollmuss and Agyeman, 2002, p. 256).

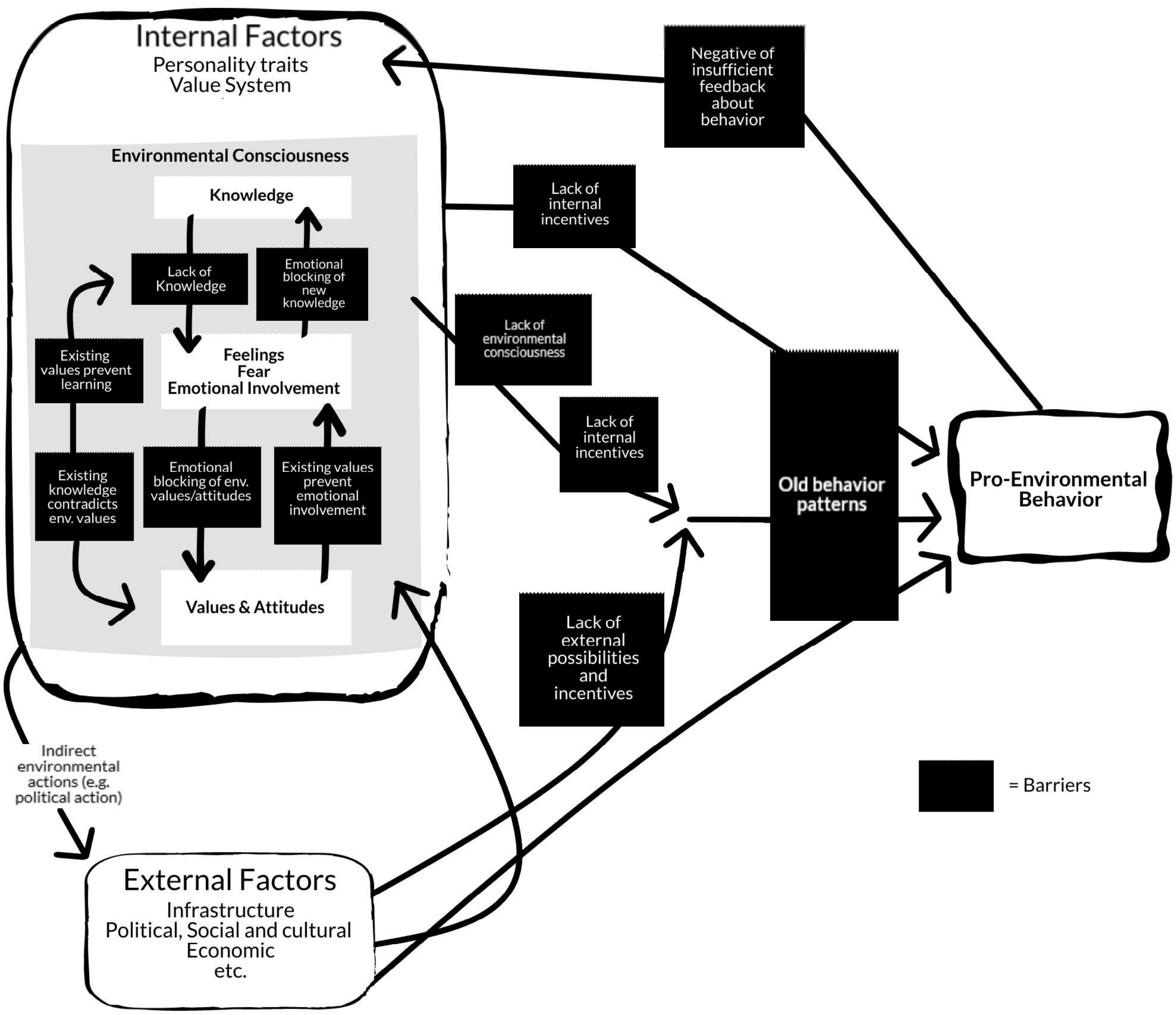


Figure 18. Model of pro-environmental behavior. Source: Adapted from Kollmuss and Agyeman, 2002.

The CCWG outreach subcommittee may wish to use these models and integrate social science research and behavioral economics to potentially improve outreach and education efforts. It is recommended that social and psychological scientists study the cesspool conversion issue and assist the CCWG to form effective messaging and outreach strategies. The hope is to have a better chance of driving behavioral change, which is necessary for cesspool conversions and the improvement of water quality and human health.

What frameworks can assist in the decision-making processes and solutions?

It remains to be seen if cesspool upgrades will have the positive ecological impact desired. Coral reef health hinges on several overlapping issues, some global and some local, and wastewater pollution is just one of them. Understanding the relationship between wastewater management, human health, and coral reef health can be complicated, indirect, and often costly. Studying ecosystem impacts can include many variables including how coastal water currents vary over time and locations, biogeochemical interactions, and nitrogen pulses from rainfall events (Swarzenski et al., 2012 as cited in Barnes et al., 2019). However, simply focusing on ecosystem impacts misses the larger context and the human connection and reliance on the environment. Pollution can negatively impact human behavior and health. Furthermore, personal beliefs about negative health effects are an important predictor of compliance to advisories (Evans et al., 1988). Improving citizen knowledge about the linkage between health and cesspools may be important to gain compliance to Act 125. By using methods like that of the West Hawai‘i Integrated Ecosystem Assessment, it can provide a framework to help track changes in key social-ecological processes, better informing policy makers, and ultimately linking tailored outreach and education activities. Such indicators may include ecological, climate, ocean, and social indicators (Gove et al., 2019).

“Ecosystems are fundamentally intertwined with human well-being and ignoring this important connection can undermine the sustainability of an ecosystem and related resource management goals” (Millennium Ecosystem Assessment 2005, quoted in Gove et al., 2019, p.40). The CCWG may wish to consider using the most reproducible and applicable available science, combined with place-based management and other policy or integrated solution-based frameworks to develop a holistic strategy to determine and define wastewater impacts, priority upgrade areas, social needs and mechanisms for replacement while balancing multiple stakeholder objectives and its own overarching goal. Using ecosystem service evaluation tools (e.g., Oleson et al., 2014) that link water models and integrate ecological indicators and stakeholder values can better inform the difficult decision-making processes. The tool stresses stakeholders' values and can help improve the effectiveness, efficiency, and equity within ecosystem-based management.

The CCWG may wish to review the formal structured decision-making (SDM) process evaluated by Babcock et al. (2019) in upcountry Maui. The SDM process is based in decision theory and risk analysis and defined as a “collaborative process for decision-making that combines analytical methods from ecology and decision science with facilitation/negotiation and social psychology to develop rigorous, inclusive, and transparent solutions” (Babcock et al., 2019, p. 4). It uses a set of concepts and steps rather than a rigid prescriptive approach (USGS, N.D). The authors of this research used this type of approach to determine how alternative management practices may influence: groundwater nutrients; cost; and where the most benefits would be realized to satisfy regulations/objectives and social goals (Babcock et al., 2019). According to the authors, the process achieved the following: 1) identified a suite of cesspool replacement options; 2) developed a range of management alternatives to upgrade cesspools that incorporate feasibility; 3) analyzed environmental benefit of each alternative; 4) enumerated costs of the alternatives; and 5) provided recommendations on the alternatives relative to cost, environmental benefit, and stakeholder-identified objectives. It then recommends a participatory and structured decision-making process to help solve wicked environmental problems, which are problems that are difficult or impossible to solve because of incomplete, contradictory, or changing requirements (Babcock et al., 2019).

A decision analysis process to identify "trigger" or priority areas impacted by wastewater pollution from OWTS may also be relevant and advantageous for the State of Hawaiʻi to identify pollution mitigation strategies in a cost-effective manner (Fig. 19; Barnes et al., 2019). Key takeaways from Barnes et al. (2019) include: there is a direct trade-off between cost and pollution reduction; low-benefit solutions do not always support ecosystem protection; solutions for pollution mitigation should be balanced with a mix of low cost (low benefit) and high cost (more benefit) strategies; and decision science, when used appropriately, can be a transparent, accessible, and a useful tool to manage ecosystem health and pollution drivers. Decision analysis parallels well with the State's 30 by 30 initiative to protect coastal areas and ecosystems by 2030 and uses SDM methods (State of Hawaiʻi Division of Aquatic Resources, 2019). A structured, rigorous and engaged decision-making approach can be applied regionally to aquifers, streams, and coasts threatened by cesspool wastewater contamination (Barnes et al., 2019).

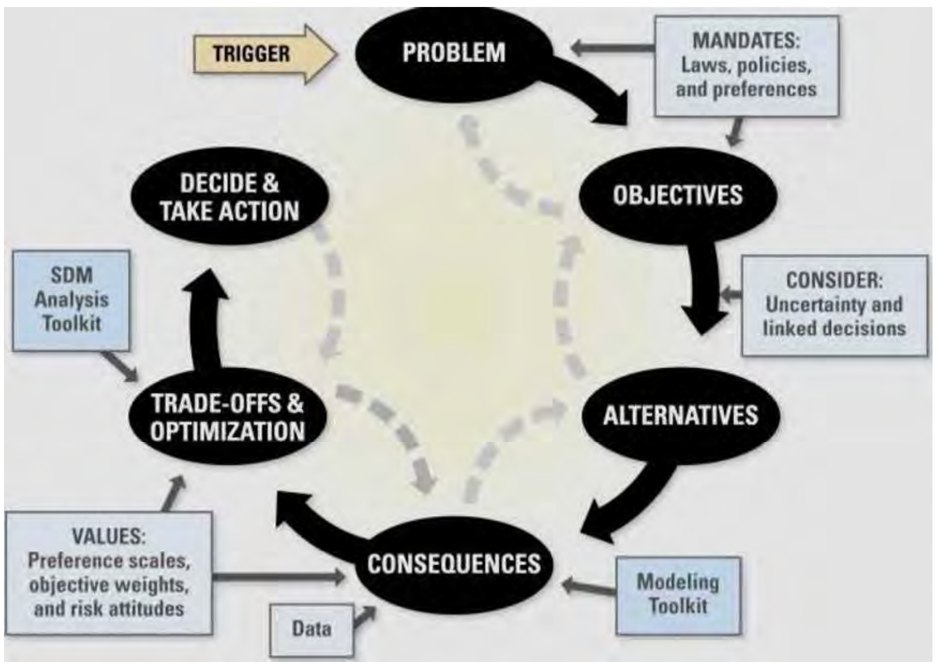
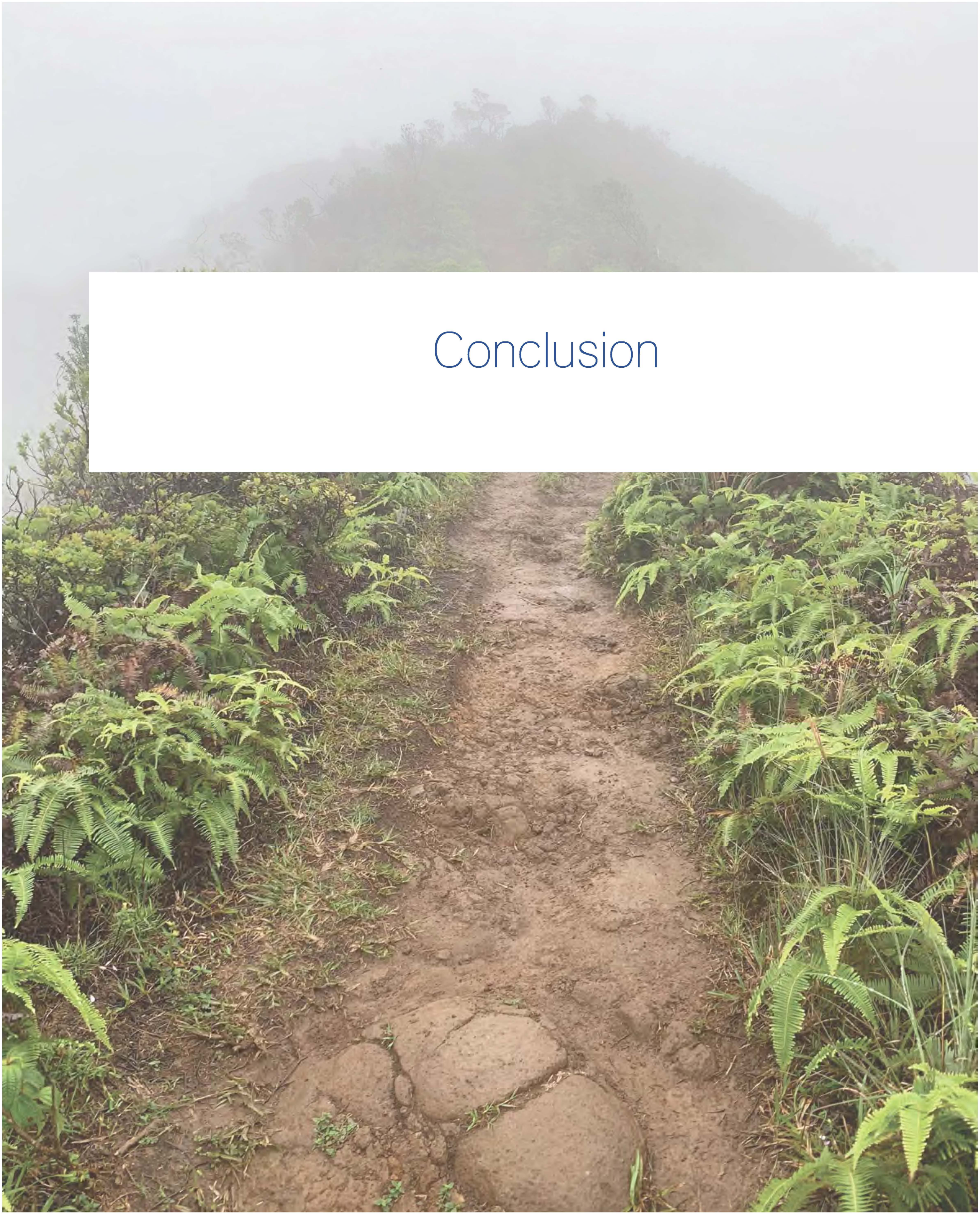


Figure 19. Decision analysis method diagram. Source: 4th Joint Government Water Conference, Kirsten L.L. Oleson; Babcock et al., 2019.

Previous work by Whittier and El-Kadi (2014) also provided a useful mechanism to calculate risk by categorizing the threats an OWTS may pose to an ecosystem and human health. The risk score was then displayed spatially on GIS maps. The risk score included factors such as the proximity of OWTS to an area that may be harmed by wastewater pollution, ability of the soil to transmit or treat OWTS effluent, amount of dilution the effluent is subjected to in the saturated zone, and other hydrologic factors (Whittier and El-Kadi, 2014). This type of scoring tool can be combined with other decision-making mechanisms to assist the CCWG with its long-range plan. Although the authors stressed that a field study is necessary to confirm model results and determine the degree groundwater is being degraded by OWTS, the expansion and update of such a scoring mechanism could be advantageous (Whittier and El-Kadi, 2014).



Conclusion

Enough valid scientific information exists to to develop a long-range comprehensive upgrade plan.

The evolving nature of research, data, and new methods to evaluate the source and severity of wastewater pollution make it difficult to create a single set of conclusive and prescriptive recommendations for prioritization. One thing that is apparent when reviewing the literature is that the current research and data can, and has supported, an informed and comprehensive decision analysis methodology and anticipatory action framework. This has been made evident by research from Barnes et al. (2019) and Babcock et al. (2019) among others. Scaling up this process and retrieving the needed information for various locations, specifically on hydraulic modeling, will take time, monetary resources, and personnel. These tools can help guide the CCWG to select high-impact and cost-efficient wastewater management strategies to meet local and state environmental and social goals (Barnes et al., 2019).

Combining the decision-making analysis framework with place-based management of ocean, land, and surface water resources could reduce human impacts and improve the resiliency and sustainability of human and natural systems, which continually face external threats such as climate change or excessive resource extraction (Delevaux et al., 2018). Coral reefs impacted by wastewater pollution cannot provide the millions, if not billions, of dollars in benefits that healthy reefs can. The cesspool conversion issue can be combined with other statewide efforts and watershed plans to resolve pressing coastal problems and issues not comprehensively addressed by a single agency or mandate. One such example is the State of Hawai‘i Ocean Resources Management Plan (ORMP). The ORMP, currently being updating from the 2013 plan, uses a place-based approach to manage connected ocean and terrestrial resources, emphasizing demonstration projects leading to potential policy changes (State of Hawai‘i Office of Planning, 2019).

There is an existential threat that exists by waiting too long to obtain large amounts of data on water quality, geology, ecosystem, or human health impacts, versus obtaining and using the right type of available data to make an informed decision or create an adaptable management strategy. Many of the studies reviewed in this analysis clearly point to wastewater pollution as a contributor, if not a significant one, to human health risks and ecosystem impacts. Coupled with the fact that Hawai‘i’s water resources are often sole source and limited in nature, this presses the need for the state to act in tandem with those performing further research or obtaining pertinent water quality information. A very useful tool to identify wastewater pollution is the use of nitrate stable isotopes ($\delta^{15}N$), which have been developed as a wastewater tracer and is well established within the scientific community. The possibility of identifying the specific source of nitrogen pollution with $\delta^{15}N$ values is realistic in Hawai‘i’ with the assistance of sophisticated and available land-use information and potential pollution sources to clarify the isotopic data. By using available scientific tools with adaptive management strategies, coupled with a structured iterative process, new information can be easily incorporated into plans, and strategies can be adjusted to meet the original stated goals. Understanding where programs have failures or gaps can also ensure that past OWTS management mistakes are not repeated if new challenges are faced.

Wastewater and water management issues, in general, can best be described as a wicked problem. Wicked problems have a high level of complexity, uncertainty, and multiple points of stakeholder involvement (Patterson et al., 2013; Cook et al., 2013 cited in Mguni, 2015). Multi-stakeholder approaches can have high degrees of complexity where stakeholder interests are entrenched or conflicting (Mguni, 2015). The CCWG may wish to evaluate how the State manages risk in terms of pollution sources and amounts, or survey and establish an acceptable risk level among multiple stakeholders impacted by OWTS pollution. The OWTS management will always have some level of risk because OWTS do not produce nutrient and chemical free effluent. In order to help address key issues of the OWTS problem, a new strategy on handling risk may be warranted. One developed by NASA (2013) and cited in Mguni (2015), manages risk through the integration of both top-down and bottom-up approaches. Policy and regulatory responsibility can be handled by those in the State and County government (or leadership positions) and coordinated with local groups who utilize affected resources at site-specific areas.

Because science evolves to provide new information, there is a need to build in site-specific adaptation to management frameworks (Mguni, 2015). According to Mguni (2015, p.28), both NASA (2013) and Beller-Simms et al. (2014) offer methods to encourage "flexible adaptation pathways" to provide "a continuous and dynamic consideration of risk tolerances and corresponding policies". Flexible adaptation pathways are established within the bounds of "acceptable risk levels" and detailed in Fig. 20. Groups are not locked into a single strategy from imperfect information but, rather, adapt as better information becomes available, dovetailing into frameworks like SDM.

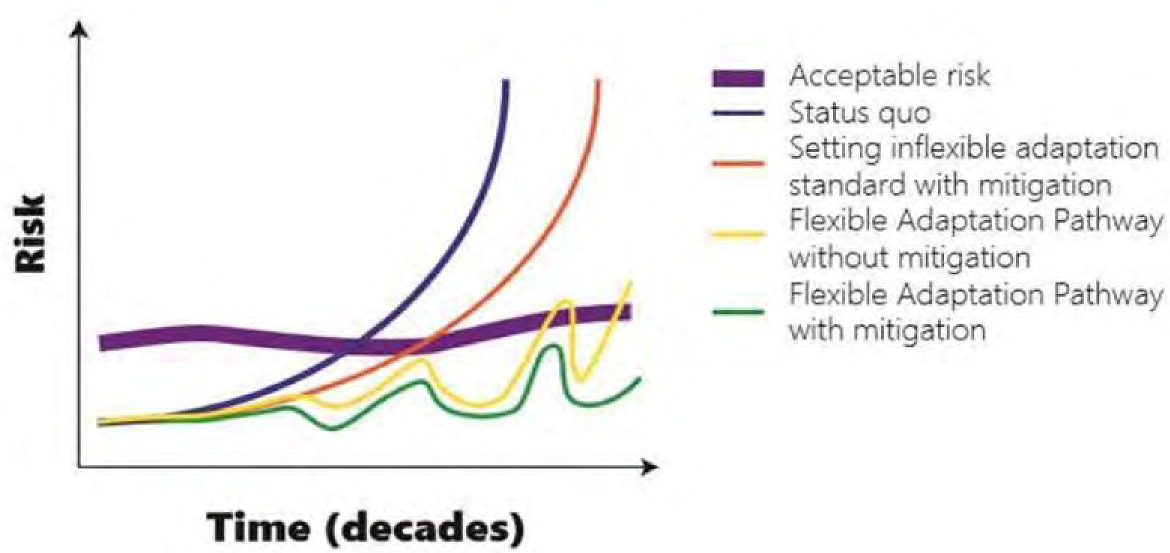


Figure 20. Adaption pathways chart. Source: Mguni, 2015.

Site specific information, such as research on nutrient pollution or ecosystem changes, can be provided by research institutions, traditional practitioners, citizen scientists, or government departments. Public policy and transparency could be improved by incorporating the best available information with flexible adaption pathways and sharing information with local stakeholders and other partners (Mguni, 2015). Additionally, community values can change through local and global contextual drivers (Ferguson et al., 2013, cited in Mguni, 2015). Resource limitations, environmental impacts, and changing socio-economic conditions create the need for an underlying and integrated structure, which is flexible and adaptable to accommodate any unforeseen changes.

Efforts to continue to bring together County and State departments involved directly or indirectly in wastewater management will be crucial to meeting the State's goals by 2050. By creating a multi-tiered strategy similar to California, Hawai‘i may be able to improve efficiency and communication between state and local agencies dealing with wastewater issues. Examples of actions may include: streamlining or improving permit processes; updating inventory of systems; integrating financial incentives; integrating water quality sampling into databases; training requirements; and public messaging (Borer, 2018; Spirandelli et al., 2019). Studying behavioral change models and integrating social science research and behavioral economics into conversion plan strategies may guide more strategic policy recommendations that encourage pro-environmental behavior. It is recommended that planners and social and psychological scientists join the outreach subcommittee to study the cesspool conversion issue and assist the CCWG to form effective messaging and outreach strategies, perhaps using professional facilitation with stakeholders to identify unique objectives and values. The CCWG may also wish to research opportunities and barriers to integrating OWTS into a one-water framework, including social research on the effectiveness of public education, outreach, and other factors that could change behavior or increase compliance with OWTS regulations (Spirandelli et al., 2019).

Finally, the CCWG may wish to invite counterparts from other states, such as New York or Rhode Island who are, or have, developed a robust OWTS management strategy and frameworks, to partner with Hawai‘i's efforts. Because of the interdisciplinary nature of water resource protection and infrastructure involved, the issues and associated mandates do not fall neatly into one agency within the state or county governments. The CCWG should review options such as the creation of a new department/utility or partnering with watershed organizations or a third party, similar to Washington State, which utilized a non-profit organization to assist with financial aspects of OWTS management and upgrades. Success or failure of a program will not be easily measured by a single variable, such as the number of systems replaced. Rather, a program should be holistic, transparent, and able to easily adapt to needed management requirements (natural or human), state, federal and local laws, financial needs, and public support and perception.

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Appendix D. Financing Cesspool Conversions in Hawai'i

Financing Cesspool Conversions in Hawaii

Executive Summary:
There are currently over 88,000 cesspools throughput the State of Hawaii, discharging over 53 million gallons of untreated sewage into the ground each day.

In 2016, the State of Hawaii banned the construction of new cesspools and in 2017 passed a law requiring all cesspools be converted by the year 2050 (Act 125). This paper explores funding sources and financial mechanisms that may be of interest to the Hawaii Cesspool Conversion Working Group. It provides an overview of United States Environmental Protection Agency (EPA), United Stated Department of Housing and Urban Development (HUD), United States Department of Veterans Affairs and United States Department of Agriculture (USDA) Rural Development federal funding programs which could potentially be used to close/convert cesspools, financial options available to the State of Hawaii and the four counties to utilize these funds and recommended next steps. The list of state financial option examples is not intended to be exhaustive but rather provide a variety of relevant examples for Hawaii to consider. The recommended next steps outline a path forward that could help Hawaii create a financially flexible program to achieve Cesspool Conversion Working Group goals. The recommended next steps are 1. Working with the Environmental Finance Center, and 2. Creating a Hawaii equivalent to the Craft3 Program.

❈ ❈ ❈ ❈ ❈

What are cesspools?
Cesspools are underground holes used throughout Hawaii for the disposal of human waste. Raw, untreated sewage is discharged directly into the ground, where it can contaminate oceans, streams and ground water by releasing disease-causing pathogens and nitrates. They were installed to serve many homes and businesses in Hawaii. Some communities adjacent to beaches are known to have high levels of bacteria and nutrients in the water due to cesspool leakage.

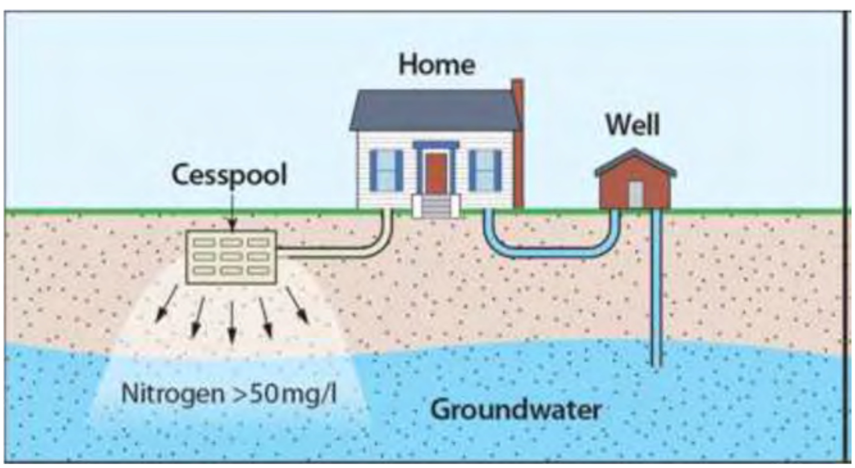


Figure 1: Cesspool Diagram

Why is US EPA Region 9 Involved?
In 1999, EPA promulgated regulations under the Safe Drinking Water Act's Underground Injection Control (UIC) Program, which prohibited the construction of new Large Capacity Cesspools (LCCs) as of April 2000 and required the closure of all existing LCCs by April 5, 2005 (see 40 C.F.R. § 144.88).

Under federal regulations, an LCC is a cesspool which serves multiple dwellings, or for non-residential facilities has the capacity to serve 20 or more persons per day.

Hawaii has one of the highest levels of reliance on groundwater for drinking water as any State (95%) and competes economically on a global scale for tourism by marketing itself as a tropical paradise, making the elimination of cesspools critical to the State's health and welfare. The current Hawaii Water Quality Integrated Report identifies numerous impaired coastal water segments which do not meet state water quality standards for nutrients (nitrogen and phosphorus). These water quality impairments are attributed largely to nonpoint sources of pollution, including cesspools. A study conducted by the State of Hawaii identified 2,500 cesspools located within the capture zones delineated around public water supply wells.

Since 2002, US EPA Region 9 has implemented a LCC outreach, education, enforcement and monitoring program. To date, EPA has identified over 4,900 LCCs in Hawaii and monitored the closure/conversion of about 71%.

State of Hawaii Law and Cesspool Conversion Working Group

The State of Hawaii recently banned new cesspools and created a law that requires all cesspools to be closed by 2050. The State of Hawaii Legislature, through Act 132, established a Cesspool Conversation Working Group. The purpose of this working group is to develop a long-range, comprehensive plan for cesspool conversion statewide for all cesspools by 2050. Act 132 is based on Senate Bill 2567, which reads "The legislature finds that public health and the quality of Hawaii's drinking water, streams, ground waters, and ocean are being harmed by water pollution from cesspools. Hawaii has eighty-eight thousand cesspools that deposit approximately fifty-three million gallons of raw sewage directly into the groundwater every day. Drinking water, public recreation, and the precious coral reefs, on which Hawaii's economy, shoreline, recreation, fisheries, and native species depend, are or may be harmed by such pollution. The purpose of this Act is to establish a cesspool upgrade task force to consider and recommend means by which the department of health can ensure that cesspools on properties that are within priority upgrade areas are converted to more environmentally-responsible waste treatment systems or connected to sewer systems within fifteen years." U.S. EPA Region 9 has a representative on this working group.

Cesspool Alternatives

Options to close/convert cesspools:
-Replace cesspools with innovative septic tank alternatives (approved by the Hawaii Department of Health, see HAR Chapter 11-62) or septic systems/individual wastewater systems.
-Combine or connect properties with cesspools or malfunctioning septic systems into a cluster system
-Connect to a new or existing Wastewater Treatment Facility (WWTF)

Available Federal Funding

EPA's Clean Water State Revolving Fund (CWSRF) may now provide financial assistance for the construction, repair, or replacement of decentralized wastewater treatment systems that treat municipal wastewater or domestic sewage. This is a change from what was previously eligible. Previously, the SRFs could only fund decentralized systems in cases where the project was correcting an existing nonpoint source problem. In effect, it only funded the repair or replacement of existing systems. In addition to what was previously eligible, we can now also fund new, publicly or privately owned decentralized systems. SRF assistance for decentralized systems can be provided to public entities, such as municipalities, county governments, and state agencies, as well as private entities such as homeowners associations, nonprofit organizations, and individual homeowners.

In general, the CWSRF grant program funds up to 80% of project costs and requires a 20% non-federal match. The Water Resources Reform and Development Act of 2014 (WRRDA) includes additional subsidizations such as principal forgiveness, negative interest loans and grants. Among its provisions are amendments to Titles I, II, V, and VI of the Federal Water Pollution Control Act (FWPCA). It also offers up to 30-year loan terms and new eligibilities. As amended, the FWPCA now includes section 603(c)(4), which states that each CWSRF may provide financial assistance: for the construction, repair, or replacement of decentralized wastewater treatment systems that treat municipal wastewater or domestic sewage.

- Publicly and privately owned decentralized wastewater treatment projects are eligible.
- Eligible projects include, but are not limited to, the construction of new decentralized systems (e.g., individual onsite systems and cluster systems), as well as the upgrade, repair, or replacement of existing systems.
- New decentralized eligibilities include: Decentralized projects do not need to address an existing NPS problem.
- Decentralized systems for new construction may now be funded as either individual or cluster onsite systems.
- Decentralized systems may be publicly or privately owned and serve either public or private purposes.

HUD's Community Development Block Grant (CDBG) can be used to fund alternatives to cesspools or connections for septic tanks as long as funding is applied to a low-moderate income family/beneficiary. CDBG could not be used to subsidize upper income households. The key caveat is the County would need to agree to use its CDBG funds towards this purpose.

Veterans Affairs can issue home loans to qualified applicants. In Hawaii, existing cesspools may be acceptable for VA Lending Purposes if the following conditions are met:

1. Lender must verify with the State of Hawaii, Department of Health, Wastewater Branch that the cesspool was properly permitted when installed. The Wastewater Branch keeps and can provide a copy of the Cesspool Registration Card. This Card must be kept in the Lender's loan file.
2. The cesspool must be tested/recertified in the following circumstances:
    a. There has been an enforcement action due to a failure of the system.
    b. The Appraiser notes obvious signs of failure of the cesspool during the inspection of the subject property.
    c. There has been significant building modification (additions to the home, not remodeling) that increases either the living area or number of fixtures disposing waste water into the cesspool.
    d. The cesspool is located in the groundwater table.

3. If one or more of the conditions listed under Item #2 apply, Lenders are responsible to order cesspool testing by a specialist acceptable to the Department of Health.
    a. Should the cesspool require testing, the NOV must be conditioned in Block 5. WATER/SEWAGE SYSTEM ACCEPTABILITY: Evidence from the local health authority or other source authorized by VA that the individual sewage disposal systems are acceptable.

USDA's Rural Development Program offers low-income families housing repair loans of up to $20,000 at 1% interest rate and/or grants to applicants of 62 years or older for up to $7,500 in eligible rural areas. Loans can be used to improve or repair rural homes and cesspool replacement costs/conversion costs are eligible. Grants must be used to remove health and safety hazards and cesspool replacement costs/conversion costs are eligible. Larger direct home loans are also available to low and very low-income households and cesspool replacement costs/conversions are eligible. Additional USDA Rural Development Program links are listed below in the references section of this document.

<u>All of Kauai, Molokai and Lanai are considered rural areas. The maps below highlight ineligible areas on Oahu, Hawaii and Maui.</u>

Figure 2. Map of Oahu. All of Oahu is considered rural except for those areas highlighted in pink.

Figure 3. Map of Hawaii. All of Hawaii is considered rural except for those areas highlighted in pink.

Figure 4. Map of Maui. All of Maui is considered rural except for those areas highlighted in pink.

State of Hawaii Wastewater Tax Credit

The Hawaii State Legislature passed a Wastewater Tax Credit that provides credits for homeowners who have cesspools upgrading to septic tanks, aerobic treatment units, sewer lines. Qualifying homeowners can receive up to $10,000 in income tax credit.
Deadline: December 31, 2020
For more information visit the Department of Health's Website:
http://health.hawaii.gov/wastewater/home/taxcredit/

State Examples of Financial Program Options

The State of Hawaii needs to decide how to best utilize available funding. Here are several financial program options the State of Hawaii could create:

Delaware: Loans

The Delaware SRF program makes direct loans to homeowners for septic system repair and replacement. The loans are secured by a mortgage lien on the property being serviced. The program is managed by the Delaware Dept of Natural Resources and Environmental Control Environmental Finance which shares a partnership with First State Community Action Agency (FSCAA) to assist with the application process.

Delaware has 2 options for funding decentralized systems, based on income:

1. **The Septic Rehabilitation Loan Program(SRLP)** provides financial assistance to moderate to low income homeowners to replace failing septic systems.

- On the financing side, up to $35k for individual homeowners is available. The average loan is $15k, and the minimum loan is $1k
- $250k can be made available for mobile home parks
- Interest rates are based on income
- Loans have a 20 year term
- Eligible loan costs include: Site evaluation, design, permits, construction costs, and closing and recording charges

- Applicants that are in bankruptcy are not eligible, and applicants must pass a basic credit check.
- Poor credit and a high debt-to-income ratio can disqualify an applicant, however they may be eligible for the Septic Extended Funding Option.
- The Septic Extended Funding Option, as described in the previous slide, provides 0% interest and no monthly payments. Loans are to be repaid if and when the property is sold.

2. **The Septic System Extended Funding Option (SEFO)** is used when an applicant is denied a SRLP loan due to the underwriting criteria. These are given a 0 percent loan with no monthly payments. The loans are forgiven after 20 years; however, principal must be repaid immediately if the property is sold or the mortgage loan is refinanced. This program is funded by an annual allocation of $500,000 that comes from a 1 percent fee charged on CWSRF municipal wastewater loans.

Washington: Pass-Through Entities/ Regional On-Site Sewage System Loan Program (RLP)/Craft3

- Provides financing to individual residents for repair of septic systems
- County or health department (pass-through entity) is responsible for loan servicing
- $15 million in CWSRF loans has been provided for the program since 1990, and over 600 homeowners have participated since 2007.
- Since 1994, Craft3 has conserved or treated 1.4 billion cumulative gallons of wastewater.
- CWSRF loans are signed with several Washington counties and conservation districts to address nonpoint water quality problems. These counties/ conservations districts act as "pass-through entities". The pass-through entities then provide sub-loans to local homeowners for repair and replacement of septic systems.
- Additionally, the Washington CWSRF funds a pass-through program with 15 counties or local health departments in the Puget Sound and marine counties, as well as the Spokane Conservation District, that provides financing to individual residents to repair failing septic systems.
- The loans may also pay for abandonment of septic systems and connection to sewer. The county or health department is responsible for local loan servicing, collecting payments, and payment tracking (but may contract these services to a lending institution).
- Through Craft3, the loan fund provides loan assistance to eligible property owners across a multi-county region to repair, upgrade, or replace failing or malfunctioning septic systems to protect public health and water quality. Craft3 works with the local authorities to ensure that every repair and replacement they fund is appropriate and approved. Craft3 assumes the financial risk associated with lending, and is obligated to repay the SRF funds. Structuring the RLP with a revolving loan fund component leverages grant-funded resources for reinvestment in local communities.
- This program is fiscally innovative. It directs more funds into the actual repair and replacement of failing septic systems than the individual county programs, and less money is spent on administration of the program.

Current Eligibility:

- Residential properties throughout Oregon and in many Washington counties.
- Loan-to-value and loan amount maximums apply to repayment types.
- One of the following must apply:
    - your septic system is at least 25 years old;
    - your system is failing;
    - you've been contacted by Health Officials; or
    - you are under orders to fix your septic system.
- Counties currently served by Craft3:
    - Residential Oregon: All

- o Residential Washington: Clallam, Clark, Cowlitz, Grays Harbor, Island, Jefferson, King, Kitsap, Mason, Pacific, Pierce, Snohomish, Thurston, Wahkiakum and Whatcom
- o Commercial septic systems: All in Oregon or Washington

CRAFT3 MAKES REPLACING SEPTIC SYSTEMS EASY

1. Apply Online. Receive pre-approval in as soon as three business days.
2. Work with the contractor to design the system, receive permits and finalize project cost.
3. Sign loan documents electronically.
4. Begin the project. Make sure work is completed to the customer's satisfaction.
5. Authorize final payment to the contractor once the project gets final approval from local officials.
6. Loan payments, if required, will be automatically withdrawn from the customer's bank account.

Minnesota: Conduit Lending
Minnesota has a Small Community Wastewater Treatment Program.
Funds for the program have been appropriated by the legislature from the Clean Water Fund via the Clean Water, Land and Legacy Amendment.

Administered by the Minnesota Public Facilities Authority, the program provides technical assistance grants and construction grants and loans for public subsurface sewage treatment systems.

Technical assistance grants up to $60,000 may be used by communities to contract with licensed SSTS professionals, counties, the University of Minnesota on-site sewage treatment program, or qualified nonprofit organization to conduct preliminary site evaluations and prepare feasibility reports, provide advice on possible SSTS alternatives, and help develop the technical, managerial, and financial capacity to build, operate, and maintain SSTS systems.

The PFA provides construction financing up to $2 million per year at 1 percent interest and grants up to 80 percent, based on affordability criteria. Disadvantaged communities may receive 50% grant/principal forgiveness. There are specific scoring protocol for projects in unsewered areas require applicants to establish a user charge system to pay for operation and maintenance costs. All unsewered communities seeking CWSRF funding for decentralized systems must create:

- Financing plan that provides a dedicated source of revenue for debt service and operation and maintenance (typically special assessments or user charges)
- Management Plan with a schedule for inspections, pumping, repair and replacement
- Alternatives analysis using the Wastewater Treatment Hierarchy "Wastewater Hierarchy". This Hierarchy encourages communities to focus on small, acute problem areas before deferring to a larger infrastructure solution to correct environmental or public health issues.

Rhode Island: Loans
Through the Rhode Island Community Septic System Loan Program (CSSLP), loans are made to communities who then distribute to individual homeowners.

- Rhode Island Housing and Mortgage Financing Corporation (RI Housing) acts as the loan servicing agent and loan administrator
- RI Housing accepts applications from homeowners, coordinates payments to septic system installers; collects repayments from homeowners, credits repayments to the principal payment of the local government unit; makes monthly reports to both the CWSRF and the local government unit.
- Communities may only qualify for funding after completing an Onsite Wastewater Management Plan

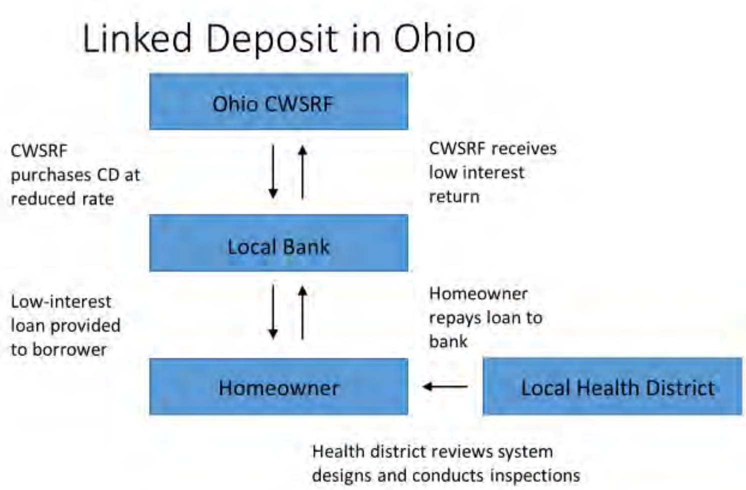
- No income limits for program participants
- Can be used for residential properties with up to 4 units
- Financing up to $25,000 at 2% for 10 years
- $300 origination fee
- 1% service fee on outstanding loan balance

Rhode Island Sewer Tie-In Loan Fund (STILF)

- Loans for homeowners to tie into the local sewer system and abandon individual septic systems
- Financing up to $150,000 to sewer system owner
- Owner then directs funds to individual homeowners via RI Housing (as above)

Ohio: Linked Deposit

- The Ohio CWSRF uses a linked deposit program to make low-interest loans available to individual homeowners in need of upgrading or replacing their decentralized systems.
- Under a linked deposit approach, a state works with their ocal banks at a reduced rate to provide assistance. This allows the borrower to receive a loan at under market rate. The CWSRF investment (deposit) is linked to a low-interest loan, hence the term "linked deposit".
- This type of program benefits CWSRF programs, local banks, and borrowers.
    - CWSRF: high priority projects are supported, risk and financial management is placed on banks
    - Local banks: earn profits from linked deposit agreements and add an additional service for their customers
    - Borrowers: save money with low-interest loans, and they find comfort in working with local banks
- The Ohio CWSRF partners with local counties, health districts, and banks to offer this program.
- The homeowner obtains a permit from the local health district, which contains specifications on the proper installations, operation, and maintenance of the onsite system.
- The homeowner is then issued a certificate that he or she can take to any bank that participates in the Linked Deposit Program.
- The bank, using its own criteria, decides whether or not to offer the applicant a loan and at what interest rate and term.
- The lending institution then notifies the Ohio CWSRF, which then deposits the loan amount in the institution at a reduced interest rate. The savings from the reduced interest rate are then passed on to the loan applicant.



Ohio: Special Purpose Grants

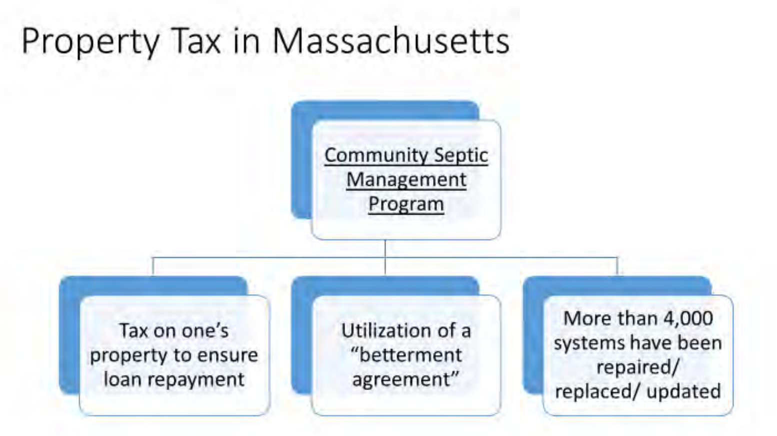
- Ohio Water Development Authority's Un-Sewered Area Assistance Program
  - Grants for the construction of a POTW for un-sewered areas that have failing on-lot
  - systems. To assist local gov't agencies who are responsible for un-sewered areas to
  - construct a POTW as affordably as possible.
  - To Qualify:
- Documented failing on-lot system (septic or cesspool)
- MHI < statewide average
- Permit-to-install for proposed improvements issued by OEPA
  - Eligible costs include
- Engineering
- Permit fees
- Land acquisition
- Construction Costs
  - Grant award amount:
- Grant award amount MHI < $20,000 MHI $20,001 - $35,000 MHI $35,001 to State
- < 100 customers $1,000,000 $750,000 $500,000
- 100-200 customers $750,000 $500,000 $250,000
  - 200 customers $500,000 $250,000 $250,000

Massachusetts: Property Tax

- Funding nontraditional eligibilities with the CWSRF often involves identifying unconventional repayment sources. While "traditional" pipe and plant infrastructure projects often have a stable revenue source, many nontraditional projects lack these options. The property tax is a creative revenue source for funding nontraditional projects.

  The Community Septic Management Program:
- was created in 1996 after the Massachusetts DEP recognized failing cesspools and septic systems as a leading cause of water pollution and drinking water contamination.
- allows municipalities to borrow funds at a below market rate (the Massachusetts Clean Water Trust provides up to $5 million a year from the CWSRF program assets to fund municipalities' needs). Municipalities in turn lend money to homeowners at a low interest rate for septic system repair or replacement.
- utilizes a "betterment agreement" that channels loans through a municipality to individuals for septic system improvements and allows the municipality to ensure that the loan is repaid as part of a property tax bill. The municipality can place a municipal lien on property if the homeowner defaults on the loan.

  A Betterment is a Financial Agreement between a homeowner and the community. The "Betterment Agreement" outlines the rights and responsibilities of the community and the homeowner for the repair, replacement or upgrade of the homeowner's septic system
  A Betterment Agreement between the community and a homeowner may be used for all costs necessary to repair or replace a failed septic system including:
    - renovating the existing system
    - hooking up to existing sewer lines
    - replacing traditional septic systems with an approved Title 5 innovative/alternative system
- Since the implementation of the Community Septic Management Program, more than 4,000 systems have been replaced, repaired, or upgraded. Over $22 million in low interest loans have been approved by the MA Clean Water Trust and the MA CWSRF program to communities.



Recommended Next Step 1: Work with the Environmental Finance Center

The Environmental Finance Center is dedicated to enhancing the ability of governments and other organizations to provide environmental programs and services in fair, effective, and financially sustainable ways. In addition to direct community outreach, the EFC at UNC works with decision-makers to assess the effectiveness of environmental finance policies at a regional or state level, and to improve those policies as a way of supporting local efforts.

In Hawaii, the Environmental Finance Center could:

- Evaluate funding and financing strategies for decentralized wastewater system repair, replacement, and on-going management.
- Work with local entities to assess, develop and market local programs.
- Work with federal, state and county entities (HDOH, SRF programs, HUD, USDA Rural Development, regulators, DBEDT) to utilize existing programs such as CWSRF funding to be used to support decentralized wastewater improvements. This has been done by a few states and there are several approaches that could be considered.
- Provide a range of finance modeling and legal framework analysis. In other words, EFC can develop multiyear finance models as well as review local and state laws related to local finance to understand options. The later task can be important when public funds are going to benefit private property owners. It is important to identify obstacles early in the process so there is sufficient time to develop solutions.

The EFC competed for and won an agreement to operate a US EPA funded Finance Center. Work related to supporting finance strategies and programs for decentralized wastewater treatment in Hawaii could be completed as part of this scope of work, if state funds are available. EFC also has an on-going EPA project that allows EFC to work directly with states and local utilities on small system management issues. For this project, EFC typically does at least one state event and carries out a combination of in-person and remote assistance activities relating to small water systems.

In the past, EFC worked directly for the Hawaii Department of Health to prepare a statewide water finance and benchmarking system: https://efc.sog.unc.edu/resource/hawaii-water-rates-dashboard. EFC also analyzed onsite wastewater financing options and examples for North Carolina. While dated, this paper describes what continue to be viable options in NC and other states: https://efc.sog.unc.edu/sites/default/files/FinancingOnsiteWastewater_0.pdf

Recommended Next Step 2: Create a Hawaii equivalent to the Craft3 Program, using the financial program options best suited for Hawaii. I am not recommending any particular financial option, but rather a program similar to Craft3 that provides maximum financial flexibility and accomplishes the Cesspool Conversion Working Group goals.

For more than ten years, Craft3 has been financing replacement of failing septic systems for families in the Northwest with their unique Clean Water Loan program, a customer-friendly, easy-to-use, one-stop-shop portal. This is not a traditional program, just like they are not a traditional financial institution, but rather a collaboration between public and private funding institutions, coming together to provide critical financial support so the state can meet their overarching environmental goals. The program is designed to work for each applicant's unique situation.

Please visit EPA's Water Infrastructure and Resiliency Finance Center Water Finance Clearinghouse to learn more about funding, financing, and other resources for the water infrastructure sector. Please watch the in-depth, step-by-step water finance guides that provide information on funding and financing options to support communities' water infrastructure decision-making. The first modules focus on the drinking water and clean water state revolving funds (SRFs), the Water Infrastructure Finance and Innovation Act (WIFIA), and Financing Septic Systems.

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Research Methodology:
This paper is written as a compendium of key information about financing cesspool conversions in Hawaii. Resources and content come from government programs and websites. Recommendations come from my own personal experience and interviews. All information in this paper is public information and may be shared.

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https://www.rd.usda.gov/programs-services/emergency-community-water-assistance-grants
https://www.rd.usda.gov/programs-services/individual-water-wastewater-grants
https://www.rd.usda.gov/programs-services/search-special-evaluation-assistance-rural-communities-and-households
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Additional State Examples include:
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https://www.epa.gov/septic/webcasts-about-onsite-wastewater-treatment#suffolk
Florida: https://www.flchamber.com/securing-floridas-water-future-a-series-featuring-fau-harbor-branch-research-professor-dr-brian-lapointe/

Appendix E. A Multi-State Regulation and Policy Survey of Onsite Wastewater Treatment System Upgrade Programs

A MULTI-STATE REGULATION AND POLICY SURVEY OF ONSITE WASTEWATER TREATMENT SYSTEM UPGRADE PROGRAMS

Michael Mezzacapo

September 2019

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PROJECT REPORT FOR
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Principal Investigator: Darren Lerner, Ph.D.

WATER RESOURCES RESEARCH CENTER
HAWAIʻI SEA GRANT COLLEGE PROGRAM
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Executive Summary

The EPA has recognized that decentralized onsite wastewater treatment systems (OWTS) can be an important alternative to centralized sewer systems by providing reliable wastewater treatment, public health benefits, and economic benefits to rural communities. However, conventional OWTS remove a limited amount of nutrients, especially within areas of permeable soils with little organic content, high oxygen levels, and poor mixing of receiving waters. Communities that face challenging nutrient loading issues may wish to evaluate many factors, including OWTS density and future climate change impacts such as sea-level rise prior to deciding which types of wastewater treatment systems would be most effective at removing nutrients for the cost.

The U.S. Environmental Protection Agency (EPA) concluded in its Guidance for Federal Land Management in the Chesapeake Bay Watershed that conventional onsite wastewater systems are not appropriate for communities with nutrient-sensitive watersheds. Many of the upgrade programs reviewed in this report recognized the need to use appropriate technologies aided by an evaluation of site-specific conditions when addressing nutrient pollution. The creation of model or pilot programs to test and evaluate new OWTS technologies with fast-track approval for validated technologies was observed in many of the states surveyed.

Innovative and advanced onsite wastewater treatment systems (I/A/E systems) can provide greater nutrient reduction, but there are many other variables to consider when choosing an appropriate replacement technology to upgrade an outdated OWTS. OWTS location, density, and maintenance schedule are all important factors when considering potential risks to groundwater supplies and designing wastewater management plans. Nitrogen removal effectiveness varies across OWTS type, residence time, climate, and location. OWTS Management programs, such as that in Barnstable County (Massachusetts), highlight the need and benefit of routine monitoring of systems combined with proactive management. Results have shown programs like these may maintain and improve nitrogen removal performance but may require repeated system checks and long-term monitoring.

The most common upgrade and conversion mechanism instituted by the states surveyed was the upgrade of OWTS at the time of the property transfer. Other common methods included upgrading OWTS if systems failed during inspections or through a blanket phase-out program of illegal waste disposal methods, such as cesspools. Many states set requirements for the timing and type of OWTS evaluations, operations and maintenance (O&M), enforcement, and options for upgrading failed or nonfunctioning OWTS. Additions to existing state and local regulations were often made to accommodate new and future wastewater technology needs. Some states incorporated sustainability and resilience elements into their plans to mitigate against climate change impacts, along with integrating updated best management practices in the fields of construction, permitting, disposal, and servicing of OWTS.

Suffolk County New York was the only state of the six states analyzed that created a single holistic program that managed all aspects of OWTS or cesspool upgrades. Creating a single program that includes elements of installation, permitting, technology approval, enforcement, and outreach may be beneficial. Many of these areas can become siloed in specific departments of state and local government offices depending on their individual mandates and politics. The state of Hawaiʻi may wish to study and develop efficient methods to integrate interdepartmental aspects of management programs, including data, licensing, permitting, and compliance. One possible solution may be to create a separate entity that is wholly tasked with handling all aspects of an OWTS upgrade and conversion programs.

Compliance and enforcement methods varied across the conversion programs evaluated. Although some states like New Jersey have maintenance requirements written into the regulations, County governments are limited in tracking compliance due to staffing and budget constraints. Rhode Island cesspool regulations included a monetary fine of up to $2,500 for failing to comply with upgrade requirements after inspection. However, enforcement actions were rarely taken as the state sought to work with property owners to facilitate compliance.

Achieving complete compliance with regulations is likely impossible. Decisions to comply, evade, or violate obligations are often determined by multiple interacting influences. Therefore, it may benefit the Cesspool Conversion Working Group to evaluate, through public outreach, the interacting influences (financial, political, regulatory, social) of those that may be required to upgrade a cesspool or outdated OWTS system as a result of Act 125.

Getting citizens to spend money to upgrade an OWTS without a direct and visible benefit or service reciprocated may dissuade some from participating, even when penalties are assessed for noncompliance. Providing education and examples of the tangible benefits realized by upgrading an OWTS, reducing pollution, and preserving ecosystem services may improve compliance outcomes. For many citizens, understanding the concept of ecosystem services and the value they provide is often abstract and indirect. Solely communicating the monetary valuation of an ecosystem service like clean water, achieved through the reduction of nutrients by OWTS upgrades, may be inappropriate, or at the very least inefficient. One theme that resonated through all the OWTS programs surveyed is the need for and value of a robust education and outreach program that allows for improvements and adjustments as homeowner and stakeholder knowledge and needs shift. Responsible entities may wish to hold community workshops to introduce the concept of ecosystem services -beyond monetary valuation- and listen to a broader range of stakeholder values associated with the targeted resources of that community. If OWTS upgrade programs can effectively communicate impacts with respect to community desires, concerns, and resource usage, they may have more success.

The ability of a responsible management entity or state to run a successful OWTS upgrade and conversion program will require obtaining, organizing, and managing a large amount of data about ecosystem impacts and current OWTS inventory, including geographic location, density, type, system age, hydrology, and servicing dates. Organizations can make more informed decisions about the management of decentralized OWTS by developing a robust dataset and improving data sharing coordination between multiple agencies and even regionally, if applicable.

A poorly executed management plan, lack of data, or poor communication between organizations and departments might cause the performance of individual OWTS to be adversely affected and ultimately impact overall nutrient reduction goals.

States and counties such as Rhode Island, Massachusetts, and Suffolk County (New York) require or entice (through funding opportunities) communities to create OWTS management plans which outline strategies and implementation measures to ensure the proper management, inspection, use and maintenance of I/A/E systems and sometimes conventional OWTS. In Rhode Island, communities were unable to obtain state grant funding to upgrade systems without a proper management plan. States such as Massachusetts and Rhode Island delegate local health departments to oversee elements of OWTS management plans, including enforcement. The OWTS management plans analyzed were typically limited to geographical community boundaries and often did not cover not an entire watershed. Due to the unique geography and hydrology, the state of Hawai'i may wish to consider creating plans around watershed boundaries if OWTS management plans are instituted.

OWTS management plans will require significant financial and public support. Homeowners, maintenance providers, and other stakeholders should be involved in the development process of OWTS management plans from the beginning. Without stakeholders understanding why a management program is important, there is little chance it will be adopted. After a program has been chosen and adopted, the management entity must keep stakeholders engaged, involved, and informed. Consistent and engaging education, messaging and outreach programs that explain the needs and benefits of new requirements and rules may increase the chances of a program’s success. OWTS conversion programs are often long-term efforts that move at a slow pace. Many of the states evaluated converted only a couple thousand OWTS units per year; therefore, it will be critical to developing a program that continuously engages homeowners and stakeholders over the long-term. An effective learning and outreach program may consider using a centralized website alongside diverse methods of communications that are tailored for a public audience allowing all aspects of the wastewater management plan to be viewed. This approach was taken by Suffolk County (New York) with the Reclaim Our Water Initiative.

Installing an OWTS requires a substantial monetary investment by the homeowner. Five of the six states surveyed created robust financial programs and incentives to ease the high cost of upgrading to innovative and advanced technologies. Programs in New York, Maryland, and Rhode Island offered homeowners modest grants and low-interest loans. Other financial incentive options included tax betterment arrangements or annual tax breaks. Conversion to innovative and advanced systems may hinge on a homeowner’s ability to cover the cost difference of conventional OWTS upgrade versus nitrogen reducing technologies. Therefore, states may wish to identify and address long-term funding challenges, including identifying sustainable sources and revenue streams to cover program administration and upgrade costs. Maryland’s Bay Restoration Fund is unique in that it charges a user fee to OWTS and municipal sewer customers to cover the cost of program administration and grant upgrade programs. The method of monetary dispersal also varied across the states with Maryland directly compensating contractors when upgrading I/A/E systems through grant funding, and others like Rhode Island distributing money directly to homeowners.

Finally, each state faced unique challenges that represented the political, financial, and cultural climate of that region. For example, Suffolk County (New York) studied many other state programs and gained information pertaining to failures and successes that informed the development of their own cesspool conversion and innovative and advanced technology upgrade program. Many of the states in this report have developed a basic foundation for a successful conversion and OWTS upgrade program. It may be advantageous for the state of Hawai‘i to borrow successful elements from other state programs while simultaneously delegating local control of program elements to the counties to adjust for differences in the unique geology, hydrology, and cultural aspects of the islands.

Acronyms/Abbreviations

ANSI	American National Standards Institute
BAT	Best Available Technology
BRF	Bay Restoration Fund
CAP	Community Aggregation Plan
CBRF	Chesapeake Bay Restoration Fund
CCWG	Cesspool Conversion Working Group
CCWT	Center for Clean Water Technology
CDBG	Community Development Block Grant
CIOWTS	Certified Installer of Onsite Wastewater Treatment
CIP	Community Inspection Plan
CO	Certificate of Occupancy
COC	Certificate of Compliance
CRA	Critical Resource Area
CSMP	Community Septic Management Program
CSSLP	Community Septic System Loan Program
CWA	Clean Water Act
CWCA	Clean Water Commerce Act
CWSRF	Clean Water State Revolving Fund
DCA	Department of Community Affairs
DEM	Department of Environmental Management
DNREC	Department of Natural Resources and Environmental Control
DOH	Department of Health
EPA	(U.S.) Environmental Protection Agency
ETV	Environmental Technology Verification
FEMA	Federal Emergency Management Agency
GIS	Geographical Information Systems
GPD	Gallons Per Day
GWMZ	Groundwater Management Zone
HSRLP	Home Septic Repair Loan Program
HTP	Homeowner Training Program
I/A/E	Innovative, Advanced or Experimental (Onsite Wastewater System)
LBH	Local Board of Health
LINAP	Long Island Nitrogen Action Plan
LSMP	Local Septic Management Plan
MASSDEP	Massachusetts Department of Environmental Protection
MASSTC	Massachusetts Alternative Septic System Test Center
MHFA	Massachusetts Housing Finance Agency
NEHA	National Environmental Health Association
NFAA	Non-Federal Administrative Account
NJDEP	New Jersey Department of Environmental Protection
NJEIT	New Jersey Environmental Infrastructure Trust
NJWB	New Jersey Water Bank
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination Systems
NSF	National Sanitation Foundation
O&M	Operations and Maintenance
OWMP	Onsite Wastewater Management Plan
OWTS	Onsite Wastewater Treatment System
PCS	Pollution Control Security
PSN3	Performance Standard Nitrogen Level 3
RICRMC	Rhode Island Coastal Resources Management Council
RIDEM	Rhode Island Department of Environmental Management
SCDH	Suffolk County Department of Health
SEFO	Septic System Extended Funding Option Program
SLOSH	Sea, Lake, and Overland Surge from Hurricanes
SRF	State Revolving Fund
SRLP	Septic Rehabilitation Loan Program
STILF	Sewer Tie-In Loan Fund
SWP	Revised Draft Subwatersheds Wastewater Plan
TMDL	Total Maximum Daily Load
TWA	Treatment Works Approval
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WIP	Watershed Implementation Plan
WQMP	Water Quality Management Plan

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Introduction

Nearly fifty-three million gallons of raw sewage enter Hawaiʻi's ground and surface waters every day, most of this pollution comes from roughly 88,000 cesspools across the state.[1] According to the Hawaiʻi State Department of Health (DOH), cesspools are a substandard method to dispose of human waste.[2] In 2017, the Hawaiʻi State Legislature passed Act 125, requiring the replacement of all cesspools by 2050. The Hawaiʻi Department of Health was tasked with investigating the number, scope, location, and priority of cesspools statewide.[1] In 2018, the Legislature established a Cesspool Conversion Working Group (CCWG) under Act 132 to create a long-range, comprehensive plan for cesspool conversion.[3]

This report was commissioned by the CCWG to evaluate and analyze cesspool and conventional on-site wastewater treatment system (OWTS) conversion methods in other states. States were chosen based upon proximity to a coastal environment, the number of cesspools, and recent legislation. Six states were evaluated based upon criteria approved by the Data and Prioritization Subgroup of the CCWG. This document is meant to briefly summarize other state efforts, policies, and procedures regarding OWTS upgrades and not meant to be an exhaustive report on state OWTS regulations. The document is organized by state and subdivided into eight categories: (1) regulation overview, (2) regulation enforcement and requirements, (3) methods to determine priority conversion areas, (4) methods to identify impaired waters, (5) nutrient reduction science, (6) conversion technologies/future approval, (7) conversion method and timelines, and (8) funding mechanisms. Embedded within the document are URL links directing the reader to sites with further information about specific policies. After each section, a bulleted summary outlines successful aspects of that state's program or potentially feasible methods that the State of Hawaiʻi may wish to evaluate when drafting its own cesspool and OWTS conversion program. Every effort has been made by the author to ensure that each state's policies and regulations are accurately represented in this report, however, some errors may still exist. When possible, chapters were edited and reviewed by counterparts within their respective state departments handling OWTS and water pollution issues.

1. Rhode Island

Rhode Island is a state in southern New England bordered by Connecticut to the west, Massachusetts to the north and east, and the Atlantic Ocean to the south. The Narragansett Bay, New England's largest estuary, is the state's most distinctive feature and contributes significantly to Rhode Island's 400 miles of coastline.[4,5] The United States Census Bureau estimates the population to be 1,057,315 as of 2018. The population density is 1,018 people per square mile.[6] The total land area of the state covers 1,045 square miles.[7] Rhode Island has a humid continental climate, with warm summers and cold winters.

1.1 Regulation Overview

Estimates calculate that almost twenty-six percent of Rhode Island's population receives drinking water from a groundwater source. In order to better protect coastal water quality, groundwater, and improve substandard waste disposal methods, Rhode Island passed The Rhode Island Cesspool Act of 2007.[8,9] When the regulation was enacted, it was estimated that Rhode Island had about 25,000 cesspools.[10] The R.I. Cesspool Act was passed in 2007 with the requirement to replace cesspools within the 200 feet zones adjacent to tidal waters, drinking water reservoirs, and public wells. This was the end result of a political process that began with a proposal for a blanket removal of all cesspools statewide. The language of the 2007 Act has been interpreted to require connections to sewers only in the 200-foot zones or when a property is sold or transferred. In 2016, the state passed a blanket cesspool phaseout program requiring the identification and replacement of cesspools of all properties subject to sale or transfer.

Efforts to only replace cesspools within environmentally sensitive regions proved to be slow and labor-intensive. According to Jon Zwarg, Senior Environmental Scientist at the Office of Water Resources in the Rhode Island Department of Environmental Management (RIDEM) (personal communication, May 2, 2019), it took years to replace about 1,000 of the 1,400 cesspools originally identified in the two hundred foot environmentally sensitive regions. The State decided that a better mechanism was needed to trigger cesspool replacement and identified a successful method used in the neighboring State of Massachusetts, the point-of-sale model. Many cesspools were being converted prior to the 2016 blanket conversion program because of an update to the OWTS rules in 2009. Cesspools were classified as substandard waste disposal methods, and many mortgage companies began requiring updates before issuing loans.

1.2 Regulation Requirements/Enforcement

All OWTS are regulated and permitted by RIDEM through the implementation of "Rules Establishing Minimum Standards Relating to Location, Design, Construction and Maintenance of Onsite Wastewater Treatment Systems."[11] However, management and enforcement of OWTS, including maintenance requirements, are delegated through local municipalities. Under the original Cesspool Act of 2007, all cesspools within two hundred feet of the inland edge of a shoreline feature bordering a tidal water area, within two hundred feet of a public drinking water well, and within two hundred feet of a surface drinking water supply were to be inspected by a specific date (D. Chopy, personal communication, April 26, 2019; J. Zwarg, personal communication, May 2, 2019).[9] Homeowners could be subject to a fine of up to $2,500 for failing to comply with cesspool upgrades after inspection.[12] However, the RIDEM sought to work with property owners to facilitate upgrades rather than take a heavy-handed regulatory approach (D. Chopy, personal communication, April 26, 2019).

OWTS Inspections are required and reported in accordance with procedures required by the RIDEM and local municipalities. Several municipalities require septic inspectors to register septic with The New England Onsite Wastewater Training Center and report inspections through an online database system at https://septicsearch.com. RIDEM does not require septic inspectors to register with the State; however, it does require OWTS designers and installers to be licensed. Cesspool inspections may be done by either a registered inspector or a licensed designer or installer. If property owners don't know if they have a cesspool, it is the homeowner's responsibility to hire a professional to identify the type of OWTS.[11] Rhode Island Class I, II, or III licensed septic system designers or Registered Septic System Inspectors are recommended by the state when homeowners are attempting to determine the type of OWTS.[13] More information on professional licensing requirements can be found on the RIDEM website.[13] Homeowners with permits for OWTS after 1990 can search and view the information in an online database that also allows towns to better manage OWTS data and inventory. The RIDEM Office of Water Resources maintains a website where homeowners can perform an OWTS permit search.[14] Permits issued prior to 1990 are also held by RIDEM but are more difficult to search online, sometimes requiring an in-person visit to RIDEM's offices (J. Zwarg, personal communication, May 2, 2019).

The Rhode Island Coastal Resources Management Council (RICRMC) has authority over construction proposed in certain coastal regions of the state.[15] The coastal region includes all coastal features and all land within two hundred feet of tidal waters, saltwater ponds, saltwater marshes, and saltwater wetlands. Cesspools within the RICRMC Special Area Management Plans for the Salt Ponds and Narrow River that must be replaced are required to upgrade to an innovative, advanced or experimental (I/A/E system) onsite wastewater treatment system that reduces nitrogen loading.[12,16]

The RIDEM has established minimum standards for OWTS throughout the state, including establishing standards related to their location, design, construction, and maintenance. RIDEM also encourages municipalities to establish local programs to meet the onsite wastewater needs of their community. Cities and towns have authority under state law to establish local management programs to encourage or require OWTS maintenance, which can help ensure systems are performing to their stated nutrient reduction expectations. These programs and requirements can be incorporated into zoning laws that allow for an additional layer of enforcement to ensure compliance by property owners (D. Chopy, personal communication, April 26, 2019). RIDEM has identified and suggested elements of a comprehensive municipal onsite wastewater program that can be found on the RIDEM website.[17] Suggested elements include a web-based tracking system, financial assistance and maintenance, and operations ordinances. Towns can require and determine appropriate ongoing maintenance requirements and enforcement beyond state requirements. The state has discussed attempting to create operational permits based upon a properly functioning and maintained I/A/E system date (D. Chopy, personal communication, April 26, 2019; J. Zwarg, personal communication, May 2, 2019).

RIDEM enforcement of the Cesspool Act of 2007 is broken into two sections. Part one includes an expedited citation notice program for cesspools within specialized protection zones. The state identified all properties that could contain a cesspool within two hundred feet of the protection zones. From that list, properties were cross-checked with permits at RIDEM and properties that have documented sewer connections (D. Chopy, personal communication, April 26, 2019). Expedited notices were then mailed to the remaining identified properties. The expedited notice program allows the state to bypass traditional notices that can be challenged in court. The notice is good for sixty days, and if the homeowner remains non-compliant, the state could assess a penalty of up to $2500.[12]

The second type of enforcement is more nuanced and involves case-by-case investigations. This method is responsible for enforcing requirements for all properties not within the specialized protection zones. RIDEM has no mechanisms in place to identify when a property replaces a cesspool during a real estate transaction because documentation is not sent to the RIDEM enforcement office. Complaints or grievances may come in from the public about potential violations. However, due to limited staff, enforcement priorities are secondary (D. Chopy, personal communication, April 26, 2019).

Designers of OWTS must renew a state license every three years and obtain continuing education credits. Installers of OWTS are licensed, however, they are not required to obtain continuing education credits.[11]

1.3 Methods to Determine Priority Conversion Areas

The U.S. Environmental Protection Agency (EPA) awarded a $3 million State and Tribal Assistance Grant to certain Rhode Island towns to develop a blueprint for creating comprehensive wastewater management plans.[18] Under the grant program, the state began to perform an extensive inventory of OWTS, which later informed the state conversion methods. More information is available within the Block Island Green Hill Pond National Community Decentralized Wastewater Treatment Demonstration Project report.[18]

In its initial cesspool conversion attempt, Rhode Island primarily used existing setback regulations for wellhead and waterbody protections to establish its cesspool priority conversion areas. The state did not perform modeling or collect water quality data to determine the priority areas to be addressed in the phaseout process. Once most of the cesspools were replaced in the established protection zones, the state shifted to a point-of-sale model for cesspool conversion. This model was borrowed from the Massachusetts Title 5 program (J. Zwarg, personal communication, May 2, 2019).

RIDEM and RICRMC used geographical information system (GIS) analysis tools, high-resolution aerial photography, and precise building location data to determine which properties were subject to the initial mandate of replacement with two-hundred feet of coastal, tidal waters, and public drinking water supplies.[19] The selection process began by mapping the inland edge of the coastal shoreline feature. Because coastal features are dynamic (beaches, bluffs, salt marsh, dunes, etc.), their boundaries sometimes shift. This requires onsite identification and verification of coastal features and distances by staff, which requires extensive resources.[19] RIDEM used photographic interpretation and approximation for the selection process. When required to convert their cesspool, homeowners were encouraged to enlist professional assistance in determining the relation to the coastal shoreline feature identified by RICRMC. More information on the selection process can be viewed on the RIDEM website archives.[19]

1.4 Methods to Identify Impaired Waters

There have been numerous studies evaluating nitrogen pollution in Rhode Island dating back to as early as the 1970s and 1980s (J. Zwarg, personal communication, May 2, 2019). EPA studies, as part of the Narragansett Bay Project, identified OWTS as a threat to the water quality of groundwater and coastal estuaries.[20] Many of these studies informed the need for the current OWTS upgrade program, however, they were not directly used to identify impaired waters for the updated OWTS regulations or Cesspool Act (J. Zwarg, personal communication, May 2, 2019).

RIDEM took a proactive approach to upgrade OWTS and converting cesspools and identified protection zones alongside the RICRMC that identified the two-hundred-foot requirements listed in the Regulation Enforcement/Requirements section.[11] RIDEM based its requirements to upgrade cesspools and mandating I/A/E systems in certain locations as a public health argument, as numerous studies identified nitrogen as a major source of pollution for coastal and groundwater sources (D. Chopy, personal communication, April 26, 2019).

1.5 Nutrient Reduction Science

RIDEM did not have the resources to develop models or perform specific research to evaluate what levels of nitrogen would be most beneficial to preserve environmental and human health in impaired areas. RIDEM monitored low dissolved oxygen levels and documented eutrophication in coastal environments but did not have the data to determine if cesspool pollution was the culprit (J. Zwarg, personal communication, May 2, 2019). According to phone conversations with Jon Zwarg (personal communication, May 2, 2019), RIDEM began to frame the argument for cesspool conversion based upon best management practices to reduce risk to coastal ecosystems, drinking water supplies, and human health. Because Massachusetts had success with its Title 5 program since the mid-1990s, and it has similar geology and climate, Rhode Island borrowed similar aspects to create its updated OWTS program (J. Zwarg, personal communication, May 2, 2019). Total maximum nitrogen discharge concentrations for all I/A/E system effluent in Rhode Island were set at 19 mg/L.[11] This number was borrowed from the Massachusetts Title 5 program (J. Zwarg, personal communication, May 2, 2019). Achieving this concentration at the point where the system discharges to the soil absorption system assumes that approximately fifty percent of the total nitrogen is removed from the influent wastewater depending on the incoming nitrogen concentration, which may vary from site to site depending on water usage and other factors.[21] Research was done by the University of Rhode Island and RIDEM in tandem with in-ground monitoring at various I/A/E systems in Rhode Island to evaluate nitrogen removal effectiveness.[22]

1.6 Conversion Technologies/Future Technology Approval

As of January 2015, 20,827 systems with I/A/E technologies and drainfields have been installed in Rhode Island. Many of these 20,000 systems were replaced for reasons other than in direct response to the R.I. Cesspool Act. Most installations were done to replace failed systems or to expand or modernize homes. As a direct result of the R.I. Cesspool Act, 148 homes have connected to a sewer system, and 361 have been identified as “need to be replaced” (J. Zwarg, personal communication, September 6, 2019).[8] RIDEM decides which areas need I/A/E systems versus conventional OWTS based upon the designation and location of critical resource areas (CRAs).[23] If residential OWTS are not within a critical resource area, RIDEM may, on a case-by-case basis, mandate an I/A/E system requirement if it will protect sensitive habitat.[11] Communities who design an Onsite Wastewater Management Plan (OWMP) can require I/A/E systems beyond CRAs to protect water resources. RIDEM has the authority to reevaluate the nitrogen effluent levels of OWTS if further water testing shows coastal areas have high enterococci levels and/or other indicators such as algal blooms and low dissolved oxygen.[24] In 2010, RIDEM attempted to work with manufacturers and municipalities to streamline permitting of new I/A/E systems as an attempt to reduce costs, however, this effort was not successful (J. Zwarg, personal communication, May 2, 2019).

1.6.1 Conventional System Conversion Methods

Two convention cesspool conversion methods are approved in Rhode Island, including connecting to a municipal sewer system or installing a conventional OWTS. Homeowners can install a conventional OWTS if it meets local and state regulations. The required minimum liquid capacity of a septic tank, below the flow line, is based on the number of bedrooms in the dwelling. The bottom of the soil absorption system must be at least three feet above the seasonal high groundwater table. For three bedrooms or less, the minimum tank capacity is one thousand gallons. For each additional bedroom, two hundred fifty gallons of capacity must be added. A garbage grinder or a one hundred gallon or greater tub will each require the septic tank capacity to be increased by two hundred fifty gallons.[11] There are no nitrogen effluent concentration requirements for conventional OWTS.[11,12] Conventional OWTS do not require a maintenance and operations contract (D. Chopy, personal communication, April 26, 2019).

Property owners must connect to a sewer if there is reasonable access and service capability, as determined by the Director of the RIDEM.[11]

The New England Onsite Wastewater Training Program is actively researching small-scale decentralized wastewater treatment systems for use in New England to meet site constraints.[18]

1.6.2 Advanced Nitrogen Removal Methods

An I/A/E system is defined as an OWTS that does not meet the location, design, or construction requirements of a conventional OWTS and demonstrates through field testing, calculations, and other engineering evaluations the ability to provide the same level of environmental and public health protection as a conventional OWTS.[11] RIDEM will maintain a list of approved alternative technologies and charge for the cost of administering the approval procedures, reviewing, monitoring, and tracking of OWTS performance standards.[25]

System evaluation criteria can be found in the OWTS Rules (page 77).[11] I/A/E systems can be removed from approval lists if applicants fail to submit reports, data, or proper permits. Manufacturers seeking approval must have a minimum of three sites and no more than ten sites where the technology is being applied. Rhode Island has created two types of I/A/E system classification.[11]

To be approved I/A/E systems must meet the following criteria for Class 1[11]:

- The vendor provides at least four consecutive years of performance data per installation for no fewer than ten installations with data collected no less frequently than quarterly that demonstrates that department standards are met; and
- The vendor demonstrates that the technology has been approved and utilized successfully for at least four consecutive years in Rhode Island with no fewer than ten installations or at least four consecutive years in at least three other jurisdictions with no fewer than ten installations in each jurisdiction. Class 1 certifications do not require renewal.

I/A/E systems must meet the following criteria for Class 2 (A or B)[11]:

A. Any Technology:

- The vendor provides at least two consecutive years of performance data per installation for no fewer than ten installations with data collected no less frequently than quarterly, that documents that RIDEM standards are met;
- The vendor demonstrates a theory or applied research; and
- The vendor demonstrates that the technology has been approved and utilized successfully for at least two consecutive years in Rhode Island or at least two consecutive years in another jurisdiction with no fewer than ten installations in each jurisdiction.

B. Nitrogen Reducing Technology:

- The vendor provides certification that the technology meets National Sanitation Foundation (NSF)/American National Standards Institute (ANSI) “Standard 245-Wastewater Treatment Systems- Nitrogen Reduction” and the testing results show a preponderance of treated effluent nitrogen concentrations of 19 mg/L or less; or
- The vendor demonstrates approval for use in another jurisdiction in an area where the temperature conditions are similar to, or colder than those in Rhode Island and with technology review criteria substantially equivalent to Class One or Class Two. Substantially equivalent review in another jurisdiction shall be held to mean the other jurisdiction has a minimum nitrogen reduction standard of fifty percent reduction in total nitrogen concentration and a maximum effluent total nitrogen concentration of 19 mg/L and the other jurisdiction has a review process in which the vendor’s data is evaluated considering a technology performance claim. Class 2 certifications require renewal every five years.

The New England Onsite Wastewater Training Center at the University of Rhode, University of Rhode Island, and RIDEM created an I/A/E system demonstration project in association with Rhode Island Independent Contractors & Associates, an organization representing contractors in construction, excavation, and utilities.[26] About fifty-eight I/A/E systems were installed and evaluated over a ten-year period. Data was then made available for industry training, performance evaluations, and the development of informed decision-making processes for OWTS regulations.[27] Approved systems were able to enter a streamlined approval process gaining provisional approval if seventy-five percent of the units installed have a combined total average effluent of 19 mg/L of nitrogen or less for at least six months of sampling.[27]

Rhode Island allows alternative toilets, including composting toilets, that comply with the requirements of the NSF Standard 41.[28] A separate OWTS for the treatment of any greywater must accompany an alternative toilet and designs on sixty percent of the normal daily design flow. Solids produced by alternative toilets may be buried on site unless the resident resides in an area designated as a CRA. Residuals shall not be applied to any food crops. Alternative toilets that generate excess liquids will be pumped to the greywater septic tank or to a separate holding tank. Liquids must be removed from this separate holding tank by a RIDEM permitted septage transporter. Owners of alternative toilets and I/A/E systems must have a valid maintenance contract with an entity or individual that is certified by the vendor. The minimum maintenance contract term is two years. RIDEM will issue a Certificate of Conformance after reviewing permits and maintenance contracts. Every two years, the I/A/E system owner must submit documents to the RIDEM showing the condition of the system and valid permits.[11]

According to Jon Zwarg (personal communication, May 2, 2019), RIDEM doesn't have adequate long-term data to determine I/A/E system nitrogen loading to ecosystems. Smaller residential OWTS aren't required to perform annual in-ground monitoring of nutrients. Nitrogen effluent estimations were calculated by technology vendors accompanied by sampling requirements for technological certification; however, long-term sampling isn't mandated for small-scale residential systems to validate claims. Therefore, the effects of lack of maintenance or climatic changes on specific I/A/E systems are unknown. RIDEM is currently in the process of evaluating if a monitoring program could be put into place to ensure systems are achieving maximal nitrogen removal. It has been best practice that vendors and maintenance providers submit maintenance contract paperwork to RIDEM to show systems are being maintained and functioning properly, however, this isn't a highly scrutinized process (D. Chopy, personal communication, April 26, 2019).

Many studies have been performed at the University of Rhode Island, including climate change impacts on the biogeochemistry of wastewater treatment in I/A/E systems.[29] Additional studies have included modeling of wastewater movement beneath OWTS soil treatment area, aerated drainfields to provide alternatives for areas prone to sea-level rise, and how removal nutrients and biochemical oxygen demand compare between conventional drainfields and shallow, narrow drainfields.[30] These types of studies can help managers approve I/A/E systems that are found to be resilient to rising water tables and changing climates. A list of approved alternative systems can be found on the RIDEM website.[30]

1.7 Conversion Method and Timeline

If a property is subject to sale or transfer after January 1, 2016, and a cesspool is found, it must be removed from service within one year of the closing date. Purchasers will have a ten-day period, unless the parties mutually agree upon a different period, to conduct an inspection of the property's OWTS.[9]

If a cesspool fails an inspection at any time, the cesspool must be replaced within one year of the failure, or less time if an imminent threat to public health is identified. A cesspool must be replaced with, at minimum, a conventional OWTS or a municipal sewer line if one is available. The upgrade requirement is triggered by the actual closing date of a property sale or transfer. If the property transaction closes prior to January 1, 2016, the upgrade requirement does not apply until the next time the property is transferred.[9,11]

Prior to the point-of-sale inspection trigger, cesspools were converted on geographical requirements (J. Zwarg, personal communication, May 2, 2019). If a cesspool is located within two hundred feet of the inland edge of all shoreline features bordering tidal water areas; two hundred feet of any public wells; or within two hundred feet of a water body with an intake for a drinking water supply, it is required to be replaced immediately.[9]

Rhode Island defines a failed cesspool as the following[9,11,31]:

- Liquid level in the cesspool is less than six inches from the bottom of the pipe that drains into it;
- Cesspool fails to accept sewage, as evidenced by sewage backing up onto the ground surface or into the building it serves;
- The cesspool must be pumped more than two times per year;
- The cesspool has been shown to have contaminated a drinking water well, stream, or wetland; or
- The bottom of the cesspool is below the groundwater table at any time of year, resulting in a direct connection between the waste in the cesspool and the groundwater.

Cesspool conversion within a year can be avoided if all criteria are met[9,11,31]:

- The cesspool has not failed,
- The property/neighborhood is to be connected to sewer by January 1, 2020,
- The property owner does not propose to increase the flow of wastewater to the cesspool (i.e., adding a bedroom to a home) prior to the installation of sewers,
- Your city or town obtains bonding authorization for expansion of sewers to the area of the building served by the cesspool, and
- You certify in writing that the building will be connected to the sewer system within six months of receipt of notification to connect to the sewer system.

A temporary hardship extension may be granted to eligible property owners and may delay the upgrade deadline as late as January 1, 2018. A temporary hardship extension expires with a property sale or transfer. To qualify for a temporary hardship extension, the property owner's income must be less than or equal to eighty percent of the area median, and the cesspool must not be classified as failed. Rhode Island allows some exceptions for the cesspool replacement requirement; including transfers between current spouses, between parents and their children, between full siblings, or where the grantor transfers the real property to be held in a revocable or irrevocable trust where at least one of the designated beneficiaries is of the first degree of relationship to the grantor.[31]

1.8 Funding Mechanisms

Towns are provided with funds (State Bond funds, Federal Nonpoint Source funds through Department of Environmental Management [DEM] grants, or EPA grants) to develop an OWMP to meet local OWTS and environmental needs. An example of an OWMP can be found on the Town Portsmouth website.[32] Program elements may include ordinances requiring system inspections, enhancing homeowner education, or specifying more stringent treatment requirements in environmentally sensitive areas. Afterward, the town is eligible to apply for the Community Septic System Loan Program (CSSLP). The Rhode Island Infrastructure Bank, RIDEM, and RIHousing launched the CSSLP in 1999.[33] Low-interest loans cover homeowner costs of conversions, repairs, and upgrades. CSSLP has been used to incentivize towns to develop an OWMP. Currently, 17 communities are participating.[33] Towns are responsible for ensuring funds are properly distributed.

CSSLP funds come from a State Revolving Fund and are administered by RIHousing.[33] RIHousing accepts applications from homeowners and coordinates payments to septic system installers. Additionally, the organization collects repayments from homeowners, adjusts repayments to local governments and makes monthly reports to both the Clean Water State Revolving Fund and the local government.

CCSLP Loan Terms[33]:

- No income limits for program participants.
- Can be used for residential properties with up to 4 units.
- One-time $300 origination fee to RIHousing and a one percent service fee on the outstanding loan balance that is split between RIHousing and the Rhode Island Infrastructure Bank for servicing the loan.
- Most programs cap loans at $25,000.
- The debt-to-income ratio cannot exceed forty-five percent.
- Non-owner occupants can participate.
- Funding covers engineering costs, as well as system replacement costs.

- Funding is released to the homeowner when RIHousing receives the DEM Certificate of Conformance.
- Work must be completed by a state-licensed installer.

The CSSLP program has distributed $12.4 million in loan funds to communities since 1999. Approximately 783 loans have been closed. The average CSSLP loan amount is $15,435, and the monthly payment for a $15,000 loan with a 10-year term would be $131.[34]

The Rhode Island Infrastructure Bank and RIHousing also oversee the Sewer Tie-In Loan Fund (STILF) to provide low-interest loans to homeowners to connect to local sewer systems and abandon their OWTS.[35] Five communities are currently participating. The Rhode Island Infrastructure Bank provides loans of up to $150,000 to the sewer system owner. The system owner then directs the STILF funds to individual homeowners through RIHousing.

STILF Loan Terms[35]:

- The maximum loan amount is $10,000, with a term of up to five years.
- Funding is released to the homeowner when RIHousing receives a Certificate of Compliance (COC) after the work is completed.
- Cost to properly abandon the existing septic system (pumping out its contents and filling it with sand) is eligible.

As of February 2018, the STILF program closed forty-two loans totaling $149,170. The average loan amount was $3,552, and the monthly payment for a $4,000 loan with a 5-year term would be $68.[35]

According to Laura Sullivan, Assistant Chief of the Rhode Island Office of Housing and Community Development (personal communication, May 1, 2019), municipalities may also apply for Community Development Block Grant funds (CDBG), allowing septic, cesspool, and sewer upgrades. Grants may be awarded to communities who design a housing rehabilitation program and then apply to the state Office of Housing and Community Development for funding. Cities and towns then provide a loan or grant to the household secured by deed restrictions.[36]

1.9 Final Analysis/Application

- Rhode Island originally adopted a cesspool conversion method by distance to important coastal and drinking water resources; however, it was changed to a point-of-sale mechanism to convert a larger number of cesspools.
- If a property is subject to sale or transfer after January 1, 2016, the cesspool must be removed from service within one year of the closing date.

- If a cesspool fails an inspection at any time, the cesspool must be replaced within one year of the failure, or less if an imminent threat to public health is identified.
- A cesspool must be replaced with a septic system or connected to a sewer system if one is available.
- OWTS permits and program functions are administered through RIDEM.
- Long-term nutrient monitoring of small-scale residential I/A/E systems is not mandated.
- Rhode Island requires total nitrogen discharge concentrations for all I/A/E system effluent not to exceed 19 mg/L. This number was derived from the Massachusetts Title 5 program.
- University and State partners created a demonstration project that would allow approved systems to enter a streamlined approval and permitting process if I/A/E systems could demonstrate reductions of nitrogen below 19/mg/L.
- Owners of I/A/E systems must have a valid maintenance contract with an entity or individual that is certified by the vendor. The minimum maintenance contract term is two years. Every two years the owner must submit documents to RIDEM showing the condition of the system and valid permits.
- A robust CSSLP enables low-interest financing of OWTS system upgrades.
- To access CSSLP funds, towns must develop an OWMP to meet local environmental needs. Program elements may include ordinances requiring system inspections, enhancing homeowner education, or specifying more stringent treatment requirements in environmentally sensitive areas.
- Only two towns will fine residents for not having a compliant maintenance contract for I/A/E systems.
- Minimal enforcement mechanisms exist at the State level. RIDEM is not required to be notified when a property replaces a cesspool during a real estate transaction. If OWTS regulations are incorporated into local zoning laws, local officials may have more options to enforce non-compliance.

2. Suffolk County, New York

Suffolk County is in the southeastern region of New York State and is bordered by Connecticut and Nassau County to the west, the Atlantic Ocean to the south and east, and the Long Island Sound and Connecticut to the north. Suffolk County has 980 miles of coastline.[37] The United States Census Bureau estimates the population to be 1,481,093 as of 2018.[38] The population density is 1,637 people per square mile, with the total land area covering 1,461 square miles.[38,39] Suffolk County is in a transition zone between a humid subtropical climate and a humid continental climate.[39]

2.1 Regulation Overview

Nearly seventy-five percent of Suffolk County does not have municipal sewer service.[40] County officials have estimated that about 252,000 cesspools and 108,000 conventional OWTS are currently in use.[41] Studies estimate that the average conventional OWTS in Suffolk County discharges nearly forty pounds of nitrogen per year into the ground.[42] Sixty-nine percent of the total nitrogen impacting ground and surface waters in Suffolk County is thought to originate from OWTS.[43] Because of the degraded water quality, the county has experienced beach closures, restrictions on shellfishing, toxic algae blooms, and massive fish kills. Like Hawaiʻi, Suffolk County relies on underground aquifers for its primary drinking water source.[44] A 1999 assessment found about seventy-percent of Suffolk County community drinking water supply wells were rated as high or very high susceptibility to nitrate contamination.[45] The loss of aquatic and coastal vegetation—which can reduce wave energy and prevent erosion—has become more evident in Suffolk County, especially in the aftermath of recent storms (e.g., Superstorm Sandy).[43a]

Suffolk County created the Reclaim Our Water Initiative in 2014 to make water quality a priority issue for the government. A central pillar of the initiative is to reduce nitrogen pollution from cesspools and outdated conventional OWTS by helping homeowners upgrade to I/A/E systems or connect to the municipal sewer.[42] Additionally, there have been updates to several articles in the County Sanitary Code, the creation of an updated Comprehensive Water Resources Management Plan, and the formation of a partnership with Stony Brook University to research new and emerging OWTS technology.[46] Finally, a temporary grant and loan mechanism was created to assist homeowners in converting outdated or substandard OWTS (C. Clapp, personal communication, June 28, 2019).

2.2 Regulation Requirements/Enforcement

Updates to Article 6 of the Suffolk County Sanitary Code include new sewage disposal requirements for new construction of a residence and the closure of a long-standing loophole that allowed an existing cesspool to be replaced with another cesspool, despite the construction of cesspools being banned since 1973.[47,48] The previous loop-hole did not require property owners to apply for a permit from the Suffolk County Department of Health (SCDH) to upgrade an OWTS when re-installing the system in-kind (C. Clapp, personal communication, June 28, 2019). The county had a previous upgrade requirement in place requiring property owners to upgrade an OWTS when additions to dwellings were proposed, however, this only captured about 242 upgrades of convention systems to I/A/E systems per year.[43]

Recent updates to County Sanitary Code outlines how I/A/E systems will be tested and certified while setting rules for the average amount of nitrogen (19 mg/L) new technology can release.[48] Article 19 establishes the SCDH as the main management entity to evaluate, approve, register, oversee, and facilitate the use of I/A/E systems.[48] As of July 2018, additional regulations require wastewater haulers to provide data regarding system replacement and pumping activities to SCDH.[47] Permits will also be required to replace or retrofit an existing OWTS beginning July 2019.[49]

Though not specifically addressed in the current Reclaim Our Water program, Suffolk County has identified emerging contaminants of concern for future studies and consideration in Section 8 of the Comprehensive Water Resources Management Plan.[43]

Suffolk County has also updated its Liquid Waste License requirements. Previous regulations allowed maintenance to be done on OWTS by license holders but did not require training to obtain a license. New regulations added eleven endorsements for the Liquid Waste License and created training requirements for each endorsement. A specific amount of continuing education credits are required upon every two-year license renewal.[47]

The county requires residents to connect to community sewer when new construction is proposed in an area of an existing sewer district, if the subsoil or groundwater conditions are not conducive to nitrogen removal, the OWTS would be located in Groundwater Management Zones (GWMZ) III, V, or VI, and the parcel is less than 40,000 square feet in area.[43] Community sewer connection is also required if the property is located outside of GWMZ III, V, and VI, and the project parcels are less than 20,000 square feet in area. More information on GWMZs is outlined in Section 2.3 of this report. Exemptions for sewer connection requirements can be found in the Suffolk County Sanitary Code Article 6 (pages 6–12). A variance or waiver on an OWTS may be granted if the general purpose and intent of an action is to protect groundwater, drinking water supplies, surface water, and other natural resources, public health, safety, and welfare.[47]

The SCDH can use enforcement procedures established in Article 2 of the Suffolk County Sanitary Code. Property owners may face additional sampling, maintenance, inspections, and/or monitoring based on the previous inspection and/or performance monitoring results after being issued a notice and the opportunity for a hearing. Fine amounts and mechanisms will be recommended in the upcoming final Subwatersheds Wastewater Plan (C. Clapp, personal communication, June 28, 2019).

Previous OWTS density requirements existed within Suffolk County and are detailed in section 2.3 of this report.

Possible additional Sanitary Code changes/requirements may include:

- Requirement of I/A/E OWTS for new construction;
- Requiring replacement of failed conventional systems with I/A/E OWTS;

- Requiring I/A/E OWTS upon property transfer; and
- Amend current zoning standards to limit one OWTS unit for all Groundwater Management Zones.

2.3 Methods to Determine Priority Conversion Areas

Prior to the Reclaim Our Water Initiative, several methods were created to identify areas where water quality protection zones were needed. The Suffolk County Department of Economic Development and Planning identified approximately 209,000 homes with OWTS in areas considered to be high priority protection areas. High priority areas were defined as areas in the 0–50 year contributing zone to public drinking water wells fields; areas in the 0–25 year contributing zone to surface waters; unsewered parcels with densities greater than what is permitted in Article 6, or areas where groundwater is less than 10 feet below grade.[43]

SCDH began to study the effects of building density on groundwater quality in the 1970s. Because of the study, eight GWMZs with differing recharge characteristics were identified. The study showed that one-acre zoning kept groundwater impacts to a minimum and allowed for reasonable development.[43] Early versions of Article 6 (many residences of Suffolk County were built before Article 6) of the County Sanitary Code set property building restrictions on certain GWMZs.[43,47] Residential properties located within GWMZ III, V, and VI were required to have a minimum lot size of 40,000 square feet of land with the use of a conventional OWTS and public water or private wells. Residential properties located in the remaining zones are required to have a minimum of 20,000 square feet of land when utilizing conventional OWTS and public water, or 40,000 square feet with private wells.[43]

Nine special groundwater protection areas have also been designated in Suffolk County through the New York State Department of Environmental Conservation Article 55 Sole Source Aquifer Protection program.[50,51] Under this program, areas are protected and managed in a way to maintain or improve existing water quality with policies and procedures directed through the development of comprehensive management plans.[51] A map of special groundwater protection areas may be found on the Suffolk County website.[52]

The Suffolk County Comprehensive Water Resources Management Plan calls for the creation of a GIS-based maps defining required wastewater treatment options based on a future study that will establish nitrogen load targets (Table 1) for the area considering effluent nitrogen requirements, distance to existing sewer districts, depth to groundwater, soil conditions, distance to surface waters, Sea, Lake, and Overland Surge from Hurricanes (SLOSH) zones, and Federal Emergency Management Agency (FEMA) flood zones.[43]

Table 1. Example of wastewater treatment categories based on studies to establish nitrogen load targets.

Category	Minimum Wastewater Nitrogen Effluent Requirement	Minimum Wastewater Treatment Option
A1	>30 mg/l	Conventional onsite sewage disposal system
A2		Innovative/alternative onsite sewage disposal system
A3		Community sewage treatment (centralized or decentralized)
B1	<30 mg/l and >10 mg/l	Innovative/alternative onsite sewage disposal system
B2		Community sewage treatment (centralized or decentralized)
C	<10 mg/l	Community sewage treatment (centralized or decentralized)

Note: Reprinted with permission of the Suffolk County Department of Health Services.

Suffolk County has also evaluated priority areas that may be impacted by sea-level rise in its Comprehensive Water Resources Management Plan. Four general recommendations were provided in the 2015 Plan. The first was the establishment of nitrogen loads for watersheds. The second relayed the need for the improvement of onsite sewage disposal technologies. The third called for expansion and/or creation of new Suffolk County operated OWTS entities and, finally, the creation of privately run centralized sewer districts. It is estimated that 80,000 of the existing 360,000 unsewered parcels within the County are currently located in areas where groundwater is less than ten feet deep.[43] Leach fields inundated by ground or floodwaters can compromise system performance and creates a conduit for nutrients to reach ground and surface water supplies. The report also recommended these areas be prioritized for evaluation of appropriate OWTS alternatives (C. Clapp, personal communication, June 28, 2019).[43]

Suffolk County completed the revised draft Subwatersheds Wastewater Plan (SWP) in mid-2019, which is a science-based report designed to bridge OWTS policy with recent groundwater studies and provide a roadmap for a wastewater management plan (J. Jobin, personal communication, July 5, 2019).[43a] This plan sets priority areas, performs models, and develops nitrogen load reduction goals. Three approaches have been identified and implemented for the establishment of load reduction goals within the revised draft SWP, including[43a]:

- Reference water body approach – this approach assumes that nitrogen loading to the priority subwatersheds should be reduced to the level of existing loading to subwatersheds with observed good water quality within Suffolk County.
- Development of stress-response relationships between nitrogen loads and desired water quality can be identified based on existing data, and that these relationships

can be used to identify the nitrogen load reductions required to achieve the desired water quality outcomes.

- Use of published guidance values – this approach was to be used if the reference water body approach and the stress-response relationships were not successful in the identification of nitrogen load reduction goals. In addition, they provide a frame of reference against which to access the results of the first two approaches.

The revised draft SWP will help Suffolk County continue to identify data gaps and use adaptive management methods to respond to future conditions, changing technology, and new data while building upon previous and existing models and studies of nutrient pollution. Overall, the revised draft SWP recommendations support the overarching goal of halting and reversing increasing nitrogen concentrations and degradation to ecosystems. Nitrogen's impact on water resources within Suffolk County is clearly detailed within the revised draft SWP, along with case studies of other geographic areas in the United States to realize benefits (social, economic, ecological) achieved by reducing nitrogen pollution.[43a]

Finally, Suffolk County created Priority Critical Areas to determine Septic Improvement Program Grant eligibility.[42] Areas are scored using three levels of Priority Critical Areas are listed below, with the first being the highest priority.

1. High and medium density residential parcels less than one acre located within the 0–2 year groundwater travel time to surface waters, or high or medium density residential parcels within 1,000 feet of enclosed water bodies.
2. High and medium density residential parcels less than one acre located within the 2–25 year groundwater travel time to surface waters.
3. A qualifying Residential Parcel located outside of a Priority Critical Area or outside of a Critical Area

A map of the priority areas can be accessed on the Reclaim Our Water website.[53]

2.4 Methods to Identify Impaired Waters

Through existing surface water quality data and by calculating nitrogen loads and hydraulic residence times, Suffolk County has concluded that lower nitrogen loads and well-flushed waters have higher water quality, as defined by dissolved oxygen content, chlorophyll-*a*, water clarity, and a reduction in harmful algal blooms. Suffolk County used several models (coastal, ground, and surface water) to show how upgrading outdated OWTS to sewer, clustered, or I/A/E systems and reducing nitrogen loading would improve water quality by improving dissolved oxygen, chlorophyll-*a*, water clarity, and reducing the number of harmful algal blooms. [43a]

Numerous historical studies from both governmental and non-governmental organizations such as the 1978 Long Island Comprehensive Treatment Management Plan, the 1987 Suffolk

County Comprehensive Waste Treatment Management Plan, and the 2015 Comprehensive Water Resources Management Plan have evaluated and documented the effects of nitrogen pollution from wastewater and other sources. A consensus of these reports concluded that a majority of the nitrogen pollution is caused by poorly performing OWTS.[43a]

The U.S. Geological Survey (USGS) operates a groundwater-monitoring network on Long Island that provides long-term hydrologic data that can be used for scientific evaluation and management of the region's resources. The current monitoring network has approximately 550 wells. More information can be found on the Long Island Groundwater Network website.[54] Previous research by the USGS was conducted from 1985 to 1996 in an attempt to estimate nitrogen sources and loads entering the Long Island Sound from groundwater and streams on Long Island. Results from the report located are available on the USGS website.[55] Additional studies sought to comprehensively document the delineations of the recharge areas and calculate travel times for groundwater discharge to Long Island streams and estuarine environments.[55]

An assessment was done in 1999 by the Suffolk County Water Authority to evaluate drinking water quality and hazards. Nearly seventy percent of the community drinking water supply wells were rated as highly, or very highly susceptible to nitrate contamination. Community water supplies are treated and blended to meet federal water quality standards, which reduces concern.[45] However, about 50,000 citizens receive water from private wells, the same aquifer as the community water supply, and without proper and consistent testing, it may be difficult to determine potential susceptible to higher nitrate levels.[45]

2.5 Nutrient Reduction Science

Nitrogen discharge concentrations from OWTS are regulated by density and lot size through the Suffolk County Sanitary Code Article 6. Based on differences in regional hydrogeology and groundwater quality conditions, the county delineated the boundaries of eight GWMZ for the protection of groundwater quality. The goal of creating the GWMZ was to limit groundwater nitrogen to 4 mg/L in GWMZ III, V, and VI and to 6 mg/L in the remaining zones.[43]

Suffolk County set minimum standards for I/A/E system nitrogen discharge concentrations of 19 mg/L borrowed from the Massachusetts Title 5 program and best available science. An annual review by the SCDH is required to evaluate I/A/E system effluent reduction standards, and nitrogen concentration requirements may be adjusted as technology improves (J. Jobin, personal communication, July 5, 2019).[47]

In cooperation with the New York Department of Environmental Conservation, Suffolk County began a multiyear initiative to develop the Long Island Nitrogen Action Plan (LINAP).[56] LINAP is a partnership with various stakeholders to determine the best methods to reduce nitrogen pollution to ground and surface waters through technical, management, and regulatory/policy actions. More information about the LINAP can be found on the New York State Department of Environmental Conservation website.[57]

Previous management efforts have been undertaken to protect drinking water supplies, however, many studies document that surface waters are able to sustain far lower nitrogen concentrations than drinking water sources. Recommended surface water nitrogen concentrations by the USEPA ranged from 0.45 mg/L for the protection of dissolved oxygen, to 0.34 mg/L for the protection of eelgrass.[57]

In order to understand how many properties may be impacted by OWTS property transfer conversion mechanisms, Suffolk County created estimates within its Comprehensive Wastewater Resources Management Plan. The number of estimated cesspool conversions that may occur through the property transfer mechanism and the amount of nitrogen load reduced within priority areas are shown in Table 2.[43]

Table 2. Predicted SCDHS I/A OWTS applications for existing dwellings at the time of property transfer.

Example of Number of Onsite Sewage Disposal System in Suffolk County That May Be Required to be Upgraded Per Year in Priority Areas at Property Transfer				
SC Home Sales (non-Condo)	**2011**	**2012**	**2013**	**Notes:** Estimated % Priority Systems [209000/360000]- = 0.58 or 58% Estimated % Sub-Standard Systems (from Fig. x) [252530/360000] =0.70 or 70% Estimated % Unsewered = 74% SCDHS Final 3 Year Avg. (1397 + 1200 + 1328)/3 = 1308 (Includes Condo's and therefore 1308 is an overestimate)
	9,460	10,735	9431	
Average Home Sales for 3 Year period	9875			
Average SCDHS Residential Construction Permits Issued Final During the same 3-year period	1308			
Number of Homes In Priority Areas Requiring Sanitary System Upgrade At the Time of Transfer Per Year		2573 (See Below)		
Assumes 74% parcels unsewered, 58% systems priority systems, 70% systems are sub-standard – See Notes				
[9875-1308] x .74 x .58 x .70 = 2537 upgrades per year				
Housing data from www.tax.ny.gov				

Note: Reprinted with permission of the Suffolk County Department of Health Services.

2.6 Conversion Technologies/Future Technology Approval

Suffolk County realized that many properties would have to remain on OWTS and that properly installed OWTS are a viable alternative to a community sewer. According to the EPA, OWTS are more affordable than centralized sewage treatment plants and can be designed to perform under a variety of specific site conditions.[58] With that in mind, the county created Article 19 with a focus on promoting the use of I/A/E systems to protect the underground aquifer and county surface water quality. Suffolk County Sanitary Code Article 19 facilitates the development and use of I/A/E systems as an environmental conservation and public health protection measure that designates SCDH as the responsible management entity. SCDH is charged with ensuring that all I/A OWTS are properly managed and maintained. Regardless of which type of OWTS technology is used for a property, conventional or innovative and advanced, Suffolk County limits the amount of sewage that can be discharged on a parcel of land based on lot area, soil type, and hydrological conditions. According to county documents, using I/A/E systems in tandem with the density requirements allows more pollution control and greater water resource protection.[59]

2.6.1 Conventional System Conversion Methods

Suffolk County has evaluated priority areas for new sewer systems, with assessment criteria that focuses on high-density communities within a 25-year groundwater-to surface water travel time (50-year travel time to a water supply well), communities that contribute nitrogen to an impaired surface water, and areas that have a depth-to-groundwater of fewer than ten feet.[60] Recommendations to install sewer systems were made in the four priority areas of Mastic (Forge River), North Babylon and West Babylon (Carlls River), Great River (Connetquot River), and Patchogue (Patchogue River).[60] The four areas are characterized by the number of substandard septic systems and cesspools, small lot sizes with dense populations, a short depth to groundwater, and short travel times for nitrogen-enriched groundwater to enter surface waters.[60]

The minimum separation distance from the bottom of a leaching pool system to the highest groundwater elevation is nine feet to ensure adequate treatment in the unsaturated zone prior to discharge to groundwater. In some instances, the minimum separation distance may be reduced for alternative treatment systems, as approved by SCDHS.[47]

2.6.2 Advanced Nitrogen Removal Methods

To incorporate and certify I/A/E systems for use in Suffolk County, intragovernmental and external systems were evaluated to ensure information was available to installers, regulations were updated, and funding mechanisms were available for implementation (J.

Jobin, personal communication, July 5, 2019). Figure 1 details the process to incorporate I/A/E systems into county regulations.

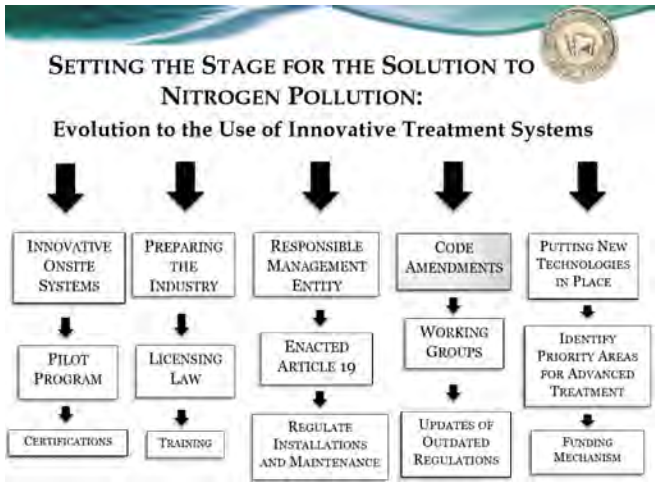

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Figure 1. Evolution process incorporating I/A/E systems.

Suffolk County defines I/A/E systems as onsite decentralized wastewater treatment systems that are designed to reduce total nitrogen in treated effluent to 19 mg/L. I/A/E systems must also achieve greater reductions in biological oxygen demand and total suspended solids than that of a conventional OWTS. An I/A/E system can serve more than one parcel but cannot be considered a community sewerage system.[47,48]

In 2014 and 2016, Suffolk launched in-field demonstration projects for I/A/E systems to evaluate design, operation, maintenance, installation, and overall ability to remove nitrogen in Suffolk County climate and geology. Manufacturers pay to install their systems for evaluation and educational purposes.[61]

Homeowners could participate in the pilot program to test I/A/E systems by entering a lottery system to select sites. As of January 2018, a total of fourteen different technologies have been installed at thirty-nine homes.[62] If seventy-five percent of the demonstration systems maintain nitrogen effluent levels of 19 mg/L or better for a minimum of six months, they are granted Provisional Use Approval through a fast-track approval process (Table 3).[61] When evaluating the nitrogen removal capacity of I/A/E systems, Suffolk County mandates that systems have a minimum of twelve samples from twenty systems of a specific I/A technology, this method was adopted from the Barnstable County (Massachusetts) I/A/E system program (J. Jobin, personal communication, July 5, 2019).[61] Suffolk County adopted these approval values and methods based upon Barnstable County's statistical analysis of monitoring data and Maryland's methods (J. Jobin, personal communication, July 5, 2019).[61]

Table 3. Summary approval chart for residential systems.

Approval Phase	No. of Systems	Sampling Frequency	Performance Requirement
Experimental	3 – 5 Year-Round	Monthly Sampling 12 months rolling average	The total dataset of 75% of the systems must have a combined average of 19 mg/L or less TN
Piloting*	8 – 12 Year-Round	Monthly Sampling 12 months rolling average	The total dataset of 75% of the systems must have a combined average of 19 mg/L or less TN
Septic Demonstration Systems*	1 – 5 Year-round	Monthly Composite Samples 6 month rolling average for streamlined approval.	The dataset of 75% of the systems must maintain a combined average of 19 mg/L or less TN
Provisional 1	First 20 Year-Round	Bi-Monthly Sampling fo 24 months rolling average	The dataset of all the 20 systems must have a combined average of 19 mg/L or less TN
Provisional 2	All Other installations during Provisional Use Approval	Every 12 months, unless seasonal then every month of operation.	The annual dataset must maintain a combined average of 19 mg/L or less TN in order to remain in the Provisional phase ***
General Use		Every 36 Months	The dataset must maintain an average of 19 mg/L or less in order to remain in General Use phase **

Note: The number of required systems is a cumulative number. For example, the minimum of 20 systems for Provisional Use includes the number of systems installed as part of Experimental and Piloting phases.

**Suffolk County Sponsored I/A OWTS Demonstration Program may permit a streamlined Pilot approval phase.*

***The combined average of the dataset in Experimental, Piloting and Provisional 1 is the requirement to achieve successful completion of that phase.*

Note: Reprinted with permission from Stony Brook University.

Outside the demonstration or experimental category, manufacturers must submit acceptable design specifications, and sampling data to SCDH to receive a pilot system permit. During the pilot system phase, a minimum of five pilot systems would be installed and sampled bi-monthly for eighteen-months. A maximum of fifteen systems may be installed during the pilot phase. Pilot systems will be granted provisional approval if they meet a minimum of seventy-five percent of the total nitrogen removal targets for twelve months. Provisional approval mandates that fifty systems must be installed and sampled for a minimum of thirty-six months. If the sample results and operational performance for the systems achieve a ninety percent success rate, the system would be granted general use approval. Systems that have a general use approval are certified for advanced nitrogen removal and can maintain the approval as long as there are no significant environmental or public health concerns.[61]

New York State-funded and established the New York State Center for Clean Water Technology (CCWT) at Stony Brook University.[63] CCWT is focused on developing efficient and cost-effective I/A/E systems to reduce the impacts of nitrogen and other contaminants to ground and surface waters caused by cesspools and conventional OWTS. CCWT adopted three core objectives regarding I/A/E systems, known as the 10-10-30 strategy. The systems must produce a total nitrogen concentration of at least 10 mg/L; cost to construct a system is approximately $10,000; the system must last thirty years. The center is also focused on creating an outreach and business development plan to create businesses revolving around clean water technology to create jobs in the community and advance technology. Additionally, CCWT is highly focused on industry training to ensure I/A/E systems are maintained properly, ultimately ensuring that systems remove nitrogen as claimed. CCWT is also studying emerging technologies such as constructed wetlands or Nitrogen Removing Biofilters as additional methods to remove nitrogen from wastewater effluent.[64,65,66]

Experimental I/A technologies must undergo additional testing and meet requirements, protocols, procedures, and standards established by the SCDH to become eligible. The SCDH has established a set of standards and methods for evaluating the performance of I/A/E systems to meet the effluent standard at each stage of the approval process based upon research from several other state's I/A/E programs.[61]

An annual review by the SCDH and CCWT of new I/A technologies occurs to ensure performance verification standards represent the best available technologies. The SCDH will maintain a Management Information System, which tracks the approval and registration information, inspection, sampling, and operations and maintenance (O&M) of all approved I/A OWTS. Maintenance providers can face enforcement if they fail to comply with any reporting or record-keeping requirements.[61]

The property owner is responsible for all necessary repairs, annual maintenance, and access after installing an I/A/E system. Every property owner must have an active O&M contract with a company that has a current Suffolk County Liquid Waste License and Innovative and Alternative Treatment System Service Provider Endorsement.[48] Property owners must notify the SCDH in writing within thirty days in the event there is a change in the maintenance provider. Maintenance providers must notify the SCDH when an O&M contract is not renewed or is canceled. Maintenance providers are also required to report all O&M and emergency I/A/E system service to the County. Maintenance providers must maintain inspection records for at least five years. The SCDH may inspect I/A/E systems and sample discharges as often as deemed necessary to determine compliance, upon reasonable notice to the property owner.[48]

Suffolk County has also considered joining a regional data-sharing program for I/A/E systems.[43] A similar program exists within the Chesapeake Bay area and allows states to approve new I/A technologies in their home state by using data from another (J. Jobin, personal communication, July 5, 2019).

2.7 Conversion Method and Timeline

Suffolk County is in the process of developing and implementing timelines and methods that require cesspool conversions and upgrades to outdated and substandard OWTS. Suffolk County is also in the process of identifying long-term dedicating funding to support OWTS conversions (C. Clapp, personal communication, August 1, 2019). The 2019 revised draft SWP identified a phased approach to convert OWTS by evaluating eight plans as a recommended roadmap for the OWTS upgrade program. Each of the eight programs consisted of the same four-phased structure listed below. “Alternative 4” was chosen as the recommended roadmap and is detailed after the phase details listed below[43a]:

Phase I: A five-year phase with the primary objective(s) of:

- Requiring I/A OWTS for all new construction;
- Establishment of a stable and recurring revenue source;
- Establishment of a Countywide wastewater management district; and,
- Continuation of the existing voluntary upgrade program(s) and Town/Village mandates.

Phase II: The timeframe of the phase varies based upon the I/A OWTS upgrade triggers selected. The kick-off for this phase is the collection of revenue from the stable recurring revenue source. This phase has the following primary objective(s):

- Continuation of existing voluntary upgrade program(s) and Town/Village mandates;
- Implementation of wastewater upgrades within the 0- to 2-year groundwater contributing area for all surface water Priority Rank 1 areas, and within all groundwater/drinking water Priority Rank 1 areas (e.g., areas within existing or predicted total nitrogen of greater than 10 mg/L).

Phase III: The timeframe of the phase varies based upon the I/A OWTS upgrade triggers selected. The kick-off for this phase is the completion of upgrades within all Phase II priority areas. This phase has the following primary objective(s):

- Continuation of existing voluntary upgrade program(s) and Town/Village mandates;
- Implementation of wastewater upgrades within the 2- to 25/50-year groundwater contributing area for all surface water bodies and within all groundwater/drinking water Priority Rank 2 areas (e.g., areas with predicted total nitrogen of between 6 mg/L and 10 mg/L).

Phase IV: The timeframe of this phase is not included within the SWP and shall be determined based on future analysis during subsequent program evaluations. The kick-off of this phase is the completion of upgrades within all Phase III priority areas. The primary objective of this phase to upgrade all remaining parcels in Suffolk County that were not addressed in the first three phases.

“Alternative 4” includes the four-phase program described above and adds upgrade requirements for existing properties at property transfer, existing OSDS failure, and the construction of a building addition. Ramp-up sub-phases are added during Phase II to accommodate program needs. To accommodate OWTS technology developments, Phase II has several sub-phases that are geographically separated when new triggers or priority areas are implemented. The goal is to complete all upgrades within Phase II in 30 years and 45 years for upgrades within all Phase III areas.[43a]

The most cost-effective solution to reduce annual nitrogen loading to surface waters as calculated by nutrient modeling and estimations of cost per pound of nitrogen removed is achieved by focusing on coastal areas within the 0–2-year groundwater travel time.[43a]

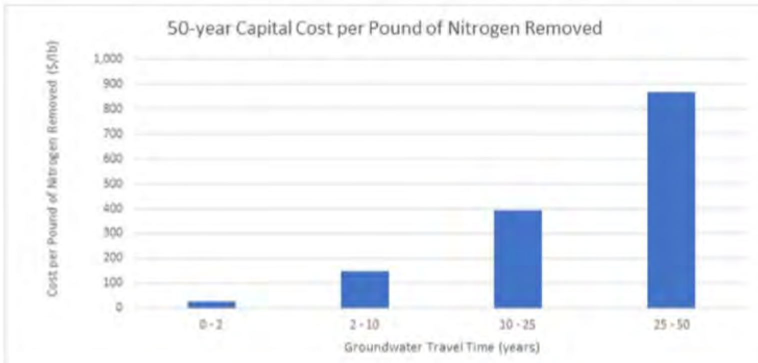

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Figure 2. 50-year capital cost per pound of nitrogen removed by I/A/E OWTS implementation in groundwater travel time intervals.

According to the revised draft SWP, Alternative 4 financially supports homeowners who voluntary update their OWTS, or upgrade after OWTS failure with one hundred percent funding through the identified stable recurring revenue source. Homeowners who construct a new building addition can obtain fifty percent funding toward an OWTS upgrade. Alternative 4 does not currently allow OWTS upgrades at property transfer to qualify for funding support. The cost to fund the upgrades is within the range of potential funding evaluated under the various stable and reoccurring revenue source models. The maximum incremental step increase in annual installs is within the range that is forecast to be acceptable for accommodating industry and RME ramp up.[43a]

A failed cesspool means any cesspool or OWTS that does not adequately treat and/or disperse wastewater so as to create a public or private nuisance or threat to public health or environmental quality, as evidenced by and including, but not limited to, one or more of the following conditions[47]:

- Continued failure to accept wastewater into the building sewer;
- Continued discharge of wastewater to a basement, subsurface drain, stormwater collection, conveyance or treatment device, or watercourse unless expressly permitted by SCDH;
- Wastewater rising to the surface of the ground over or near any part of an OWTS or seeping from the Absorption Area at any change in grade, bank or road cut;
- Where pumping of the Cesspool, septic tank, I/A OWTS, or Leaching Structure is required four or more times per year due to the infiltration of groundwater into the system, a collapsed Leaching Structure, or clogged Absorption Area which does not allow effluent to infiltrate the surrounding soils. This condition excludes grease trap

maintenance or commercially reasonable, regular/scheduled preventative maintenance of a Cesspool, septic tank, I/A OWTS, or Leaching Structure. The Department may promulgate Standards pursuant to this Article defining commercially reasonable, regular/scheduled preventative maintenance;

- Where groundwater seeps into a septic tank, Cesspool, pump tank/basin, distribution box/utility hole, or Leaching Structure after it is pumped;
- Any structural damage or deterioration that has caused structural damage to the Individual Sewerage System, as determined by a New York State (NYS) Licensed Design Professional or a contractor/Developer holding an active Liquid Waste License through the Suffolk County Department of Labor, Licensing and Consumer Affairs. A determination of structural damage or deterioration that causes structural damage by an NYS Licensed Design Professional (registered architect or licensed professional engineer) shall supersede a Liquid Waste License holder's determination.

2.8 Funding Mechanisms

Suffolk County created a Septic Improvement Grant and Loan Program, where homeowners who decide to replace their cesspool or conventional OWTS in the near term may be eligible for a grant of up to $30,000 with funds from Suffolk County and New York State.[42] The county has enough funding to issue approximately 185 to 200 grants per year (J. Jobin, personal communication, July 5, 2019). Suffolk County has also increased staffing for SCDHS to administer the expanded grant program. Grant awards are expected to increase from 200 per year to 1,000 per year as more funding is developed. In addition to the grant, those who qualify can receive additional funding to finance any remaining costs over fifteen years at a three percent fixed interest rate. The loan program will be administered by the Community Development Corporation of Long Island Funding Corp, with financial support from Bridgehampton National Bank, in the amount of $1 million and financial commitments from several philanthropic foundations.[42]

Grant applicants must meet the following criteria[42]:

- The residence must be served by a conventional OWTS or cesspool and not located within a proposed sewer district.
- New construction on vacant lots is not eligible.
- The property does not have any outstanding or open real property tax liens.
- There must be a valid certificate of occupancy (CO) or equivalent issued by the applicable town or village.
- Income verification

New York State created a pilot Septic System Replacement Program Fund as part of its Clean Water Infrastructure Act of 2017.[67] In 2018, New York State announced that Suffolk County would be awarded over $10 million. The fund provides funding for the replacement of cesspools and conventional OWTS to reduce the environmental and public health impacts associated with the discharge of wastewater effluent. The State Department of Environmental Conservation and SCDH will determine priority areas to provide grant funding. Priority areas are based on a location's vulnerability to contamination. Areas are evaluated on factors such as the presence of a sole-source aquifer or known contamination or impairment, population density, soils, hydrogeology, and climate. Counties in priority areas can obtain funding to provide grants to property owners for up to fifty percent of the eligible costs (maximum of $10,000) of their eligible OWTS project.[67]

Clean Water State Revolving Fund (CWSRF) can assist property owners to upgrade their OWTS by providing low-interest loans, but a countywide wastewater management district must exist for funds to become available. Under the CWSRF, Suffolk County can receive funds for nonpoint source pollution projects, including decentralized wastewater treatment systems to replace outdated or failing OWTS, in addition to I/A projects that demonstrate new approaches to delivering services or managing water resources.[43]

Though grant and loan programs exist for Suffolk County, these programs have been created from pilot funds, which may not provide a steady, sustainable source of funding for future OWTS conversion. The county is exploring options such as increased water delivery and disposal fees, or through property tax mechanisms (C. Clapp, personal communication, June 28, 2019). Some towns within Suffolk County, such as East Hampton and South Hampton, have passed an expansion of existing local Community Preservation Funds to incentivize the voluntary upgrade of outdated OWTS to I/A/E systems.[68] A two percent tax is added to real estate transfers after a certain monetary value, which provides funding to upgrade OWTS or cesspools to those who qualify. According to town documents, approximately $4,600,000 will be available annually for water quality improvement projects. Many towns are creating their own programs because local economies are closely linked to tourism, fishing, and real estate.[68]

2.9 Final Analysis/Application

- Created the Reclaim Our Water Initiative effectively making a public brand to promote the new OWTS regulations and rally homeowners to protect Long Island's water quality.
- Developed easy online grant and loan applications to encourage participation in financial programs.
- Extensive outreach on OWTS performed by the County and CCWT directed towards the public, manufacturers, and businesses.
- Suffolk County has specific density requirements for OWTS.

- Towns can create more stringent OWTS regulations to protect public health, safety, welfare, and the environment.
- Created demonstration programs that have allowed the evaluation of system design, O&M, installation issues, and analysis of nitrogen reduction objectives. A lottery scheme was developed to provide homeowners with free systems in exchange for the testing of I/A technologies that may eventually gain general use approval under a fast track process.
- Suffolk County uses key financial incentives, including grants and low-interest loans, to promote conversion to I/A technology.
- Suffolk County and New York State partnered with Stony Brook University, creating the Center for Clean Water Technology to create a bridge between research institutions, regulatory agencies, and private sector resources in hopes of overcoming knowledge and technology gaps in regional water quality restoration solutions.
- The County has estimated the number of parcels at risk for climate change impacts, including those impacted by sea-level rise and groundwater inundation.
- New York State created a $75 million Septic System Replacement Fund.
- For I/A/E system approval, Suffolk County is using data from a minimum of twelve samples from twenty systems of a specific technology to make a determination on the level of nitrogen removal. According to documents, Suffolk County is the first jurisdiction to adopt an approval process based on the Barnstable County statistical analysis.

3. Delaware

Delaware is a state in the Mid-Atlantic region bordered by Maryland to the west and south, Pennsylvania to the north, and the Delaware Bay, Atlantic Ocean, and New Jersey to the east. Delaware has 381 miles of coastline.[69] The United States Census Bureau estimates the population to be 967,171 as of 2018.[70] The population density is 460 people per square mile, with the total land area covering 1,954 square miles.[71,72] Delaware has a humid subtropical climate, with hot and humid summers and cool to mild winters.

3.1 Regulation Overview

Statewide regulations in Delaware regarding the installation and operation of OWTS have existed since 1968. However, according to the state, years of inappropriate installations, poor operation, and maintenance practices have contaminated groundwater and threatened public health.[73] To better protect public health and the environment, the Delaware Department of Natural Resources and Environmental Control's (DNREC) updated regulations in 2014 regarding site evaluation, siting density, installation, operation and maintenance of OWTS. This updated regulation entitled 7 Delaware Code Chapter 60 can be viewed on the DNRC website.[74]

Currently, almost all of Delaware's rivers and streams are listed as impaired due to excess nutrients and bacteria. DNREC's Division of Water estimates that approximately eighteen percent of the state's 70,000 OWTS may be malfunctioning. The regulatory changes for OWTS represent five-plus years of work by DNREC and included thirteen workshops and three public hearings.[75]

In 2014, Delaware began requiring inspections of all OWTS prior to property transfer. New inspection protocols for OWTS contractors and inspectors were also created. Additionally, a novel program that allowed homeowners to maintain their own I/A/E system, once certified through a homeowner-training program was implemented. In 2015, all cesspools were prohibited and when discovered and must be replaced within one year. The state also required upgrades to all new and replacement systems within 1,000 feet of tidal portions of the Nanticoke River and Broad Creek, assisting Delaware in meeting federal targets to clean up the Chesapeake Bay Watershed. Additional measures taken by Delaware include establishing statewide performance standards for all I/A/E systems and requiring waste haulers to report septic tank pump-outs mandated at every three years for conventional systems, and greater frequencies for I/A/E systems.[74,75]

3.2 Regulation Requirements/Enforcement

All OWTS are regulated and permitted through the DNREC. DNREC requires inspection of all OWTS by a Class H system inspector prior to property transfers.[76] A Class H inspection is a comprehensive and mandatory inspection of the OWTS to check its functionality.[75] A cesspool or seepage pit must be replaced within one year of identification. There are extensions for sheriff sales, auctions, short sales, and cash sales for up to ninety calendar days from the date settlement date. Inspection reports are submitted to DNREC within seventy-two hours of an inspection. Three situations exist where a Class H inspection is not required[74]:

- The certificate of completion for transfers of new property was issued within the past twenty-four months;
- An inspection has occurred within the previous thirty-six months and the property owner can provide proof of pump-out;
- The owner of an I/A/E system provides proof of a licensed operator or has a service contract with a certified service provider.

In the 2014 updated regulations, Delaware incorporated FEMA guidelines when siting OWTS in flood-prone areas. Certification by a registered professional engineer (Class C) is required for all new and replacement OWTS. OWTS must be located and designed to minimize or eliminate flood damage, infiltration of floodwaters, and discharges from the system into floodwaters. Rules also stipulate that new and replacement OWTS must also be located to minimize alterations to any sand dunes.[74]

When DNREC determines that construction of OWTS should be limited or prohibited in an area, it can issue an order limiting or prohibiting construction; these areas are called Moratorium Areas. The order will contain a specific description of the Moratorium Area and be limited to the area immediately threatened with groundwater or surface water contamination. Currently, there is only one proposed moratorium area identified by the state.[74,77]

For residential dwellings, the maximum OWTS siting density is one dwelling unit per one-half acre. For multiple-family dwellings, or where more than one dwelling is to be served by an OWTS, the maximum siting density is based on the net pervious area (e.g., unpaved, without structures) available for groundwater recharge after total project completion.[74]

DNREC administers a program for the licensing of many types of wastewater professionals. All applicants will be required to pass an examination prepared and administered by DNREC to test competency and knowledge. Depending on the Class of licensing, additional qualifications and professional certifications may be required and can be reviewed on page 35 of 7 Delaware Code Chapter 60.[74]

<u>Wastewater Professional Classifications</u>[74]:

Class A—Percolation Tester
Class B—Conventional System Designer
Class C—Innovative/Alternative Designer
Class D—Soil Scientist/Site Evaluator
Class E—System Contractor
Class F—Liquid Waste Hauler
Class H—System Inspector
Class I—Construction Inspector

OWTS owners are responsible for operating and maintaining their systems. Each conventional OWTS should be pumped by a licensed Class F liquid waste hauler once every three years, however, this is not mandatory. I/A/E systems must be pumped according to manufacturer recommendations unless determined that the tank is less than one-third full of solids. A pumping schedule is prescribed in accordance with current DNREC guidelines based on the size of the treatment unit and an anticipated number of residents. The owner of the conventional OWTS should maintain a record indicating when the system has been pumped.[74]

All I/A/E systems have strict operation and maintenance requirements. For new construction, and prior to DNREC granting a COC, the owner must enter into a service contract with a certified service provider, for a minimum of two years when the OWTS becomes functional (unless certified by the homeowner training program). For replacement systems, this service contract must be submitted with the permit application. An online reporting system was created to report when a system is pumped. This system records the pumper's license number, the address of the system pumped, and how many gallons were pumped. Under the new regulations, the waste hauler is now responsible for reporting to DNREC how much they pump quarterly.[74]

Inspection programs for I/A/E systems include a schedule indicating inspection frequency, inspection objectives, inspection details, necessary operation and maintenance activities, additional sampling if required, and recordkeeping requirements. A service contract must outline that the certified service provider is to inspect the system once every six months or otherwise as approved by the DNREC. A certified service provider must document all inspections. Reports document the date and time of the inspection, sampling and laboratory analysis results, operation and maintenance performed, repairs, an assessment indicating the current performance status of the entire treatment and disposal system, and any corrective actions that must be taken prior to the next inspection.[74]

Delaware has a unique program entitled the Homeowner Training Program (HTP). HTP allows homeowners to maintain their own I/A/E system, once certified. In order to become certified, a service provider is required to meet with the homeowner during the first sixth-month inspection to educate the homeowner on the components of the system and on the proper O&M requirements. The certified service provider must also provide the homeowner with an operation and maintenance manual.[74]

Following the initial two-year service contract period, the owner is required to maintain a service contract for the system by renewing the existing contract annually, at a minimum, contracting with another certified service provider or being certified by the homeowner training program. DNREC reserves the right to collect and analyze samples of I/A/E systems to ensure proper treatment levels and system performance.[74]

Waivers in cases of extreme and unusual hardship may be granted to OWTS owners. The DNREC may consider the following factors in reviewing an application for a waiver based on hardship including data from DNREC; Division of Water or Groundwater Discharges Section; advanced age or bad health of the applicant; need of applicant to care for aged, incapacitated, or disabled relatives; relative insignificance of the environmental impact of granting a waiver.[74] Owners of OWTS may be investigated by DNREC's Enforcement section under 7 Delaware Code §6019, and fines may be issued accordingly. However, 7 Delaware Code Chapter 60, does not specifically list fine amounts or procedures, other than DNREC will initially attempt to gain voluntary compliance.[74]

3.3 Methods to Determine Priority Conversion Areas

The Delaware OWTS regulations do not specify methods for testing, evaluation, or determination of priority areas for cesspool or conventional OWTS replacement on a state level (J. Baumgartner, personal communication, July 5, 2019). The main mechanism for converting cesspools or outdated and failing OWTS is through the real estate inspection program. A map of proposed areas for I/A/E systems within Chesapeake and Inland Bays watersheds can be viewed on the DNRC website.[78] The state has a goal of eliminating a minimum of 6,074 conventional OWTS by 2025.[79]

3.4 Methods to Identify Impaired Waters

Specific provisions about the state identifying impaired waters from cesspool or septic system pollution were not included in the updated OWTS regulations. All new and replacement OWTS permitted within 1,000 feet of the Chesapeake Bay tidal waters must meet the performance standards for nitrogen and phosphorus set forth in 7 Delaware Code Chapter 60. Delaware's Chesapeake Bay WIP and the Inland Bays Pollution Control Strategy (PCS) does seek to address loading issues from OWTS; however, it does not appear that the state underwent any additional methods to scientifically identify impaired waters in the updated OWTS regulations.[80,81]

3.5 Nutrient Reduction Science

Delaware did not develop models or perform specific scientific research to evaluate what levels of nitrogen would be most beneficial to preserve environmental and human health (J. Baumgartner, personal communication, July 1, 2019).[74] The updated OWTS regulations list specific nitrogen requirements for I/A/E systems. However, small-scale I/A/E systems (<2,500 gallons per day [gpd]), do not require in-ground testing to confirm nitrogen reduction prior to certification, or in-ground monitoring post-installation to confirm manufacturer performance metrics. There are no long-term programs within the 7 Delaware Code Chapter 60 that track reductions in nitrogen pollution from cesspools or septic tanks and ecosystem changes (J. Baumgartner, personal communication, July 1, 2019).[74] Additional state programs or projects to evaluate nutrient levels related to wastewater discharge was not discovered while researching the state of Delaware.

3.6 Conversion Technologies/Future Technology Approval

The DNREC encourages the development of new I/A/E systems, processes, and techniques for eliminating, reusing, or recovering resources from wastewater. This includes eliminating, reusing, or recovering resources from wastewater via greywater collection and use, nutrient recovery, and source reduction of wastewater.[74] All innovative technologies are subject to review and approval by DNREC. All new and replacement systems permitted within 1,000 feet of the Chesapeake Bay tidal waters must meet the performance standards for nitrogen and phosphorus set forth in the 7 Delaware Code Chapter 60. Small I/A/E systems must meet specific nitrogen performance specifications (see below), and requirements become effective one year from the update of 7 Delaware Code Chapter 60. As of 2019, around 2,000 permitted I/A/E systems exist in Delaware, according to Jason Baumgartner, Environmental Scientist with the DNREC Groundwater Discharges Section (personal communication, July 1, 2019).

3.6.1 Conventional System Conversion Methods

When a central wastewater system is deemed both physically and legally available, the connection must occur within a timeframe as set forth by the wastewater system owner and the existing OWTS must be abandoned. A central wastewater system is deemed physically available if its nearest connection point from the property line or boundary to be served is within two hundred feet for all single-family dwellings.[74]

Conventional OWTS are permitted under Delaware law if an I/A/E system is not required. DNREC has recognized that many home lots are small and have incorporated some exemptions to ease siting problems. These can include waiving isolation distances or downsizing a system. The very last resort for small lots is the pumping and hauling of a holding tank when it is three-fourths full. The required minimum liquid capacity of a septic tank for flows less than or equal to 500 gpd is one thousand gallons. For each additional bedroom, add two hundred fifty gallons must be added to capacity. If large flow surges are anticipated, the septic tank size must be increased to accommodate surges without causing sludge or scum to be discharged from the tank. There are no nitrogen effluent concentration requirements for conventional OWTS.[74]

3.6.2 Advanced Nitrogen Removal Methods

Composting toilets are permissible under Delaware law. Homeowners would still need to process greywater, including wastewater from bathtubs, showers, bathroom washbasins, clothes washing machines, laundry tubs, and other wastewater that do not present a threat from contamination by unhealthy processing or operating wastes. Wastewater from kitchen sinks or dishwashers is considered blackwater and requires separate treatment from greywater.[74] According to Jason Baumgartner, only a handful of permits exist for composting toilets across the state (personal communication, July 1, 2019).

I/A/E systems provide advanced treatment for the reduction of nitrogen and are part of the Chesapeake Bay WIP and PCS for the Inland Bays. I/A/E systems less than 2500gpd are not required to be field-tested prior to certification for use. Manufacturers submit third-party testing results based upon the NSF protocols and apply for approval with the state. All new and replacement systems requiring advanced treatment units must adhere to the performance standard nitrogen level 3 (PSN3).[74]

PSN3 total nitrogen levels achieve either[74]:

- An average annual concentration of 20 mg/L (ppm) total nitrogen in effluent sampled at the end-of-pipe of the advanced treatment unit; or
- A fifty percent reduction in effluent total nitrogen concentration when compared to the influent total nitrogen concentration at the end-of-pipe of the advanced treatment unit; or
- A fifty percent reduction in effluent total nitrogen concentration when compared to the influent total nitrogen concentration beneath any permitted on-site wastewater treatment and disposal system as verified by in-field monitoring or third-party test results.

I/A/E systems may be appropriate for areas where site constraints limit the suitability for conventional OWTS. DNREC considers applications for I/A/E system use in the state on a case-by-case basis from manufacturers. Applications for I/A/E systems must provide documentation of the capabilities of the proposed system; this can include long-term usage data or short-term documentation from controlled projects from reliable sources such as Universities or the National Sanitation Foundation International. Alternative treatment units with flows <2,500 gpd must meet treatment levels prescribed for PSN3.[74]

Sites may be considered for I/A/E system permits where soils, climate, groundwater, or topographical conditions are indicating the seasonal high-water table, or a limiting condition encountered deeper than ten inches below the soil surface or observation well data determines the seasonal high-water table is deeper than ten inches.[74]

There are no long-term or post-installation monitoring requirements by DNREC to ensure I/A OWTS effluent is meeting nitrogen standards. When performance standards have not been achieved on an annual average basis after the appropriate system start-up period, as defined in the regulations and/or applicable on-site system permit, those persons may qualify to participate in a nutrient offset program subject to review and approval by the Department on a site-specific basis (J. Baumgartner, personal communication, July 5, 2019). A list of approved alternative systems can be found on the DNRC website.[82]

3.7 Conversion Method and Timeline

A cesspool or seepage pit must be replaced within one year of identification through a real estate inspection or investigation by DNREC. A failed cesspool is defined as the existence of cesspool or seepage pit. Delaware does not evaluate the condition or assess whether a system is functioned to determine if a cesspool or seepage pit classifies as failing (J. Baumgartner, personal communication, July 5, 2019). There are no other defined timelines regarding the replace of cesspools or outdated OWTS.[74]

3.8 Funding Mechanisms

A Community Septic System Outreach Program was developed as a partnership between the Community Action Agency and the Delaware Environmental Finance Office.[83] It exists to identify low- and moderate-income homeowners in the Chesapeake and Inland Bay Watersheds that may need financial assistance to replace failed and/or failing OWTS.

Two main financial mechanisms exist for individual homeowners. The first is the Septic Rehabilitation Loan Program (SRLP) to replace failing OWTS or cesspools with new OWTS or help with sewer hookups.[84] Financing is available at interest rates of three or six percent, depending on income.[85] A loan of $1,000 (minimum) to $35,000 (maximum) for individual systems and $250,000 (maximum for community or mobile home park systems) can be repaid over 20 years with no prepayment penalty. There is a non-refundable fee of $11 for individual and $15 for a joint credit history report. Loans are secured by a mortgage lien on the rehabilitated property. The SRLP is managed by Environmental Finance with technical assistance from the Ground Water Discharges Branch. Eligible costs for OWTS include site evaluation, septic system design, permits, construction costs, and closing and recording charges. Eligible costs for central sewer projects include impact fees, connection fees, permit costs, electrical, and abandonment of septic systems.[83,84]

The second program uses a Non-Federal Administrative Account (NFAA), which funds the Septic System Extended Funding Option Program (SEFO). Loans under the SEFO program become due and payable upon property transfer. Applicants must first be denied for an SRLP loan (due to insufficient income, credit problems, liens and/or judgments, etc.) before being considered for an SEFO loan.[83]

Elderly deferral or tax betterment mechanisms were not discovered while researching financial programs for OWTS upgrades within the state of Delaware.

3.9 Final Analysis/Application

- In 2014, Delaware began requiring inspections of all OWTS prior to property transfer. New inspection protocols for OWTS contractors and inspectors were also created.
- In 2015, all cesspools were prohibited and when discovered and must be replaced within one year. The state also required upgrades to all new and replacement systems within 1,000 feet of tidal portions of the Nanticoke River and Broad Creek,

assisting Delaware in meeting federal targets to clean up the Chesapeake Bay Watershed.

- Delaware established statewide performance standards for all I/A/E systems and requiring waste haulers to report septic tank pump-outs mandated at every three years for conventional systems, and greater frequencies for I/A/E systems.
- Delaware created a program for the licensing of many types of wastewater professionals. All applicants are required to pass an examination prepared and administered by DNREC to test competency and knowledge.
- All I/A/E systems have strict operation and maintenance requirements. For new construction, and prior to DNREC granting a COC, the owner must enter into a service contract with a certified service provider, for a minimum of two years when the OWTS becomes functional (unless certified by the homeowner training program).
- Delaware created the HTP, which allows homeowners to maintain their own I/A/E system, once certified. To become certified, a service provider is required to meet with the homeowner during the first sixth-month inspection to educate the homeowner on the components of the system and the proper operation and maintenance requirements.
- Connection to a central wastewater system is required when available, and the existing OWTS must be abandoned.
- All new and replacement systems permitted within 1,000 feet of the Chesapeake Bay tidal waters must meet the performance standards for nitrogen and phosphorus.
- There are no long-term or post-installation monitoring requirements by DNREC to ensure I/A OWTS effluent is meeting nitrogen standards.
- Two main financial mechanisms exist for individual homeowners. The first is the SRLP to replace failing OWTS or cesspools with new OWTS or help with sewer hookup. Financing is available at interest rates of three or six percent, depending on income.

4. Massachusetts

Massachusetts is a state in New England bordered by New York to the west, Connecticut, Rhode Island, and the Atlantic Ocean to the south, Vermont and New Hampshire to the north, and the Atlantic Ocean to the east. Massachusetts has 1,519 miles of coastline.[69] The United States Census Bureau estimates the population to be 6,902,149 as of 2018.[86] The 2017 population density is 871 people per square mile, with the total land area covering 7,840 square miles.[87,88] Massachusetts has a typically humid continental climate, with warm summers and cold, snowy winters. Some eastern parts of the state have a humid subtropical climate, characterized by hot and humid summers and cool to mild winters.

4.1 Regulation Overview

Title 5 is the state's main mechanism governing OWTS and was created in 1995 to provide protection of public health, safety, welfare, and the environment by regulating the proper siting, construction, and maintenance of OWTS.[89] Title 5 requires inspections of OWTS prior to property transfer or dwelling enlargement. If an OWTS fails an inspection, they must be repaired or replaced within two years. In 1996, the law also required a soil evaluation test to be performed by a Massachusetts Department of Environmental Protection (MassDEP) approved soil evaluator. Title 5 is the minimum code, and a Local Board of Health (LBH) may create more stringent and optimal ordinances concerning OWTS in their area and environmental needs.[90] Additional information about Title 5 policies and guidance can be found on the MassDEP website.[89,91]

4.2 Regulation Requirements/Enforcement

Title 5 is implemented and enforced by an LBH with oversight and assistance by the MassDEP. The approval of any OWTS, including the issuance of permits, approvals, and COC, will be handled by the LBH. An LBH may enforce Title 5 in the same way local health rules and regulations are enforced. More stringent regulations can be added by an LBH or county to protect public health, safety, welfare, and the environment (B. Dudley, personal communication, April 12, 2019).[89] If an LBH fails to enforce Title 5 regulations within a reasonable time, MassDEP may act to bring the LBH into compliance. The MassDEP will be the responsible agent charged with approval and enforcement systems owned or operated by an agency of the Commonwealth or of the federal government.[89,91]

Each OWTS system will obtain a COC. Before a COC is issued, system designers file an electronic registration for the system. The OWTS installer and the designer will certify that the system has been constructed in compliance with Title 5. The LBH may inspect the OWTS to determine that the work has been completed in compliance with the requirements of Title 5.[89]

Massachusetts implemented a new professional position and permit when updating Title 5. The soil evaluator position was created to enhance the review and approval of proposed systems by ensuring that appropriate expertise in soil identification, groundwater hydrology, and topography was involved in the OWTS process. The Disposal Systems Installer Permit was created to ensure installers demonstrate knowledge of and experience with the proper construction and installation of systems in accordance with Title 5 (B. Dudley, personal communication, April 12, 2019).[89]

Fines and penalties may be issued to those who fail to comply with orders issued by MassDEP or an LBH regarding Title 5 regulations. Enforcement actions may consist of noncompliance letters, non-compliance orders, or an imminent threat order. When a homeowner is issued a non-compliance letter, a request is made for the owner to take corrective actions necessary to come into compliance with Title 5. The letter is not an order and is not appealable. When a homeowner is issued a non-compliance order**,** the owner of an OWTS, inspector, system installer, designers, or soil evaluator is required to come into compliance with the provisions of Title 5, or to take any other action necessary to protect public health, safety, welfare or the environment. If an order is issued by a local authority, the order may be appealed in court. If issued by MassDEP, an adjudicatory hearing would be afforded. An imminent threat order may be issued in the case of an imminent threat to public health, safety, welfare or the environment exists, the local Board of Health or MassDEP may issue an emergency, requiring that corrective action be taken as necessary.[89]

Title 5 has certain requirements for system inspections. The overall goal of system inspection is to provide enough information to decide as to whether the system is adequate to protect public health and the environment (B. Dudley, personal communication, April 12, 2019). Inspections are performed by Massachusetts Registered Professional Engineers, Massachusetts Registered Sanitarians, Massachusetts Certified Health Officers, individuals certified as on-site inspectors by the NSF, or other approved certifying organizations. OWTS failing to protect public health or the environment must be repaired, replaced, or upgraded. An inspection document whether the system has been continually operated as approved, if the system consists of a greywater filter, whether it is operating properly, and whether compost and blackwater are disposed of off-site in accordance with all applicable laws and regulations. MassDEP or other state agencies do not regulate OWTS inspection fees.[89]

If an OWTS passes inspection, documents are submitted to the LBH within 30 days, and the homeowner must provide a copy to the buyer if a real estate transfer is taking place. Lending institutions may also require a copy of the inspection. If an OWTS fails inspection, documents are submitted to the LBH within 30 days and the system must be repaired or upgraded within two years, regardless if the property is sold. The LBH maintains records for each OWTS within its jurisdiction.[89]

Title 5 requires that all OWTS must be inspected at or within two years prior to the time of transfer of title, Title 5 requires all advanced OWTS (or those with increased flow rates) be inspected on an annual basis. An inspection conducted up to three years before the time of transfer may be used if the inspection report is accompanied by system pumping records demonstrating that the system has been pumped at least once a year during that time. For full inspection requirements, see page 65 of Title 5.[89]

Inspections are not required when an LBH has issued a COC within two years before the time of transfer of title or when the community has adopted a comprehensive plan approved by MassDEP requiring periodic inspections. Inspections are also exempt when the homeowner has entered into an enforceable agreement, binding on subsequent buyers, or when an LBH requires a connection to the municipal sewer system within two years of transfer or sale. Additional Title 5 inspection exemptions were passed in 2004 and are not required if the transfer is of residential property and is between current spouses; parents and their children; between full siblings; and where the grantor transfers the real property to be held in a revocable or irrevocable trust, where at least one of the designated beneficiaries is of the first degree of relationship to the grantor.[89,92]

Title 5 provides guidance for OWTS pumping and maintenance. Every conventional OWTS or cesspool is recommended to be pumped whenever necessary to ensure the proper functioning of the system. At a minimum, conventional OWTS are recommended to be pumped every three years. Pumping is required whenever the top of the sludge or solids layer is within twelve inches of the bottom of the outlet tee, or the top of the scum layer is within two inches of the top of the outlet tee, or the bottom of the scum layer is within two inches of the bottom of the outlet tee. I/A/E system pumping and maintenance requirements are discussed in Section 4.6.2.[89] MassDEP, in collaboration with other institutions, has produced educational materials to the public describing the importance of proper maintenance and operation of OWTS and the impact of systems on public health and the environment (B. Dudley, personal communication, April 12, 2019).[89,93]

4.3 Methods to Determine Priority Conversion Areas

Massachusetts did not research specific science-based methods to determine what cesspools or conventional OWTS would be prioritized for upgrade. When the state originally developed the real estate transfer inspections, the method was controversial, with some concessions made to ensure statewide passage (B. Dudley, personal communication, April 12, 2019). Many communities in environmentally sensitive areas, however, did institute more stringent local standards (including setbacks) that targeted cesspools and OWTS nitrogen pollution. Massachusetts has a strong tradition of local control, and Title 5 allows for the adoption of more stringent local standards as needed (B. Dudley, personal communication, April 12, 2019).

Nitrogen loading limitations were part of Title 5 regulations. New construction of OWTS in nitrogen sensitive areas must be designed to discharge no more than 440 gallons of design flow per day per acre unless the system can meet effluent standards of 10 mg/L of nitrogen. Systems using recirculating sand filters must not discharge more than 25 mg/L of nitrogen in wastewater effluent (B. Dudley, personal communication, April 12, 2019).[89]

In areas where the use of both OWTS and private drinking water supply well is proposed, systems must be designed to receive no more than 440 gallons of design flow per day per acre from residential uses unless property owners are participating in the Aggregate Flows

Rule or Enhanced Nitrogen Removal method, which are discussed later in this chapter. Owners of OWTS must also ascertain whether the system to be constructed will be within a nitrogen sensitive area (definition below). MassDEP will publish locations of nitrogen sensitive areas accessible to the public via maps (B. Dudley, personal communication, April 12, 2019).[89]

MassDEP has determined specific geographic areas listed below to be particularly sensitive to the discharge of pollutants from OWTS. These areas will be required to have increased treatment of pollutants and reduction in effluent nutrients discharged from OWTS to protect water resources. OWTS in Zone I of a public water supply well are prohibited.[89]

- Interim Wellhead Protection Areas and Department approved Zone IIs of public water supplies;
- Nitrogen sensitive embayments or other areas that are designated as nitrogen sensitive. These areas will be mapped based on scientific evaluations of the affected water body and adopted through parallel public processes in relation to Title 5 and the Massachusetts Water Quality Standards.

4.4 Methods to Identify Impaired Waters

Title 5 applies to all OWTS statewide and did not include specific methods to identify impaired waters in conjunction with the OWTS regulations. However, there are other programs within the MassDEP that do identify impaired waters (B. Dudley, personal communication, April 12, 2019). Development of the Integrated List of Impaired Waters under Section 303d of the Federal Clean Water Act (CWA) is the state's primary mechanism.[94] In southeastern Massachusetts, the state has also developed the Massachusetts Estuaries Project to evaluate the level of impairment in coastal ecosystems.[95]

4.5 Nutrient Reduction Science

Combined efforts by local communities, county, state, and the Massachusetts Estuaries Project have identified many of the causes of nitrogen pollution and the degree of impairment in coastal water bodies and groundwater (B. Dudley, personal communication, April 12, 2019).[95]

An update to the original 1978 Water Quality Management Plan for Cape Cod was made in 2015 to develop an integrated water and wastewater management to remediate groundwater and surface water impairments.[96] This plan reevaluates sources of nutrient pollution, regulations, models used to evaluate nitrogen, impacts to waterbodies, and solutions needed. The updated plan recommends actions to streamline the regulatory process, provide transparent processes for citizens, reduce community costs to waters already impacted by nitrogen, increase financial support mechanisms, and provide more support to local water quality efforts.[96]

Massachusetts' regulations and calculations for total nitrogen discharge concentrations of all I/A/E system effluent were created not to exceed 19 mg/L. Achieving this concentration, at the point where the system discharges to the soil absorption system, assumes that approximately fifty percent of the total nitrogen is removed from the influent wastewater of I/A/E systems compared to conventional OWTS nitrogen concentrations estimated at 38 mg/L. This performance level was based upon the best available technology (BAT) at the time the Title 5 OWTS rules were being created (B. Dudley, personal communication, April 12, 2019).[89] It should be noted that new technologies can achieve seventy-five percent or more nitrogen concertation reductions.[97] Performance evaluations were performed, and results were outlined in a report on I/A/E systems and web-based reporting in Barnstable County between 1999–2007. It found that systems that were properly maintained removed nitrogen at rates closer to the manufacturer specifications.[98]

Title 5 set new OWTS standard flow rates of 440 gpd per acre (40,000 sq. ft); this roughly translates to 110 gpd for each bedroom. The state used a rudimentary mass balance equation considering nitrogen concentrations of conventional septic effluent of roughly 35 mg/L and applied a groundwater recharge rate of 18 inches per year. The result equates to about 10 mg/L of nitrogen at the property line with adequate mixing assumed in the aquifer (B. Dudley, personal communication, April 12, 2019).[89]

Enhanced treatment allows an increase in acceptable flow rates, increasing the effluent flow rate to 550 gpd per acre. This would allow a homeowner to place a dwelling with more bedrooms on a smaller property footprint. Additionally, a homeowner may participate in the Aggregate Determinations of Flows Program if they own land to offset nitrogen loadings (detailed in Section 4.6) (B. Dudley, personal communication, April 12, 2019).[89]
Figure 3 shows an example of mass nitrogen loading (mg/acre/day) for a system with and without a nitrogen removal system capable of fifty-five percent nitrogen reduction.[99]

Without nitrogen removal: design flow= 440 gpd/acre = 1663 L per day/acre
Assume total nitrogen = 42 mg/L
42 mg/L x 1663 L per day = 69,846 mg N per day per acre
With nitrogen removal: design flow = 660 gpd/acre = 2495 L per day/acre
Assume total nitrogen = 19 mg/L
19 mg/L x 2495 L per day/acre = 47,405 mg N per day per acre
47,405 / 69,846 = 0.68 i.e. about a 30% reduction in total nitrogen load

Note: Reprinted with permission from Barnstable County Health Department.

Figure 3. Example of mass nitrogen loading calculation.

4.6 Conversion Technologies/Future Technology Approval

Every OWTS must be designed by a Massachusetts Registered Professional Engineer or a Massachusetts Registered Sanitarian. Any other agent of the owner may prepare plans for the repair of one or more components, excluding the soil absorption system, of an OWTS designed to discharge less than 2,000 gpd provided the repair plans are reviewed and stamped by a Massachusetts Registered Sanitarian or Massachusetts Registered Professional Engineer and approved by the LBH.[89]

If an OWTS cannot meet the 440 gpd per acre nitrogen loading limitation and the landowner is not using an I/A/E system, a landowner can meet the correct loadings by using eligible Nitrogen Credit Land. This program is listed within Title 5 under Aggregate Determinations of Flows and Nitrogen Loadings.[100] Essentially, if a property owner has a lot that cannot meet OWTS nitrogen effluent requirements, the owner may use other property to achieve the gap. OWTS must be located within a community or region covered by an approved Community Aggregation Plan (CAP) that is approved by MassDEP. Other applicants, not in a CAP, seeking an aggregate determination of flows and nitrogen loading must prepare a Facility Aggregation Plan to be eligible.[89,100]

To qualify as Nitrogen Credit Land under Title 5, the land must be within the same Nitrogen Sensitive Area as the system. Credit land may not have any human-made sources of nitrogen, including, but not limited to wastewater discharges and nitrogen-based fertilizer. Land cannot be used for raising, breeding, or keeping of animals. Land must be pervious and be outside of Zone A's, Velocity Zones, and Regulatory Floodways. Land cannot be covered by any surface water body; including a river, stream, lake, pond, or ocean. Land located within a Zone I of a public water supply well may be used as Nitrogen Credit Land unless the well is determined to be at risk in accordance with the MassDEP guidelines or the proposed design flow is 2,000 gpd or greater.[89,100]

A CAP allows a city or town to seek approval for aggregate determination of flows and nitrogen loading across a region-wide area, including a Zone II of a public water supply well. Site-specific facility aggregation plans may exist within an approved CAP.[89,100]

The following conditions must be met for a CAP to be approved by MassDEP[89]:

- The plan contains a mechanism to protect surface and groundwater supplies within the community or region from pollutant and nitrogen loading and a proposed mechanism for implementing the Plan;
- The plan meets the criteria in MassDEP's Guidelines for Title 5 Aggregation of Flows and Nitrogen Loading;
- For areas that include a Zone II, the plan includes a nitrate loading analysis and nitrate management plan; and

- Any other conditions that MassDEP deems appropriate.

4.6.1 Conventional System Conversion Methods

If a community sewer is available, an OWTS must be abandoned, except in certain circumstances and when promoting recharge of stressed basins, improving low streamflow, or addressing other local water resource needs. An owner is not required to connect to a sewer if an OWTS is an I/A/E system, and the LBH has determined I/A/E systems do not need to connect to community sewer or a variance from the requirement is obtained from an LBH. More information can be found in the MassDEP Title 5 of the State Environmental Code (section 15.004: Applicability) regulations.[89]

Conventional OWTS are allowed under Title 5 regulations unless an I/A/E system is required in Interim Wellhead Protection Areas, Zone II of public water supplies, or nitrogen sensitive embayments. Title 5 allows for the use of shared systems for new construction and existing systems with increases in flows for both conventional and I/A/E systems. New construction that exceeds the 10,000 gpd flow limit exceeds Title 5 regulations and would require a groundwater discharge permit and appropriate treatment plant (B. Dudley, personal communication, April 12, 2019).[89]

Septic tanks for a single-family dwelling must have a design flow of fewer than 1,000 gpd and a minimum effective liquid capacity of two-hundred percent of the design flow or a minimum hydraulic detention flow of 48 hours, whichever is greater. If the septic tank will serve facilities other than a single-family dwelling unit or the calculated design flow is 1,000 gpd or greater, a two-compartment tank or two tanks in series are required. If a garbage grinder is installed, the minimum liquid capacity of the septic tank must be two hundred percent of the design flow with a minimum tank size of 1,500 gallons. Garbage grinders are prohibited in facilities that include an elevated septic tank. Minimum depth above the high groundwater tables for conventional OWTS is four feet in soils with a percolation rate of more than two minutes per inch and five feet in soils with a percolation rate of two minutes or less per inch.[89]

4.6.2 Advanced Nitrogen Removal Methods

I/A/E systems under Massachusetts law may include humus or other composting toilets; mounded systems designed to overcome limiting site conditions; any system designed to chemically or mechanically aerate, filter, separate or pump the liquid, semi-solid or solid constituents in the system; or any system designed specifically to reduce, convert, or remove nitrogenous compounds, phosphorus, or pathogenic organisms (including bacteria and viruses) by biological, chemical, or physical means. I/A/E systems may include substitutes or alternatives for one or more components of a conventional system or may be fundamentally different approaches intended to eliminate the need for a conventional system.[89]

Humus and composting toilets are approved for general use, assuming there is no liquid waste discharge from the toilet. If the toilet produces a liquid by-product that is not recycled through the toilet, the liquid by-product must be either discharged through a greywater system on the facility that includes a septic tank and leaching system or removed by a licensed septage hauler. Any other disposal of a liquid by-product requires specific approval by the MassDEP. More information on alternative disposal methods can be found within the text of Title 5, page 58.[89]

MassDEP or an LBH may issue a Remedial Use Permit for the rapid approval of an alternative system that is likely to improve existing conditions at a facility or facilities currently served by a failed, failing, or nonconforming system.[89]

Massachusetts has a well-developed system to evaluate and approve new I/A OWTS technologies that appear technically capable of providing levels of protection at least equivalent to those of conventional OWTS. These approvals will be used to determine whether, under field conditions in Massachusetts, the general use of the alternative system will provide environmental protection; and to determine whether any additional conditions addressing long-term operation, maintenance, and monitoring considerations are necessary.[89]

I/A/E systems have different requirements for the provisional standards. General use approval is granted after completing the pilot and provisional stages. The specific stages are detailed below[89]:

- Pilot stage: Intended to provide a field-testing and technical demonstration to determine if the technology can or cannot function effectively. Can install up to fifteen systems and meet required monitoring for eighteen months, with twelve months of results where seventy percent of systems meet your stated nitrogen criteria.
- Provisional use: Approval is intended for the evaluation of alternative systems that appear technically capable of providing levels of protection at least equivalent to those of a standard on-site disposal system. Allows the installation of up to fifty systems (35 more from the 15 in the pilot stage). Monitoring must continue for an additional three years, and if ninety percent meet standards manufacturer is awarded a General use permit.
- General use: Systems will provide a level of environmental protection at least equivalent to that of a conventional on-site system designed in accordance with Title 5 and requires service contract and monitoring to be paid by the owner.

- Remedial use: Systems to improve existing conditions at a facility served by a failed, failing, or nonconforming system.

The Massachusetts Alternative Septic System Test Center (MASSTC) was developed to address impacts to coastal environments from nitrogen.[101] Barnstable County Department of Health and Environment, in conjunction with the Massachusetts Coastal Zone Management through the Buzzards Bay Project, created MASSTC. In 1999, the center began testing I/A technologies. Working with the EPA and NSF of Ann Arbor (Michigan), MASSTC conducted a refined nutrient testing protocol in 2002, referred to as the Environmental Technology Verification (ETV). Further refinement of the nutrient standards was completed in 2007 by the NSF and resulted in the NSF 245 Standard.[101]

Barnstable County leads the state in innovative technologies and policies regarding I/A/E system data management (E.-M. Olmstead, personal communication, July 3, 2019). The county requires that homeowners with I/A/E systems monitor nitrogen concentrations (through self-reporting by O&M personnel) to ensure systems are performing to their stated capabilities by manufactures and legal requirements. This standard goes beyond simply requiring systems to be pumped and allows for more robust maintenance with timely tweaks and updates to ensure systems are performing appropriately, fix problems earlier, and track the amount of nitrogen that I/A/E systems are releasing. Regulatory and enforcement authority over OWTS remains at the local level (typically the board of health).[102]

The Barnstable County OWTS Tracking program provides system compliance monitoring services to fourteen towns in the County via an online database.[102] The program was originally funded with a 604b grant to assist with water quality assessment and management planning.[103] The I/A/E system database allows system operators (state-licensed wastewater treatment operators who are contracted by homeowners for system maintenance) to submit maintenance and sampling reports online. Many parameters of an I/A/E system performance can be tracked through the system. Data points range from parameters such as total nitrogen in the effluent to influent biochemical oxygen demand and water meter readings (E.-M. Olmstead, personal communication, July 3, 2019).[102] Using a large collection of data from its tracking system, Barnstable County was able to establish the optimum number of I/A/E systems and the number of samples needed from each system to provide enough data to evaluate the performance of new nitrogen-reducing technology. Suffolk County (New York) subsequently adopted these rules for their program (C. Clapp, personal communication, June 27, 2019). I/A/E system owners in towns that participate are billed a user fee to fund administrative costs; this fee is collected by operations and maintenance company contracts. Conventional OWTS are not required to monitor nitrogen effluent. Since the results are self-reported, there are challenges to ensuring validation and timeliness of test results (E.-M. Olmstead, personal communication, July 3, 2019).[102]

A list of approved I/A/E systems, as of May 14, 2019, can be found on the MassDEP website.[104]

A website tutorial and self-paced learning module, maintained by Barnstable County, was created to assist LBH members with their understanding of Title 5. The module was developed under a grant from the Federal 319(b) Program, administered by the MassDEP.[99]

4.7 Conversion Method and Timeline

Title 5 mandates that a failing OWTS or cesspool must be upgraded within two years of discovery unless a shorter period is set by the LBH or the MassDEP determines the existence of an imminent health hazard. Continued use of the OWTS is permitted by the LBH with proper approvals. OWTS may be used if future proposals to connect to a sanitary sewer or shared system are in place with a financial commitment to a sewer plan or shared system plan, proposing connection or replacement of the failing system within five years, and an enforceable commitment by the owner to perform interim measures (for example, regular pumping) for approval.[89]

A failed cesspool definition falls under two categories[89]:

- A cesspool or privy is located within one-hundred feet of a surface water supply or tributary to a surface water supply, within a Zone I of a public well, within fifty feet of a private water supply wells, and less than one-hundred feet but fifty feet or more from a private water supply well. (Unless a well water analysis indicates an absence of fecal coliform bacteria and the presence of ammonia nitrogen and nitrate nitrogen is equal to or less than 5 ppm).
- A cesspool or privy is within fifty feet of surface waters or within fifty feet of a bordering vegetated wetland or a salt marsh and the LBH, in its professional judgment, determines the system is not functioning in a manner to protect the public health and safety, welfare and the environment.

In determining a failing system, the LBH will consider[89]:

- the condition, design, and treatment provided by the existing system;
- the vertical separation of the existing soil absorption system from groundwater;
- the horizontal separation of the existing soil absorption system from the water body;
- the soil characteristics of the site; and

- the condition of the water body or wetland, including any sensitive use areas such as beaches or shellfish beds.

Failing conditions applicable to all OWTS[89]:

- there is a backup of sewage into the facility served by the system or any component of the system due to overloaded and/or clogged soil absorption system or cesspool;
- discharge of effluent directly or indirectly to the surface of the ground through ponding, surface breakout or damp soils above the disposal area, or to surface water;
- the static liquid level in the distribution box is above the level of the outlet invert;
- the liquid depth in a cesspool is less than six inches from the inlet pipe invert or the remaining available volume within a cesspool above the liquid depth is less than half of one day's design flow;
- the septic tank or cesspool requires pumping more than four times a year;
- the septic tank and/or the tight tank is made of metal, or the septic tank and/or the tight tank is cracked or is otherwise structurally unsound, indicating that substantial infiltration or exfiltration is occurring or is imminent; or
- a cesspool, privy, or any portion of the soil absorption system extends below the high groundwater elevation.

4.8 Funding Mechanisms

The Massachusetts legislature passed a Title 5 tax credit that provides eligible homeowners with a tax credit equal to forty percent of the design and construction costs incurred to upgrade or repair a septic system (B. Dudley, Personal Communication, April 12, 2019). The tax credit relief measure provides credits against personal income tax imposed up to $1,500 per year for qualified homeowners with a maximum credit of $6,000 over four years. This tax credit is available for all septic system and cesspool upgrade and repairs that occurred on or after January 1, 1997. More information about Personal Income Tax Credit for Failed Cesspool or Septic System Title 5 Expenditures can be found on the MassDEP website.[105]

Additional financial assistance is available in the form of low-interest loans through the Massachusetts Housing Finance Agency (MHFA) and the Rural Economic Development Service Loan program. The MassDEP allocated $13 million for financing septic loan repairs. MassDEP has contracted with MHFA to implement and administer the Home Septic Repair Loan Program (HSRLP).[106] The HSRLP is available to owners of owner-occupied 1–4 family properties and condominium associations with failed septic or cesspool systems. To encourage lender participation, the Commonwealth will provide a $500 per-loan origination fee to lenders. Loans are backed by mortgage security.[107]

Loan size may range from $1,000 to $25,000 (Table 4). The minimum monthly payment must equal $27. Loans are fully amortizing at an interest rate of zero, three, or five percent depending on household income. All loans are due in full upon sale, transfer, or refinancing of the first mortgage. Refinancing of the first mortgage will require payoff of the Septic Repair Loan.[108]

In addition, eligible municipalities can make low-interest 20-year loans to low-to-moderate income homeowners, repaid by adding an annual betterment to their tax bill, called the Betterment Fund Program.[109] Betterment Loans can only be made after a community has adopted an inspection or management plan and been awarded monies from the state. A Betterment Agreement between the community and a homeowner may be used for all costs necessary to repair or replace a failed septic system, including renovating the existing system, hooking-up to existing sewer lines, or replacing traditional septic systems with an approved Title 5 alternative system.[109]

Table 4. Maximum loan terms for septic system and cesspool upgrade and repairs.

Years	Range ($)
3	1,000 – 3,000
5	3,001 – 5,000
10	5,001 – 10,000
15	10,001 – 15,000
20	15,001 – 25,000

Note: Reprinted with permission from MassDEP. Loans to borrowers qualified for 0% interest with debt-to-income ratios greater than 50% will be eligible for a 0% non-amortizing loan. These loans are due in full upon sale, transfer, or refinancing of the first mortgage. Very low-income households with considerable equity may also qualify for a deferred loan on a case-by-case basis.

The Community Septic Management Program (CSMP) offers loans to communities to develop OWTS management plans.[110] The CSMP was developed in collaboration with the MassDEP, the Executive Office of Administration and Finance, the Office of the State Treasurer, and the Department of Revenue.[111] Initial funding was provided by the 1996 Open Space Bond Bill that authorized MassDEP to spend $30 million dollars on funding loans. The CSMP provides funding of up to $200,000 in the form of low-cost loans to allow communities to devise a Community Inspection Plan (CIP) or a Local Septic Management Plan (LSMP). Each plan must include provisions for financial assistance to homeowners using Betterment Agreements.[110,111]

A CIP is designed to protect environmentally sensitive areas from contamination from OWTS. Inspections are performed every seven years. CIPs relieve property owners covered under the plan from their obligation to have their OWTS inspected upon ownership transfer. More details about CIPs can be found on the MassDEP website.[110]

An LSMP identifies, monitors, and addresses proper operation, maintenance, and upgrade of OWTS in a comprehensive manner. Plans must include identification and prioritization of areas containing systems that warrant more regular monitoring and maintenance and/or upgrade. LSMPs also include the development of a database system for tracking the inspection of OWTS. The database must also track whether failed systems are being upgraded in accordance with timelines outlined in Title 5. Finally, LSMPs require a schedule for periodic pumping and other routine maintenance of systems covered by the program.[110]

Some towns have developed additional financial programs. Gloucester (Massachusetts) developed an Elderly Deferral Program.[112] Loan payments may be able to be deferred if applicants are over age 65, have a gross income in the previous year that did not exceed $30,000, have lived in Massachusetts for the past ten years, and the applicant has owned and occupied the home for the last five years. A new deferral agreement must be filed each year with the LBH. The entire amount of the deferral, plus interest of eight percent, and recording fees is due and payable upon death, sale, or transfer of title.[112]

4.9 Final Analysis/Application

- Title 5 requires inspections of OWTS prior to property transfer or dwelling enlargement.
- Title 5 mandates that a failing OWTS or cesspool must be upgraded within two years of discovery unless the LBH sets a shorter period or the MassDEP determines the existence of an imminent health hazard.
- Title 5 set new OWTS standard flow rates of 440 gpd per acre (40,000 sq. ft), roughly translating to 110 gpd for each bedroom.
- Massachusetts regulations and calculations for total nitrogen discharge concentrations of all I/A/E system effluent was created not to exceed 19 mg/L. This performance level was based upon the BAT at the time the Title 5 OWTS rules were being created.
- Towns can create more stringent OWTS regulations to protect public health, safety, welfare, and the environment.
- An I/A/E system is required in an Interim Wellhead Protection Areas, Zone II of public water supplies, or nitrogen sensitive embayments.
- If an OWTS cannot meet the 440 gpd per acre nitrogen loading limitation and the landowner is not using an I/A/E system, a landowner can meet the correct loadings by using eligible Nitrogen Credit Land.

- Massachusetts has a well-developed system to evaluate and approve new I/A OWTS technologies. Approvals will be used to determine whether, under field conditions in Massachusetts, the general use of the alternative system will provide environmental protection, and to determine whether any additional conditions addressing long-term operation, maintenance and monitoring considerations are necessary.
- The MASSTC was developed to address impacts to coastal environments from nitrogen by testing new and innovative OWTS technologies.
- Barnstable County created an I/A OWTS database that allows system operators (state-licensed wastewater treatment operators who are contracted by homeowners for system maintenance) to submit maintenance and sampling reports online.
- Massachusetts passed a Title 5 tax credit that provides eligible homeowners with tax relief. The tax credit relief measure provides credits against personal income tax imposed up to $1,500 per year for qualified homeowners with a maximum credit of $6,000 over four years.
- In addition, eligible municipalities can make low-interest 20-year loans to low-to-moderate income homeowners, repaid by adding an annual betterment to their tax bill, called the Betterment Fund Program.
- The MassDEP allocated $13 million for financing septic loan repairs. MassDEP has contracted with MHFA to implement and administer the HSRLP.
- Some towns have developed additional financial programs. Gloucester, Massachusetts developed an Elderly Deferral Program.

5. Maryland

Maryland is a state in the Mid-Atlantic region bordered by West Virginia to the west, Virginia to the south, Pennsylvania to the north, and Delaware to the east. Maryland has 3,190 miles of coastline.[69] The United States Census Bureau estimates the population to be 6,042,718 as of 2018.[113] The population density is 594 people per square mile, with the total land area covering 7,141 square miles.[114,115] Maryland has a range of climates from humid subtropical to humid continental.

This chapter will briefly cover Maryland's OWTS regulations and programs with a specific focus on the Chesapeake Bay Restoration Fund (CBRF), the Chesapeake Bay Critical Areas, and Maryland's requirements for BAT (also known as I/A/E systems). An extensive review of the state's onsite wastewater program was deemed to be unfitting due to an insufficient number of cesspools within the state.

5.1 Regulation Overview

The Chesapeake Bay has experienced a decline in water quality over many years due to the over-enrichment of nutrients, including nitrogen. In 2004, Maryland Senate Bill 320 was passed to create the Bay Restoration Fund (BRF) as a method to fund and upgrade OWTS and wastewater treatment plants to remove nitrogen in wastewater effluent.[116,117] There are approximately 420,000 OWTS in Maryland.[118] According to state documents, Maryland has a goal of reducing nitrogen loading in the Chesapeake Bay by over 7.5 million pounds of nitrogen per year.[119] The BRF included the creation of an Advisory Committee with many duties, including the analysis of nutrient removal from wastewater facilities, advising on outreach and education, and providing recommendations to improve the efficiency of programs.[120] In 2012, Maryland's House Bill 446 passed, effectively increasing the BRF fees, in addition to creating a financial hardship fee waiver.[121] The Maryland Department of the Environment updated Title 26 in 2013, its OWTS requirements, by requiring the installation of BAT in certain areas.[122] In 2017, The Clean Water Commerce Act (CWCA) passed, made up of Senate Bill 314 and House Bill 417, which allows the use of BRF by the state to include costs associated with the purchase of nitrogen loading reductions if they are determined to be cost-effective.[123,116,124] Essentially, this program allows the state to fund the outcomes of nutrient reduction projects rather than the project itself.

5.2 Regulation Requirements/Enforcement

Maryland's OWTS are regulated through 26.04.02 of Title 26 with permits administered by an LBH.[125] A list of LBH jurisdictions can be found on the Maryland Department of the Environment Onsite Systems website.[126]

I/A/E systems may be required by an LBH due to site or limiting conditions, even if outside a critical resource area (CRA) (T. Sterner, personal communication, June 14, 2019).[125]

Violations of Title 26.04.02 can result in a misdemeanor charge and fines of not less than $50 and not more than $100 for each offense.[125] Each day's failure to comply with any provision of these regulations is considered a separate violation. A court order to enforce regulations may be taken against those who violate the regulations.[125]

5.3 Methods to Determine Priority Conversion Areas

About six percent of Maryland's total nitrogen load to the Chesapeake Bay is from OWTS.[127] OWTS are projected to have a small increase in pollution loads on the Chesapeake Bay over time, reaching about seven percent by the year 2025, largely because a number of systems installed in the state exceed the number of existing OWTS upgraded.[127]

To prioritize areas to convert OWTS, Maryland has identified CRAs using geographic boundaries.[128] CRAs are classified as land within 1,000 feet of tidal waters and wetlands. It also includes the waters of the Chesapeake Bay, the Atlantic Coastal Bays, their tidal tributaries, and the lands underneath these tidal areas. It is estimated that 52,000 OWTS are located within CRAs.[118] These areas are priority areas to implement I/A technologies and assist with the Chesapeake Bay TMDL.[118]

In addition to CRAs, The BRF uses a priority list to address specific OWTS for conversion. The following list is arranged in order of importance, with the first being the most prioritized for upgrade and funding[118]:

- Failing OWTS in the Critical Areas
- Failing OWTS outside the Critical Areas
- Non-conforming OWTS in the Critical Areas
- Non-conforming OWTS outside the Critical Areas
- Other OWTS in the Critical Areas, including new construction
- Other OWTS outside the Critical Areas, including new construction

Maryland currently has no statutory definition for a failing OWTS.[129] Systems that are classified as failing can be subject to enforcement. A bill is currently being introduced in the state to address this issue (T. Sterner, personal communication, June 14, 2019).

5.4 Methods to Identify Impaired Waters

The Chesapeake Bay is the largest estuary in the United States.[130] In the late 1970s, Congress funded a five-year study to analyze the bay's rapid loss of wildlife and aquatic life (T. Sterner, personal communication, June 14, 2019).[131] The study identified excess nutrient pollution as the main source of degradation. The study led to the Chesapeake Bay Program as a method to restore the bay. Maryland, along with other Atlantic states, has implemented various programs attempting to address pollution in the Chesapeake Bay[131]. In spite of these efforts and due to a lack of results, the EPA in 2010 established the Chesapeake Bay Total Maximum Daily Load program.[132] Maryland is part of the Chesapeake Bay Program and has developed WIP that spells out detailed, specific steps to meet pollution reductions by 2025.[127]

According to Greg Bush of the Maryland Department of the Environment (personal communication, June 13, 2019), addressing nitrogen pollution from OWTS and implementing their conversion has been a challenge. If OWTS are only evaluated through the lens of nitrogen reduction, the cost-benefit of replacing OWTS is low (T. Sterner, personal communication, June 14, 2019). Other difficulties of replacing OWTS include the distribution of systems over large areas, private property interests, longer implementation horizons, and required engineering plans and approvals. Maryland is currently looking at other metrics, such as groundwater protection and public health, to include in cost-benefit analyses of replacing OWTS in hopes of boosting the focus on replacing OWTS (T. Sterner, personal communication, June 14, 2019).

5.5 Nutrient Reduction Science

According to conversations with Travis Sterner of the Maryland Department of the Environment (personal communication, July 22, 2019), nutrient reduction science was based upon the ability of I/A/E systems to reduce the total nitrogen concentrations a minimum of fifty percent versus conventional OWTS. For a technology to be considered I/A, systems must reduce nitrogen concentrations to 30 mg/L or less. Many systems were able to achieve less than 30 mg/L of nitrogen concentrations based upon site conditions and soil abortion systems.[133] A fifty percent reduction assumes a total Kjeldahl Nitrogen amount of 60 mg/L, depending on the adsorption area behind the BAT more reduction of nitrogen may occur (T. Sterner, personal communication, July 22, 2019).

5.6 Conversion Technologies/Future Technology Approval

There are no specific requirements in the state regulations for OWTS owners to convert to sewer systems within connection boundaries (T. Sterner, personal communication, July 22, 2019). However, a county can expand a community sewer system requiring owners of OWTS within the connection zone to connect to the community sewer. From 2013 to 2017, all-new construction across the state required homeowners to install I/A/E systems. In 2017 the governor eliminated this requirement, currently only new construction within a CRA requires an I/A/E system be installed (T. Sterner, personal communication, July 22, 2019).

Maryland refers to I/A/E systems as BAT. The Maryland I/A/E system approval process has five different classifications.[134] An I/A/E system verification program approval flowchart, outlining BAT Class II technologies, was created in 2015 and is available on the Maryland Department of the Environment website.[135] Class I BAT systems are units that are approved under protocols identified by the State of Maryland and capable of reducing total nitrogen concentrations by fifty percent to 30 mg/L or less.[122] This standard is the least stringent of all states reviewed. I/A units currently on the approved list have successfully completed field verification testing. A list of approved I/A/E systems can be found on the Maryland Department of the Environment website.[136] The most efficient approved I/A/E system, reduced mean nitrogen concentrations of seventy-six percent over conventional OWTS. Units that are still under field verification are listed as BAT Class II and upon successful completion of the field, verification will become BAT Class I (T. Sterner, personal communication, July 22, 2019).

An OWTS owner must maintain and operate all new and existing I/A/E systems for the life of the system. The I/A/E system must be operated and maintained by an approved management entity, a certified service provider, or covered by a renewable operating permit. An I/A/E system must be inspected and have the necessary operation and maintenance performed at a minimum of once per year. Maryland also requires I/A/E systems to include a two-year operation and maintenance contract and a two-year warranty offered by the manufacturer. Prior to 2017, Class I BAT systems were required to have a five-year warranty and operations and maintenance contract. Because inspections must be performed by the system distributor's trained inspector, OWTS owners have limited choices to who performs the annual inspections (T. Sterner, personal communication, July 22, 2019).[122]

As of 2015, Delaware, Maryland, Pennsylvania, Virginia, and West Virginia have a Memorandum of Cooperation to share data developed to document the performance of I/A/E systems and nitrogen reduction methods.[118] It is the hope that the Memorandum of Cooperation aides in the simplification and time reduction of the OWTS approval processes, as well as reduce costs to residents and manufacturers.[118]

5.7 Conversion Method and Timeline

Research did not indicate that cesspools were a major issue in Maryland. However, the state did identify outdated and poorly functioning conventional OWTS as a contributor to pollution in the Chesapeake Bay. No specific timeline or number of required OWTS upgrades was listed in updated legislation on the issue (T. Sterner, personal communication, July 22, 2019). The replacement process is driven by available funds in the BRF and Watershed Implementation Plans for each county. The goal is to incentivize people to convert early and take advantage of the funds before they are exhausted. The Maryland Department of the Environment has upgraded over 12,000 conventional OWTS by either connecting them to a public sewer installing an I/A/E system through the Bay Restoration Fund.[118] On average, approximately 1,200 OWTS annually are upgraded to I/A/E systems.[127] I/A/E systems are not required outside the Chesapeake Bay or Atlantic Coastal Bays Critical Areas; however, local regulations may require I/A/E systems to protect public health or water quality.[137] New construction or replacement OWTS within CRAs are required to use an I/A/E system.[137]

5.8 Funding Mechanisms

Maryland has established two novel funds to assist with covering OWTS and municipal wastewater treatment plant upgrades. As of 2012, all municipal sewer customers are charged a $5.00 monthly fee. The fee is deposited into an interest-earning fund, which municipal wastewater facilities discharging to the Chesapeake Bay who meets the criteria specified by the BRF, have priority to available funding to upgrade treatment plants to tertiary levels (less than 4 mg/L of nitrogen) (T. Sterner, personal communication, July 22, 2019).[116] BRF funds can also be used to connect existing dwellings (served by OWTS) to sewer, where public sewer is available. Grants are limited to $20,000 per household and can be applied toward the capital facility, user connection, and master plumber's charges. Priority to grant funds will be given to properties located in CRAs, priority funding areas and those within existing or planned areas. The property owner is responsible for any costs more than the grant amount (T. Sterner, personal communication, July 22, 2019).[116]

The OWTS BRF charges a $60 annual fee collected from each user served by an OWTS. Sixty percent of these funds are used for septic system upgrades, and the remaining forty percent is used to support farmers planting cover crops. OWTS BRF funds can be used statewide, however, CRA areas have priority. OWTS BRF funds can only be used to purchase a Class I BAT unit, an effluent disposal system (low-income households only), or a holding tank if a proper onsite system cannot be installed. Money from the BRF cannot be used to install a conventional OWTS (T. Sterner, personal communication, July 22, 2019).[118]

The estimated annual program income from the OWTS fee is about $27 million.[118] Between 2016–2018, Maryland spent roughly $10.1 million annually for installing roughly 1,000 I/A/E systems.[127] Priority for OWTS BRF funds is given to failing OWTS in critical areas (T. Sterner, personal communication, July 22, 2019). Funds can cover upgrades to BAT for nitrogen removal or for the marginal cost of using the best BAT, instead of conventional technology. If an owner receives funding to upgrade to an I/A/E system, the state of Maryland obtains an easement to access the I/A/E system for testing and maintenance. Grant money can be used toward the cost of the upgrade, which includes five years of O&M. The amount of assistance (up to a hundred percent in some cases) is determined based on income guidelines (T. Sterner, personal communication, July 22, 2019).

Maryland also has a Water Quality Trading Program, which creates a public market for nutrient reductions, including nitrogen.[138] The program promotes OWTS upgrades as a mechanism for generating a credit to meet National Pollutant Discharge Elimination System permit requirements. This program is voluntary and was created to assist the state restore and protect the Chesapeake Bay by promoting nutrient removal technology and cost reductions. Because the program is relatively new, not all elements of this program have been implemented (T. Sterner, personal communication, July 22, 2019).[138] Each county has a specific total maximum daily load (TMDL) goals and can reach these goals by upgrading OWTS to BAT or expanding municipal sewer systems. If counties connect OWTS to sewer or expand sewer capacity, they can receive additional nitrogen credits on top of the TMDL reduction.[138]

Maryland has a Linked Deposit Program, which is designed to provide a source of low-interest financing for private landowners or water system owners to make improvements that will reduce nutrients to the Chesapeake Bay.[139] A Linked Deposit program describes the relationship between the below-market rate of an interest investment agreement provided to a lender by the Maryland Department of the Environment Water Quality Financing Administration and the below-market rate of interest loan that is passed on to the borrower to fund OWTS upgrades. The below-market interest rate loan provided to a borrower is "linked" to the below-market rate of interest investment WQFA makes with a participating lender.[139]

Any financial institution that meets the following lender qualifications is eligible to participate in the program[139]:

- Eligible to make commercial loans
- Public depositor of state funds
- Agrees to receive linked deposits
- Insured by the Federal Deposit Insurance Corporation

5.9 Final Analysis/Application

- BRF charges fees to owners of OWTS and those connected to municipal sewer systems. Funds are used to help upgrade OWTS and wastewater treatment plants to reduce nitrogen, phosphorus, and sediment inputs to the Bay.
- When BRS is used to replace an OWTS with an I/A/E system, an easement to the OWTS is obtained by the state, ensuring that maintenance and monitoring can be performed.
- Maryland created CRAs using a geographic boundary. CRAs are classified as land within 1,000 feet of tidal waters and wetlands. OWTS within these areas are prioritized for an upgrade to I/A/E systems. Owners are incentivized by available funds from the BRF, sometimes covering all the costs of an upgrade depending on income level and the type of system.
- The Water Quality Trading Program, a voluntary program, promotes OWTS upgrades as a mechanism for generating a credit to meet NPDES permit requirements.
- A Memorandum of Cooperation to share data developed to document the performance of I/A/E systems and nitrogen reduction methods was implemented with states that are in the Chesapeake Bay Watershed. It is the hope that the Memorandum of Cooperation aids in the simplification and time reduction of the OWTS approval processes, as well as reduce costs to residents and manufacturers.
- The Clean Water Commerce Act of 2017 creates a market to purchase successful outcomes of nutrient reduction programs rather than funding projects by using high-

resolution land-cover data from the Chesapeake Conservancy's Conservation Innovation Center.
- Utilizes the combined average of an I/A technology's total nitrogen results in order to represent the overall ability of a technology.

6. New Jersey

New Jersey is a state in the Mid-Atlantic region of the United States bordered by Pennsylvania and Delaware to the west, Delaware and the Atlantic Ocean to the south, New York and Pennsylvania to the north and the Atlantic Ocean to the east. New Jersey has 1,792 miles of coastline.[69] The United States Census Bureau estimates the population to be 8,908,520 as of 2018.[140] The population density is 1,196 people per square mile, with the total land area covering 7,417 square miles.[141,142] New Jersey has a humid subtropical climate, characterized by hot and humid summers and cool to mild winters.

6.1 Regulation Overview

In 1978 New Jersey banned the use of cesspools in new construction, however many cesspools were still in use across the state.[143] In 2012, the state amended the rules that govern OWTS by imposing state-wide minimum standards for inspections of existing systems during a real estate transaction. The updated regulations, entitled N.J.A.C 7:9A, also required cesspools to be upgraded regardless of their "working" condition.[144] The rules do not mandate OWTS inspections to be done. However, it is State Standard and a best practice to perform an OWTS inspection. Inspections are typically required by mortgage lenders, banks, or home buyers and are conducted by private entities who must report results to the local approving authority (typically the Local Health Department), making it part of the property record.[145] Inspection protocol can be found in the Technical Guidance for Inspections of Onsite Wastewater Treatment and Disposal Systems report.[146] The new regulations do not specify who is responsible for the necessary upgrades during a real property transfer (seller or buyer). An upgrade must be completed before a unit can be occupied.[144] N.J.A.C 7:9A also allows for more stringent local ordinances regarding OWTS.[144] One such example is the Township of Jefferson, New Jersey. Jefferson Township developed stricter OWTS requirements titled Chapter 436, outlining requirements for OWTS operating permits, fines, enforcement, and educational programs.[147]

Management programs with advanced maintenance and record-keeping activities for traditional OWTS with design flows of less than 2,000 gpd exist in eight municipalities, located in Morris, Somerset, and Sussex counties.[148] These programs generally require licenses for the operation of each system. When OWTS owners apply for a license, they must show that the conditions of renewal have been met. Standards may include pumping of tanks, inspections, and owners must attest that the system is functioning properly.[148]

Under the previous rules, and until April 2012, a property owner with an existing cesspool could (with a permit from the LBH) add a septic tank in front of the cesspool, creating a seepage pit system. Under the new provisions, the addition of a septic tank in front of the cesspool will no longer be allowed.[144]

An updated 2013 law (not part of N.J.A.C 7:9A) NJ Rev Stat 58:11-24.1 states that the New Jersey Department of Environmental Protection (NJDEP) will establish a septic system density standard to prevent degradation of water quality, or to restore water quality pursuant to the state's Water Pollution Control Act or Water Quality Planning Act.[149]

6.2 Regulation Requirements/Enforcement

All types of OWTS are regulated by the state and through local or county health departments. The updated OWTS standards passed in 2012 allowed I/A/E systems to be installed without a special Treatment Works Approval (TWA) permit from NJDEP.[144,150]

Existing OWTS that are not cesspools, privies, outhouses, latrines, or pit toilets that serve existing structures, may continue to be used without change provided that these systems are compliant with the conditions upon which they were approved, are not malfunctioning, and there is no expansion or change in use of the existing structure that increases the estimated volume of sanitary sewage from the structure or changes the type of waste generated.[144]

Non-compliant systems are defined as an OWTS that do not perform as approved, or that malfunction include, but are not limited to the following[144]:

- Contamination of nearby wells or surface water bodies by sewage or effluent as indicated by the presence of fecal bacteria where the ratio of fecal coliform to fecal streptococci is four or greater;
- Ponding or breakout of sewage or effluent onto the surface of the ground;
- Seepage of sanitary sewage or effluent into portions of buildings below ground;
- Back-up of sanitary sewage into the building served, which is not caused by a physical blockage of the internal plumbing;
- Any leakage from or into septic tanks, connecting pipes, distribution boxes and other components that are not designed to discharge sanitary sewage or effluent; or
- Any discharge of sanitary sewage without a zone of treatment.

A homeowner or an agent of a homeowner must notify the LBH upon detection of a non-compliant system, non-compliance may include a failing system or an I/A/E system without a valid service contract . The LBH will typically perform an investigation whenever they have knowledge through a report or direct observation of the existence of a non-compliant system. If an LBH is notified of the existence of a potentially non-compliant system, the LBH will respond to the notification and provide its findings to the system owner within ten business days. If immediate action is necessary to abate potential public health or environmental impact, the LBH may respond according to its outlined procedures.[144]

Beginning in 2013, New Jersey began requiring authorized installers must be a New Jersey licensed professional engineer and have a valid Certified Installer of Onsite Wastewater Treatment Systems (CIOWTS) Advanced Level certification from the National Environmental Health Association (NEHA) or hold an S2 or higher public wastewater treatment system operator license from the NJDEP.[144,151]

Since 1990 municipalities are required to educate owners of OWTS on proper operation and maintenance. The education/notice must occur at the time of permit approval and at least every three years thereafter. According to New Jersey regulations, a mass mailing to owners of OWTS will satisfy this obligation.[144,152]

6.3 Methods to Determine Priority Conversion Areas

No specific provisions were written into N.J.A.C. 7:9A about the state determining priority replacement areas of cesspools or outdated OWTS.

6.4 Methods to Identify Impaired Waters

No specific provisions were written into N.J.A.C. 7:9A about the state identifying impaired waters from a cesspool or OWTS pollution. However, the state does have several other programs (listed below) and permitting procedures that limit impacts to environmentally sensitive areas.

Subchapter 9 of the Coastal Zone Management rules in N.J.A.C. 7:7 outlines “special areas” found in the coastal zone that are regulated by NJDEP. A list of sites can be found on the NJEDP Division of Land Use Regulation website.[153] Some special area sites may contain a variety of regulatory requirements for construction activities. Septic system installation, repair, and/or replacement may result in impacts to “special areas” and multiple permits from the Division of Land Use Regulation may be required prior to site preparation or construction.[153] An online mapping program of the state’s “special areas” may be found on the NJDEP Bureau of GIS website.[154]

The state also has specific areas with Water Quality Management Plans (WQMP). These plans do not directly address the management of individual OWTS. Some WQMPs do mention OWTS as a non-point source of pollution and provide information on managing these systems.[155]

6.5 Nutrient Reduction Science

No specific provisions were written into N.J.A.C. 7:9A about the level of nitrogen in wastewater effluent that must be achieved for OWTS. The Pinelands Commission has created methods to track nitrogen effluent from I/A/E systems.[156]

6.6 Conversion Technologies/Future Technology Approval

A COC is required to build an OWTS. The LBH will inspect the OWTS during construction, installation, or alteration to ensure compliance with the requirements and approved engineering design. A COC may also be issued if a licensed professional engineer submits a statement in writing, signed, and sealed that states the OWTS has been located, constructed, installed, or altered in compliance with the proper requirements, standards, and the approved engineering design.[144]

There are four major types of OWTS approvals in New Jersey prior to constructing a system. The standards for OWTS require that septic permits be obtained before locating, designing, constructing, installing, altering, and operating a septic system are listed below[144,157]:

- Local Health Department Approval
- Alternative Design Treatment Works Approval
- Certification of 50 or more Realty Improvement Developments
- New Jersey Pollution Discharge Elimination System (NJPDES) Approval (required for systems above 2,000 gpd)

The Pinelands area of New Jersey has special considerations for OWTS, and the LBH must have a Pinelands Commission issued Notice of Filing, COC, Certificate of Filing, development approval, or a written statement that no approval from the Pinelands Commission for an OWTS to be constructed.[158] The Pinelands Commission is an independent state agency administering a comprehensive plan guiding land use, development, and natural resource protection in the 938,000-acre Pinelands Area of southern New Jersey.[159] The Pinelands Commission allows the use of conventional septic systems when they are installed at development densities that are consistent with the environment's carrying capacity. The carrying capacity is determined in the Pinelands by using a mass balance Pinelands Septic Dilution Model and requires a minimum of 3.2 acres for a conventional OWTS.[158]

6.6.1 Conventional System Conversion Methods

New Jersey has a state requirement that residents connect to a municipal sewer line if available within 150 feet of a dwelling. Townships, counties, or special designation areas such as those within the Pinelands district can restrict sewer development outside designated growth areas to protect habitat and aesthetics (E. Wengrowski, personal communication, July 12, 2019). Smaller community wastewater treatment systems are permissible under New Jersey regulations.[144] However, according to Edward Wengrowski, Environmental Technologies Coordinator with the New Jersey Pinelands Commission (personal communication, July 12, 2019), there are few examples of decentralized community systems. If a decentralized community system exceeds the 2,000 gpd threshold, the decentralized plant must meet NJDEP nitrogen standard, have a licensed operator, perform monitoring, and acquire discharge permits (E. Wengrowski, personal communication, July 12, 2019).

Conventional OWTS are permitted as a conversion method for cesspools.[144] Each component of the individual subsurface sewage disposal system must be designed and constructed to adequately treat and dispose of the expected volume of sanitary sewage to be discharged from the premises to be served. The expected volume of sanitary sewage from single residential occupancy activities will be determined by the number of bedrooms. Daily OWTS volume requirements for the first bedroom are 200 gpd. For each additional bedroom, the system must add 150 gpd capacity.[144]

A reduction of the daily design volume for a one-bedroom age-restricted unit or one-bedroom mobile home dwelling units less than 500 square feet may be approved to 200 gpd. A single-family unit must have a septic tank with a minimum capacity of 250 gpd per bedroom. A septic tank capacity cannot be less than 1,000 gallons. When domestic garbage grinder units or sanitary sewage ejector pumps are installed or proposed, a multiple compartment septic tank is required, and the liquid capacity of the septic tank(s) must be at least fifty percent greater than the minimum 1,000-gallon capacity.[144] Conventional OWTS in the Pinelands designated area must have systems inspected, cleaned, and certified once every three years.[160] The county and municipal governments are tasked with enforcement of OWTS regulations; the Pinelands Commission does not have enforcement capability. According to Edward Wengrowski (personal communication, July 12, 2019), many of the Counties in the state do not have adequate resources for enforcement capacity in terms of funding or personnel.

6.6.2 Advanced Nitrogen Removal Methods

The New Jersey definition of an I/A/E system is an NSF International Standard 40 or Standard 245 certified technology that is designed, installed, operated, monitored, and maintained in accordance with that certification and N.J.A.C 7:9A regulations.[144] NJDEP encourages the development and use of new technologies that may improve the treatment of sanitary sewage prior to discharge or allow environmentally safe disposal of sanitary sewage in areas where standard sewage disposal systems might not function adequately (E. Wengrowski, personal communication, July 12, 2019). I/A/E systems may reduce the size and height of disposal fields because of a 2.5-foot reduction in the minimum vertical separation to the seasonal high-water table.[161] However, strict operation and maintenance must be conducted on I/A/E systems to ensure proper treatment and environmental protection.[161]

An acceptable alternative waste treatment system is identified as one that has been approved for use by NJDEP and is properly operated and maintained so as not to cause a health hazard or nuisance. Acceptable treatments may include an organic waste treatment system or compost toilet operating on the principle of decomposition of heterogeneous organic materials by aerobic and facultatively anaerobic organisms and utilizes an effective aerobic composting process, which produces a stabilized humus. An acceptable alternative waste treatment system does not include a septic tank—drain field system or another system that results in a discharge to the ground or surface water of this state.[144]

Composting toilets are not specifically addressed in N.J.A.C. 7:9A. A waiver from the plumbing code is needed for a property owner to install a composting toilet, but they are acceptable. In these cases, the design flow is calculated as prescribed in N.J.A.C. 7:9A – 7.4. Greywater is considered sanitary waste and will still need a treatment system (S. Kumpf, personal communication, June 3, 2019).

Since advanced OWTS options are highly case-specific, the NJDEP encourages people to speak with technology vendors and manufacturers and their local health departments; the state only provides minimal guidance on I/A/E systems (S. Kumpf, personal communication, June 3, 2019).[144] Guidance documents for three types of advanced treatment (Aerobic Treatment Systems, Peat Biofilters, and Drip Dispersal Systems) can be found on the NJDEP Bureau of Nonpoint Pollution Control website.[162] NJDEP maintains a list of I/A approved devices. Evaluation criteria can be found on page 77 of the OWTS Rules.[144]

For individual systems with expected volumes of sanitary sewage less than or equal to 1,500 gpd, I/A/E systems must have obtained an NSF Standard 40 and/or Standard 245 certification. I/A/E systems must also have service contracts throughout the life of the system with an authorized service provider. To obtain a COC, occupancy permit, or any sign off by the local administrative authority required for the issuance of any construction application, a service contract must be in place.[144]

I/A/E system minimum maintenance and inspection schedules include requirements for an initial inspection within thirty days following system startup; twice per year for the first two years of system operation, once per year thereafter; at the time of transfer of the property with the new system owner; and inspections shall be conducted on a more frequent basis if required by the manufacturer or system integrator, as applicable.[144] Inspection results are recorded and stored at the LBH. The forms must be signed by the authorized service provider and shall be submitted to the administrative authority within thirty days after the inspection. Online access or electronic submission of the data may be substituted for the physical form, at the administrative authority's discretion.[144] A list of I/A/E systems can be found NJDEP Bureau of Nonpoint Pollution Control website.[162]

A comprehensive I/A program is in place in the Pinelands region of New Jersey, which was designed to meet the needs of the Pinelands Comprehensive Management Plan.[156,163] In 2000 an OWTS committee to research I/A/E systems was formed.[156] Based on the results of the research, five I/A/E systems were identified to meet water quality standards for the Pinelands region. In 2002 an I/A/E system pilot program was established to evaluate the effectiveness of I/A/E systems in real-world conditions. As of 2018, a total of 320 pilot program I/A/E systems have been installed in the Pinelands Area (E. Wengrowski, personal communication, July 12, 2019].[156,164] All pilot program systems must be covered under five-year parts and labor warranty without additional cost to homeowners.[164] Annual reports are presented to the commission on the pilot program results, the most recent report is available for 2018 on the New Jersey Pinelands Commission website.[161] Over the sixteen years the pilot program has been operational, three I/A/E systems have been identified as meeting the water quality standard of 2 mg/L of nitrogen when placed on appropriately sized residential parcels (E. Wengrowski, personal communication, July 12, 2019). Based upon reported nitrogen removal efficiencies and the Pinelands Septic Dilution Model, four approved I/A/E systems could be installed on lots with a minimum size of one acre, and one I/A/E system requires a minimum of one and a half acres.[156,161]

All Pinelands I/A/E systems must be equipped with alarm dialing capability with a service contract for the life of the system. OWTS vendors must ensure that samples of treated wastewater are collected and analyzed during the initial three years of system operation to determine each system's nitrogen removal efficiency. Testing is performed by NJDEP certified laboratories and lab results are provided to the Pinelands Commission. Testing or sampling is not required after approval is granted upon completion of the pilot stage.[164]

Recent Water Quality Management Planning Rules (N.J.A.C. 7:15) amended in 2016 dictate that counties served by OWTS are subject to a mandatory maintenance program, including the creation of local ordinances to ensure OWTS are inspected periodically to determine functionality.[158] Failure to have a valid service contract for I/A OWTS constitutes a violation of the Water Pollution Control Act, and a noncompliance violation of N.J.A.C. 7:9A. Each day the property owner fails to have in place a valid service contract shall constitute a separate and distinct violation. If a property owner fails to renew the service contract, the authorized service provider will provide written notification of the service contract expiration within thirty days after the expiration to the administrative authority.[158]

6.7 Conversion Method and Timeline

Effective June 2, 2012, all cesspools, privies, outhouses, latrines, and pit toilets that are part of a real property transfer shall be abandoned and replaced at the time of property transfer. Properties that are not being sold or transferred may continue to use their cesspool. The state does not have a failed system definition. However, New Jersey has deemed that cesspools, privies, outhouses, latrines, pit toilets, or similar sanitary sewage disposal units are not OWTS. When an administrative authority discovers one of these units or any cesspool that serves a structure and that needs repair or alteration, an order will be issued to abandon the unit and install a conforming system.[144]

Some exceptions exist with N.J.A.C. 7:9A. A cesspool that is not malfunctioning may continue to serve the structure after a real property transfer only in the following circumstances[144]:

- A conveyance for a consideration of less than $100.00;
- A conveyance by or to the United States of America, the State of New Jersey, or any instrumentality, agency or subdivision thereof;
- A conveyance encumbering realty, or providing for the modification, release or discharge of a debt, obligation or encumbrance, or the foreclosure of a mortgage or lien, or sheriff and execution sales;
- A deed which confirms or corrects a deed previously recorded;
- A sale for delinquent taxes or assessments and the foreclosure of same;
- Judicial proceedings affecting interests in real estate, and documents filed in connection thereto;
- A conveyance by a receiver, trustee in bankruptcy or liquidation, or assignee for the benefit of creditors;
- A deed eligible to be recorded as an “ancient deed” pursuant to N.J.S.A. 46:16-7;
- A deed or map that memorializes subdivisions of land, or which creates or affects easements or restrictions or other burdens upon title;
- A conveyance between family members or former spouses;
- Execution of a lease or license;
- In specific performance of final judgment;
- A deed releasing a right of reversion;
- A deed by an executor or administrator of a decedent to a devisee or heir to effect the distribution of the decedent’s property in accordance with the provisions of the

decedent's will or the intestacy laws of New Jersey, or the passage of title by intestacy or descent; or

- A deed to effectuate a boundary line agreement.

6.8 Funding Mechanisms

The New Jersey Water Bank (NJWB), formerly known as the Environmental Infrastructure Financing Program, is run in conjunction with NJDEP and the New Jersey Environmental Infrastructure Trust (NJEIT) to provide low-cost financing for the design, construction, and implementation of projects that help protect and improve water quality.[165] More information on the types of projects and programs funded can be found in a 2017 report from the NJDEP and New Jersey Infrastructure Trust.[166]

The NJWB finances projects by utilizing two funding sources. The NJEIT issues revenue bonds that are used in combination with zero percent interest funds to provide very low-interest loans for water infrastructure improvements and the NJDEP administers a combination of federal-state revolving fund capitalization grants, as well as the state's matching funds, loan repayments, state appropriations and interest earned on such funds.[165]

To receive funds through the NJWB, a public sponsor such as a community, must come forward and develop a septic management district with a set of policies and procedures governing system maintenance, repairs, and management.[165] According to Charles Jenkins of the NJDEP Municipal Finance and Construction Element (personal communication June 20, 2019), no public entities have utilized this funding mechanism, and the program has existed for nearly twenty years.

The state is in development of a program to invest unexpended capital funds from CWSRF and funnel the monies to individual homeowners through a Link Deposit Program.[167] A state CWSRF program purchases a reduced-rate certificate of deposit from a private financial institution. The financial institution then loans out the deposited funds (at a slightly lower interest rate) to individuals for smaller-scale water quality projects (i.e., allow individuals to replace cesspools).[167]

Because the law requires cesspools be upgraded during a real estate transaction, the state has recognized that funds or financing mechanisms may be available through New Jersey Department of Community Affairs (DCA) community development block grants or U.S. Department of Agriculture (USDA) rural development housing grants (C. Jenkins, personal communication, June 20, 2019).

6.9 Final Analysis/Application

- Effective June 2, 2012, all cesspools, privies, outhouses, latrines, and pit toilets that are part of a real property transfer shall be abandoned and replaced at the time of property transfer.
- In 2012, the state amended the rules that govern OWTS by imposing statewide minimum standards for inspections of existing systems during a real estate transaction. The updated regulations also required cesspools to be upgraded regardless of their "working" condition.
- The rules do not mandate inspections to be done. However, it is a state standard and best practice to perform an OWTS inspection.
- No specific provisions were written into law about the level of nitrogen in wastewater effluent that must be achieved for OWTS. Some environmentally sensitive areas like the Pinelands have created methods to track nitrogen effluent from I/A/E systems.
- Some areas like the Pinelands have specific density requirements.
- The 2012 law also allows for more stringent local ordinances regarding OWTS—more information is available on examples of ordinances that provide more strict pollution control.
- Management programs with advanced maintenance and record-keeping activities for traditional OWTS exist in eight municipalities. These programs generally require licenses for the operation of each system. Standards for licensing may include pumping of tanks, inspections, and owners must attest that the system is functioning properly.
- Beginning in 2013, New Jersey began requiring authorized installers must be a New Jersey licensed professional engineer and have a valid CIOWTS advanced level certification.
- Since 1990 municipalities are required to educate owners of OWTS on proper operation and maintenance. The education/notice must occur at the time of permit approval and at least every three years after that.
- I/A/E systems must have obtained an NSF Standard 40 and/or Standard 245 certification.
- I/A/E systems must also have service contracts throughout the life of the system with an authorized service provider.
- Pinelands I/A/E systems must be equipped with alarm dialing capability.
- The Pinelands Commission allows the use of conventional septic systems when they are installed at development densities that are consistent with the environment's carrying capacity. The carrying capacity is determined in the Pinelands by using a mass balance Pinelands Septic Dilution Model and requires a minimum of 3.2 acres for a conventional OWTS.

- New Jersey Water Bank has funds available. However, a public sponsor such as a community, must come forward and develop a septic management district with a set of policies and procedures governing system maintenance and repairs.
- The state is in development of a program to invest unexpended capital funds from CWSRF and funnel the monies to individual homeowners through a “Link Deposit Program.”

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Appendix F. Investigation of Cesspool Upgrade Alternatives in Upcountry Maui Final Report

Investigation of Cesspool Upgrade Alternatives in Upcountry Maui

Final Report

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To:

Hawaii Department of Health, Safe Drinking Water Branch
In fulfillment of contract SDWB-19-001-RW

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Executive Summary

Background and Project Aims

In Hawaiʻi, sewage has been identified as a major management challenge. Acknowledging the high risk associated with poor sewage management, recent legislation banned new cesspools across Hawaiʻi, but legacy cesspools remain and are polluting groundwater and the nearshore environment. Some areas in the State are at particularly high risk to the negative impacts of poor sewage management. The 12,000 homes and community facilities serving an area population of almost 31,000 people on the west facing slope of Haleakala Volcano, Maui, USA, referred to as Upcountry Maui, rely on 10,040 onsite sewage disposal system (OSDS) for domestic wastewater disposal. Of these, more than 7,400 are cesspools that release an estimated 4.4 million gallons per day of untreated wastewater containing 697 kg of nitrogen to the shallow subsurface. Nitrate concentrations of nearly 9 milligrams per liter (mg/L) have been measured in the groundwater water of Upcountry Maui, prompting the State Department of Health (DoH) to designate Upcountry Maui as a Priority 1 Cesspool Upgrade Area. This designation implies that cesspools in this area present a "significant risk of human impacts, drinking water impacts, or draining to sensitive waters", and are highest priority for action. A comprehensive analysis of upgrade alternatives is needed to inform a cost-effective strategy.

The aim of this research is to use evidence to help design nutrient pollution solutions that will reduce the most pollution at a reasonable cost, while considering equity. We employ a structured decision-making approach to determine how alternative management practices may influence groundwater nitrogen levels and at what cost; and where nutrient reductions would be most beneficial to meet both water quality regulations/objectives, and other social goals. Specifically, we 1) identify a range of cesspool replacement options, 2) develop a range of management alternatives that incorporate technical feasibility, 3) analyze environmental benefit of each alternative; 4) enumerate costs of the alternatives; and 5) provide recommendations on the alternatives relative to cost, environmental benefit, and stakeholder-identified objectives.

Approach

The structured decision-making process involved seven steps, consistent with a decision-theoretic process:

1) Define the problem – In brief, based on its mandate to protect drinking water, the Department of Health is empowered to recommend action to the State legislature to address pollutant levels in the groundwater that are nearing safe drinking water standards. In the case of Upcountry Maui, cesspools are a major current contributor of nitrogen flux into the groundwater.

2) Define objectives and select metrics – A stakeholder working group that included community members and government officials identified twelve objectives and metrics spanning cost, nitrogen reductions, equity in cost sharing, and feasibility that they want to achieve.

3) Identify, cost, and map feasible options (and constraints) – Various cesspool conversion options exist, from on-site systems that better reduce nitrogen than cesspools to alternative technologies to sewering. We specified the capital investment and operation and maintenance costs for each option, as well as their conditions and constraints (e.g., site characteristics).

4) Screen options – For each of the OSDS units in our study area, we assessed the feasibility of each of the upgrade options considered, using geospatial data corresponding to the constraints.

5) Develop alternatives – During exercises designed specifically to elicit creative thinking, participants of stakeholder discussions and a workshop developed alternative packages of options to upgrade cesspools. The project team used these inputs to design 41 alternatives to define, map, and evaluate.

6) Estimate consequences (accounting for local preferences and values) – Alternatives were evaluated using an existing groundwater flow and transport model that predicted how the various packages of upgrade options would perform when deployed across the landscape. The net present value of all capital and operation and maintenance costs were assessed for each alternative. A modified cost-benefit analysis assessed the nitrogen flux reduction per dollar cost. Equity was assessed by calculating the variability in cost burden across the households with cesspools and by comparing the costs borne by these households to the sewage fees paid by other Maui homes connected to county sewer systems. Other social objectives, such as design standards and maintenance burden, were evaluated using expert opinion.

7) Consider trade-offs – The final step evaluated how the various alternatives fared for each of the 10 objectives and considered the trade-offs. All alternatives were compared to each other, and to the “do nothing” (i.e., status quo) option. The results of this analysis are summarized below.

Results

Status quo. Under current conditions, the groundwater model predicted a maximum concentration of dissolved inorganic nitrogen of over 10 mg/l in one part of the project area (990 acres) and over 5 mg/L in a larger part (nearly 9,000 acres). Cesspools were estimated to be the second largest contributor (24%) of nitrogen flux to the groundwater after historical sugar cane production (55%).

Alternatives.

A strategy evaluation table is designed to serve as a decision aid. The table can be used to evaluate individual alternatives, or compare across alternatives. The first cut are alternatives that perform poorly across multiple objectives, and should thus not be considered – such as well-head treatment, which fails to decrease groundwater risk, and consequently also has zero cost-effectiveness.

The strategy evaluation table (reveals an obvious winner, composting toilets, which meets the fundamental objectives of reducing cost, impact, and risk, while ensuring equity, but it does not meet the cesspool ban nor comply with current regulations. There are also significant technical and social hurdles to overcome, which we did not address in this analysis. A number of septic tank alternatives (Alt 6, 8, 10, 19A) perform well across multiple objectives, as do the sewering Makawao (or Pukalani) combined with septic tank to Presby where possible alternatives (Alt 20-22, 23B-25B). The key difference between these alternatives is the risk of exceeding 5 and 10mg/l nitrate standards, which is quite a bit higher in the former. Alternatives that only sewer the neighborhoods without attending to the cesspools at all are the cheapest alternatives, both overall and per household, but they result in potentially unacceptable risk to aquifers and low flux reduction benefits.

If decision makers cannot allow any area to reach >10mg/l, then many alternatives are eliminated. The lowest cost alternative to meet the 10mg/l standard will cost $227 million over the 60-year project timeframe. Relatively low-cost septic tank-based alternatives (8, 10) meet this standard, at a much cheaper cost per household than the sewering alternatives (Alt 20-25), which have similar overall costs.

Alternatives that target the TMKs with the highest nitrogen contributions (Alt 19A and 19B) would cost $116 and $250 million, but the additional cost for 19B does not buy much result. 19B is far less cost-effective than 19A. Both these alternatives reduce the area at risk of over 10mg/L to about 100 acres, and only affect ~15% of households

Recommendations

This study represents the best available science on how different options for upgrading cesspools in Upcountry Maui would achieve stakeholder objectives. The research took a structured decision making approach, engaging a large working group of stakeholders in a participatory process to identify and assess how these options performed across an array of objectives using data and state-of-the-art modeling. Decision-makers can now use the analysis to choose their preferred options based on how well they perform against the objectives. It is up to the policy maker to weigh the various objectives. For instance, decision-makers concerned solely with minimizing nitrogen flux (protection of aquifer for drinking water) should choose Alternatives 20-25 or composting toilets, while those concerned with the lowest cost per household while meeting cesspool ban should focus on alternatives 10, 4B and 1. The following abbreviated recommendations are provided (longer descriptions are presented at the end of this report):

1. General

   a. Aquifers that are designated as potable should be maintained in that state and preserved for current and future use to the extent that is feasible via source control. In the case of Upcountry Maui, the only feasibly controllable source is OSDSs, which constitute approximately one third of the total nitrogen inputs which includes cesspools (24%). Cesspool upgrade alternatives that preserve the groundwater for potable use (nitrate-N <10 mg/L for 100% of the land area) include Alternatives 3, 4, 7, 8, 10-18, 20-25, and composting toilets.
2. Further Investigations
   a. Investigate inputs of chloramine into drinking water and thus emissions via cesspools, and, if appropriate, incorporate it into the groundwater model.
   b. Conduct a study on small cluster systems which could have cost efficiencies but require a detailed study than we were not able to provide.
   c. Investigate the cost of centralized sewering of the entire Upcountry community including a WWTP and a disposal system.
   d. Conduct a pilot study and then develop design standards for passive denitrifying absorption systems (Alts 9, 10, 17, 18) as well as Nitrex and Eliminite and Presby (with De-nyte) systems for the same purpose.
   e. Extend the study of Alts 19A/B to determine how many more TMKs would have to be included (in addition to the worst 20%) to achieve zero acres of >10mg/L nitrate.
   f. Conduct composting toilet study, to gain familiarity, experience maintenance issues, determine pathogen risks in compost, acceptable handling practices, and develop regulatory standards including permitting and maintenance requirements.
   g. Investigate financing options for completing any alternative program of upgrades, including: individual homeowner pays, state/federal grants, state tax credits, privatization of individual systems , County owning/operating all individual systems, and other options.
3. Program Management and Efficiency
   a. Conduct a study to determine a program management framework and the required DOH staffing to regulate all the OSDSs including the 88,000 upgraded cesspools in order to ensure public health is protected in the state.
   b. Develop design standards for drip irrigation systems, ET systems passive denitrifying absorption systems, to make approval of such systems routine instead of one-off design for each property as is the current situation.
   c. Develop regulations for operation and maintenance of composting toilets

4. Legislation and Administrative Actions
    a. Based on the investigations recommended above, write legislation to facilitate gray water, composting toilets, drip irrigation, ET systems, passive denitrifying absorption systems, program management including issuing OSDS permits and associated requirements, and financing methods.
    b. Criteria are needed to guide homeowner choices to ensure that sufficient nitrogen is removed, such that cumulatively all groundwater is maintained with <10mg/l of nitrate. We therefore strongly recommend that DOH develop such criteria.

The cesspool ban has regulatory efficiency, however, a systems perspective would improve outcomes, i.e., when the fundamental objective can be met by intervening in part of the system, these areas are targeted and exemptions to the ban might be considered for remaining households. Any system-scale solution would, of course, require subsidizing homeowners who upgrade. We recommend that DOH adopt a systems perspective, and design collective solutions and creative funding mechanisms to improve the economic efficiency. The project team would like to acknowledge the diligent and valuable inputs from the stakeholder working group participants. It is important to flag that they contributed to the process in good faith, despite fundamental disagreement with some of the key underlying premises of the project. This project started from the fact that Upcountry Maui is a Priority 1 area, and its aims were to identify the most cost-effective actions to upgrade cesspools in the area. Many of the stakeholders strongly disagreed with the prioritization of Upcountry for a number of reasons. They argued that that nitrogen flux from cesspools is a minor contributor compared to other sources; nitrogen from cesspools doesn't reach the groundwater; nitrogen loads in the groundwater are below drinking water standards nearly everywhere; evidence of contamination is limited to a handful of samples in a discrete area; no Upcountry residents get their water from the aquifer so drinking water standards aren't applicable; the only users of the aquifer for drinking water are private for-profit developers who choose not to wait for municipal water supply; and there is no documented evidence of human health/stream/coastal impacts. The project team were able to use empirical evidence and modeling to discuss some of these arguments, but the issue of prioritization remains a thorny one that is outside the scope of this analysis.

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Background

In Hawaiʻi, sewage has been identified as a major management challenge. Acknowledging the high risk associated with poor sewage management, new cesspools have been banned across Hawaiʻi, but legacy cesspools remain and are polluting groundwater and the nearshore environment (Whittier and El-Kadi 2009). In 2017, the Hawaii State Legislature passed Act 125 "Relating to Cesspools". This Act accomplished three things. First, it mandated that all cesspools in the State be either upgraded or converted by 2050, unless granted an exception for a legitimate reason, which include small lot sizes, steep topography, poor soils, and accessibility issues. Second, the Act expanded the criteria for an existing $10,000 tax credit to any citizen with a cesspool within 500 meters of a perennial stream, shoreline, or wetland; within an area designated as a source of drinking water; affecting drinking water supplies or recreational waters; or appropriate for connection to an existing sewerage system. Third, Act 125 requires the state Department of Health (DoH) to "investigate the number, scope, location, and priority of cesspools statewide that require upgrade, conversion, or connection based on each cesspool's impact on public health…and recommend any proposed legislation and administrative action". In parallel, DoH was mandated to assess the feasibility of a grant program to help property owners comply.

Some areas in the State are at particularly high risk to the negative impacts of poor sewage management. In 2017, DoH published its report prioritizing areas across the Main Hawaiian Islands, based on actual or potential impacts from cesspools to human health, drinking water, and sensitive waters. Due to the density of cesspools in the area and elevated groundwater nitrate concentrations, Upcountry Maui has been designated a Priority 1 Cesspool Upgrade Area (DOH, 2017). The 12,000 homes and community facilities on the west facing slope of Haleakala Volcano, Maui, USA, referred to as Upcountry Maui, rely on 10,040 onsite sewage disposal system (OSDS) for domestic wastewater disposal (DOH, 2018). Of these, more than 7,400 are cesspools that release untreated wastewater to the shallow subsurface. Nitrate concentrations of nearly 9 milligrams per liter (mg/L) have been measured in the groundwater water of Upcountry Maui (DOH, 2017). The USEPA health-based Maximum Contaminant Level (MCL) for nitrate is 10 mg/L. A Hawaii Department of Health investigation into the sources of the elevated groundwater nitrate concluded that, while not the only source, OSDS, primarily cesspools, significantly increased the groundwater nitrate concentration in the groundwater of Upcountry Maui. That study further estimated that the nitrate concentrations downgradient of the areas with the highest OSDS densities likely exceed the MCL of 10 mg/L (DOH, 2017 and 2018). Assuming 7,400 cesspools in Upcountry Maui required replacement at costs ranging from $20,000 to $60,000 each, the total cost of cesspool replacement could range from $120 million to $360 million. In addition, there will be on-going operation/maintenance costs as well as the need for a funded, effective management program. This is an onerous cost burden on the residents of Upcountry Maui and a comprehensive analysis of upgrade alternatives and a cost/benefit analysis is needed.

While the DOH report fulfilled the mandate in Act 125 to identify priority areas, it acknowledged the need for further analysis and continued stakeholder collaboration regarding the problems and solutions in the report in order to "eliminat[e] cesspools in an economically feasible way". The aim of this research is to use evidence to help design nutrient pollution solutions that will reduce the most pollution at the least cost, while considering equity. We seek to identify and compare options including various types of cesspool upgrades and installation of sewers. To achieve the largest pollution reduction possible at the lowest cost, decision-makers require appropriate analytical tools to determine (i) how alternative management practices may influence groundwater nitrogen levels and at what cost; and (ii) where nutrient reductions would be most beneficial to meet both water quality regulations/objectives, and other social goals.

While this "best bang for your buck" mindset may seem simple, management of water quality in Hawaiʻi is characterized by complicated decisions under conditions of high uncertainty and risk. Managers frequently have to choose among complex and often competing environmental, social, and economic objectives – and effects of management are often uncertain (Liu et al. 2012). Consequently, managers often rely on *ad hoc* decision making, which ultimately falls short of achieving desired outcomes. A more structured approach, informed by decision science, can increase conservation impact, reduce costs, and increase cooperation across management agencies.

Structured decision making (SDM) is a collaborative process for decision-making that combines analytical methods from ecology and decision science with facilitation/negotiation and social psychology to develop rigorous, inclusive, and transparent decisions that balance multiple stakeholder objectives. It has been applied to resolve a spectrum of wicked environmental management problems. SDM draws on decision analysis (DA) – a discipline with a deep theory and body of practice (Howard 1988; Pratt et al. 1995; Skinner et al. 2011) that uses established methods and tools to formally dissect key aspects of complex decisions in order to recommend actions that lead to outcomes that ultimately maximize expected utility (Keeney 1996).

Decision analysis tools can lead to better outcomes for nature and people, stronger community support for actions, and more cost efficient and impactful choices (White et al. 2012). It is particularly well suited to finding solutions to problems where there are many unknowns, or where risks may be high, as in the case of Hawaii's cesspools. In the face of high levels of uncertainty in cost, benefit, feasibility, and effectiveness of management options, under accelerating future change, decision models maximize outcomes over long term planning horizons, while accounting for near term needs, resulting in more strategic decisions (Gregory et al. 2012). A decision analytic approach can evaluate alternate management and policy options, assess trade-offs, and identify optimal solutions and strategies (Huang et al. 2011; Linkov et al. 2006; White et al. 2012).

The main project objectives are to: 1) identify a suite of cesspool replacement options, 2) develop a range of management alternatives to upgrade cesspools that incorporate feasibility, 3) analyze environmental benefit of each alternative; 4) enumerate costs of the alternatives; and 5) provide recommendations on the alternatives relative to cost, environmental benefit, and stakeholder-identified objectives. Overarching strategic goals are to begin building the framework for a much better academic-agency collaboration, and to pilot a collaborative decision-making framework with communities that will have pay-offs for agency decision making far into the future. Hopefully recommendations from this report can help the DoH craft proposed legislation and administrative action to the benefit of the people and environment of Hawaiʻi.

Approach

Decision analysis

At the request of the Hawaii Department of Health (DoH), we undertook a decision analysis process to evaluate the utility of proposed actions to address groundwater nitrogen pollution in Upcountry Maui. This process involved convening a local stakeholder group (Appendix I) and collaboratively engaging in a structured decision-making process. Stakeholders were identified via conversations with the DoH, and via emails from public comments on a DoH Upcountry Maui groundwater investigation report and public presentation (DOH, 2018). The Upcountry Maui Stakeholder Group consisted of 28 people, representing the state DoH, the county departments of water supply and environmental management, elected officials, farmers, ranchers, large landowners, concerned citizens and environmental groups.

The structured decision-making process involves seven steps, consistent with a decision-theoretic process. Below we summarize the following steps:

1. Define problem
2. Define objectives and select metrics
3. Identify, cost and map feasible options (and constraints)
4. Screen options
5. Develop alternatives
6. Estimate consequences (accounting for local preferences and values)
7. Consider trade-offs

All analysis was conducted in R Version 3.5.0 (R Core Team 2018) and ArcGIS 10.2.2 (ESRI 2017) unless otherwise specified.

Step 1. Problem Statement

A problem statement addresses:

- What is the decision—what kind of action needs to be taken?
- What triggered this decision; why does it matter?
- Who is the decision maker?
- What is the decision timing and frequency; are other decisions linked to this one?
- What is the scope of the problem (how broad or complicated is it)?

- What are the legal context and constraints?

Recent sampling data results and analysis have indicated elevated concentrations of nitrate in the aquifer underlying Upcountry Maui. These levels are approaching U.S. Environmental Protection Agency (EPA) safe drinking water standards in certain places (https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations). DOH views these nitrate concentrations approaching the Maximum Contaminant Levels (10mg/L Nitrate – measured as Nitrogen) as a significant groundwater contamination problem.

Because DOH is charged with protecting scarce freshwater resources, it is obligated to work to correct the source of contamination. DOH identified Upcountry Maui as a Priority 1 area for cesspool conversion (DOH, 2017). The DOH report to Legislature recommends immediate conversion, although there is no legal or regulatory requirement for the cesspools in Upcountry Maui to be upgraded any sooner than cesspools elsewhere in the State under this recommendation. Priority 1 designation (including Upcountry Maui) have priority for funds in the event that public funding was to become available.

Independently, in 2017, the State of Hawaii passed Act 125 which mandated that all cesspools across the State be eliminated by 2050 to address water quality challenges.

DoH is empowered to: make recommendations for action to the Hawaii State legislature, regulate cesspool upgrade options, and seek funding to address water quality in Upcountry Maui, and throughout the State, from other government sources, including infrastructure funds, depending on the actions proposed. DoH is also tasked with monitoring and enforcing any statutory or legislative actions that may be required.

The State of Hawaii is empowered to pass new regulations. These include regulations that might assign funding, other incentives such as tax breaks, or penalties. They are also empowered to cost-share national infrastructure projects. The County of Maui can also cost-share state and national infrastructure projects, and is empowered to install sewer, change zoning, and manage permitting of new infrastructure, which could facilitate or limit future developments.

The community wishes to ensure that the burden for wastewater management is equitably shared among residents, and between residents, developers, and other parties. Parties do not all agree on what equity looks like. Some think that means that developers should pay, others that polluters should pay.

Parties recognize that options for transitioning from cesspools to alternate waste management systems can involve large costs, and result in widely varying improvements to water quality depending on their type and site conditions. Some transition options may take a long time to realize. Since technology moves fast, and both efficacy and cost change rapidly, in that timeframe, the landscape of management options may change drastically – with possibly better management and more economical options available in future. Consequently, there may seem to be little incentive, particularly for individuals, to act now. However, dealing with the scale of change required means that action and planning is necessary now, particularly as large-scale infrastructure options may be required, and some may become less feasible over time.

It is also recognized that the estimated costs are likely to be significant, so a range of feasible options with different costs are desirable for affected individuals as well as options that could take the burden from individuals due to eligibility for public funding or possibly commercial investment.

A range of management options are likely feasible, but those that are possible in Upcountry Maui have not yet been identified or costed. To address this data gap, the University of Hawaii is leading a process to identify, screen, and cost options to address nitrate contamination in Upcountry Maui groundwater. Existing design regulations and approval processes based on engineering and regulatory constraints exist for some options but not others; where these are not available, one constraint to implementation is that an approval phase would be required.

To address this problem, we applied a structured decision-making process as a tool to work through and address the issues associated with groundwater management in Upcountry Maui. UH worked with a DoH-developed groundwater model to evaluate the effects of several alternatives, and with local stakeholders to develop objectives that reflect their goals, including protection of public health, and finally to evaluate the cost effectiveness of the alternatives.

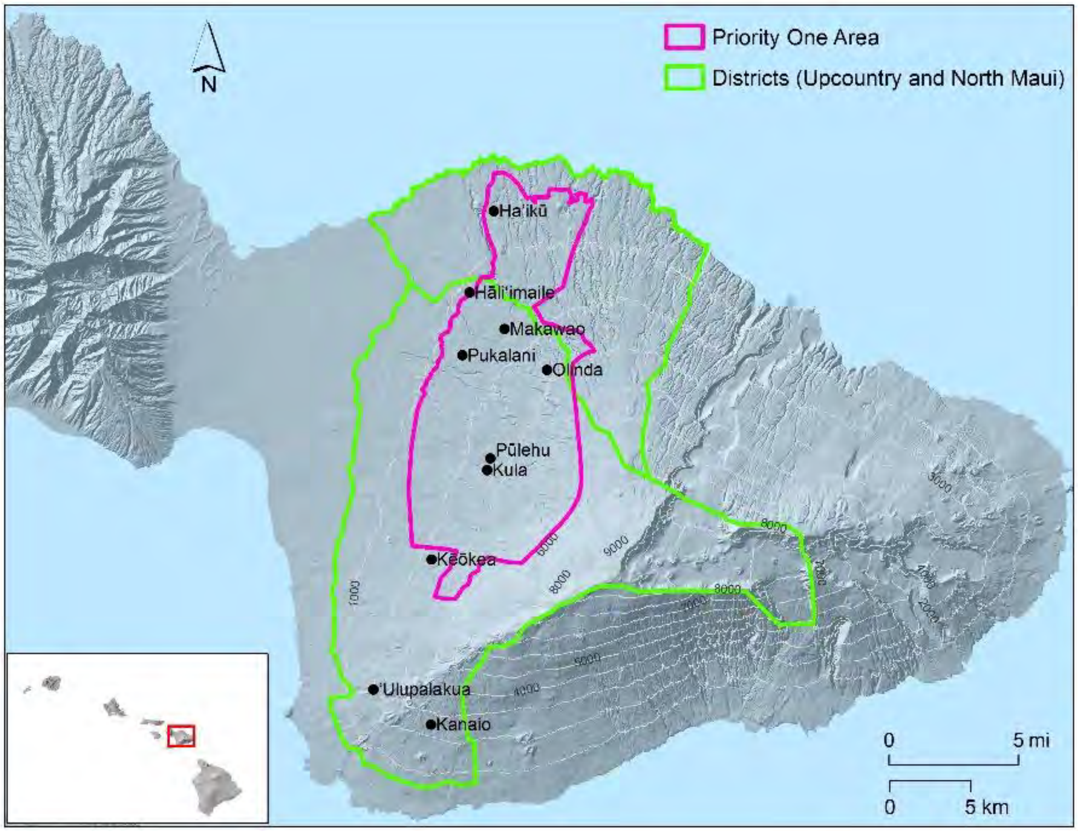

Figure 1. Maui study area; study focuses on cesspool upgrade options for priority areas in Upcountry and North Maui. Priority One Area was identified by DOH, based on elevated nitrate concentrations in the Upcountry Maui groundwater and Statewide analysis (Whittier and El-Kadi 2014).

Additional Concerns/Considerations related to the problem statement

It is important to note that the stakeholder working group participants voiced fundamental disagreement with the key underlying premises of the problem. This project started from the fact that Upcountry Maui is a Priority 1 area, and its aims were to identify cost-effective and technically feasible options to upgrade cesspools in the area. Many of the stakeholders strongly disagreed with the prioritization of Upcountry for a number of reasons. They argued that that nitrogen flux from cesspools is a minor contributor compared to other sources; nitrogen from cesspools doesn't reach the groundwater; nitrogen loads in the groundwater are below drinking water standards nearly everywhere; evidence of contamination is limited to a handful of samples in a discrete area; no Upcountry residents get their water from the aquifer so drinking water standards aren't applicable; the only users of the aquifer for drinking water are private for-profit developers who choose not to wait for municipal water supply; and there is no documented evidence of human health/stream/coastal impacts. One stakeholder raised the concern that municipal drinking water in Upcountry Maui included large amounts of chloramine, a chemical that may lead to increased nitrogen under the right circumstances. This issue was beyond the scope of this analysis, however, disinfectant residuals in drinking water are generally very low due to cost concerns and regulations (less than 0.5 mg/L). Still, inputs of chloramine into drinking water and thus emissions via cesspools should be further investigated, and, if appropriate, incorporated into the groundwater model. The project team were able to use empirical evidence and modeling to discuss some of these valid arguments, but the issue of prioritization remains a thorny one that is outside the scope of this analysis.

Step 2. Objectives and metrics

Objectives were developed by the project team based on a series of consultations with members of the Upcountry Maui Stakeholder Group, including a site visit and one-on-one conversations with many members of the stakeholder group (Appendix I). We developed metrics to measure each objective (Table 1).

Table 1. Objectives for groundwater nitrogen management and the metrics developed to evaluate them.

	Objective	**Metric**
O1.	Minimize costs	Costs (C) = Net present value of cost in USD 2018
O2.	Minimize costs to community (individual households, and the community overall)	Mean cost (USD 2018) per 12,000 Upcountry Maui households over the 60-year cost horizon
O3.	Meet State and EPA drinking water quality standards.	State and EPA drinking water standards applied to groundwater: maximum concentration simulated by groundwater model is below 10mg/L nitrogen, measured as area under 10mg/L
O4.	Minimize aquifer nutrient loading	Benefit (B) = change in nitrogen mass flux resulting from intervention
O5.	Minimize risk to drinking water aquifers	Final groundwater N concentration below 5mg/L, measured by area over 5mg/L
O6.	Maximize cost-efficiency in minimizing nutrient pollution	Cost efficiency (CE) = B/C
O7.	Maximize equity	1: Number of households implicated in alternative 2: Worst polluters
O8.	Maximize equity Maui wide	Difference in cost per household of upgrade per annum and mean sewer fees per annum across Maui
O9.	Meets existing design standards	Proportion of N reduction contributed by not yet approved technologies? For options, matrix of Yes/No
O10	Minimizes Maintenance Burden	Qualitative classification conducted by engineers (High, Medium or Low levels of maintenance)

Additional Concerns/Considerations related to Fairness and Equity

In SDM, alternative courses of action are assessed against the objectives to guide the decision. As noted in the problem statement, this analysis is focused on finding alternatives to upgrade the cesspools within Upcountry Maui, therefore some concerns and considerations could not be adequately captured at this scale. We discuss these below.

Stakeholders raised concerns about fairness at two scales: within their community and more broadly at the county level. Stakeholders perceived an unfair burden to the homeowners compared to their other households with cesspools in Upcountry Maui, other Maui residents, including those with cesspools in “non-priority areas,” as well as households who have the good fortune to be hooked up to the public sewer system. These concerns boil down to three questions: (1) Why should I have to pay if my neighbors aren’t? (2) Why should I have to pay if I am not the problem? (3) Why should I have to pay more than other people on Maui for my household waste disposal? We have tried to incorporate all three of these though Objectives 7 and 8.

An additional dimension of equity arose as some stakeholders believed that their long-term use of the ground as a receptacle for household wastewater only became a problem when developers starting tapping the groundwater to provide drinking water to new homes. Some felt that these developers should bear some (or all) of the costs of preserving the groundwater quality, as they were the ones privately profiting from the public good. Many stakeholders also doubted the relative importance of cesspools as a pollution source, compared to other offenders, such as agriculture. Indeed, legacy nitrogen from former sugarcane production is the largest current contributor to nitrogen in the broader area. However, little can be done about this source at this point – the legacy nitrogen is needs to work its way through the system, while cesspools are actively polluting the groundwater.

Step 3. Identify, cost, map options

Various cesspool upgrade options are available, and these are reviewed in more depth in Appendix II. The general categories of options include the following:

- **Treatment systems**: these typically provide primary (physical) or secondary (including biological) treatment of raw household wastewater. Treatment systems include septic tanks and aerobic treatment units capable of nitrification and/or denitrification.

- **Disposal systems:** these are paired with a treatment system as the means for appropriately disposing treated wastewater. Examples of disposal systems are absorption systems (leach fields), seepage pits, and Presby Advanced Eniro-Septic®, which also includes a treatment component.

- **Technologies requiring approval under the Hawaii Administrative Rules (HAR):** these are feasible options included in the HAR, but require additional approval of specific designs and specifications. Examples of these options are evapotranspiration and recirculating sand filters.

- **Innovative technologies:** although these are not included in the HAR and will require more extensive review and certifications, they have potential as cesspool replacements. These types of technologies consist of either treatment and disposal options such as constructed wetlands, drip irrigation, and novel commercial systems such as Eliminite and NITREX.

- **Emerging technologies:** these have been tested experimentally or in pilot field tests and have promising results. Many of these options are passive, requiring little or no maintenance. Methods include recirculating gravel filter systems, layered soil treatment systems, and nitrification/denitrification biofilters. More extensive studies, especially on their performance on Maui, will be necessary.

- **Alternative toilets:** compost toilets are commercially available and incinerating toilets are in development. These are essentially zero-discharge systems with proper operation and maintenance. This allows for a home to set up a graywater (discharges not from toilets and kitchen sinks) reuse system. A wastewater treatment disposal system must still be present, however, because the State of Hawaii requires graywater to have an overflow pathway to prevent spills.

- **Sewering:** homes can be connected via sewers in decentralized or centralized sanitary sewer system. In a decentralized system, groups of homes connected via a cluster system may have a satellite treatment facility and/or a common disposal system. This could be extended to a centralized system with more homes connected to a wastewater treatment plant.

Table 2 shows the treatment and disposal options considered in this study (descriptions are found in Appendix II). Table 2 also shows the annual operation and maintenance costs which are considered independent of system size. Operation costs are for electricity and thus only those systems that require power have an operation cost. Electricity costs are generally very small for these systems (assumed 100W power draw, \$0.35/KWH, thus \$25/mo). Maintenance costs are for inspection by a professional (\$150) and for pumping/hauling/disposal of accumulated solids (\$250). Most of the systems are assumed to last for either 30 or 60 years, at which time they will have to be replaced. This affects the 60-yr life cycle cost which is discussed further below.

Table Annual costs for operation and maintenance of OSDS treatment and disposal systems including replacement intervals

	OSDS Treatment and Disposal Systems	Operation	Maintenance	Replacement interval (yrs)
Treatment Options	ATU-N	$300	$400	30
	ATU-N/DN	$300	$400	30
	Septic Tank	$0	$400	60
	Passive Biofilters (in-ground, medium, FL)	$0	$400	60
	Passive Biofilters (in-ground, high, FL)	$0	$400	60
	Composting toilets (also use for incinerating)	$300	$400	30
Disposal Options	Absorption System (bed or trench)	$0	0	60
	Constructed Wetland	$0	$400	30
	Disinfection	$150	$50	20
	Drip Irrigation	$300	$150	30
	Seepage Pit (new)	$0	$400	60
	Evapotranspiration	$0	$150	60
	NITREX ®	$0	$400	30
	Presby Advanced Enviro-Septic & De-Nyte ®	$0	$125	60
	Recirculating Sand Filter	$300	$400	30
	Eliminite ®	$300	$150	30
	Layered Soil Treatment System (MA)	$300	$150	60
	Gray Water system	$0	$150	30

Additional Concerns/Considerations related to management burden of upgrades

Another concern is program management by the DOH. The DOH WWB is tasked with approving and managing OSDSs. Currently, OSDSs statewide are managed at the time of design/approval/installation and there are no resources for on-going management of the approximately 100,000 systems. The cesspool ban will mean that 88,000 systems will be upgraded and each will have to go through the approval process which includes review and approval of test data and design submittals from engineers, and keeping of records. This will be a huge task that would require several additional staff. In addition, it will become even more important for the DOH to implement a more comprehensive life-cycle type management program for OSDSs. Previous work by the investigator used USEPA guidance documents to establish minimum maintenance, performance and inspection standards for OSDSs in Hawaii. The recommended model was to issue, monitor, and enforce 2-yr cycle OSDS operating permits to homeowners, and to certify and license OSDS service providers and OSDS inspectors. The items produced included a model law, a management program framework and roles of all parties, minimum maintenance requirements, inspection checksheets & protocols, and application/renewal forms.

Step 4. Screen options

Each treatment and each disposal system has its own constraints and necessary site conditions, including groundwater elevation, lot size, soil percolation rate, topographic slope, location in a flood zone, proximity to inland or coastal waters, and surrounding density of cesspools (Table). The characteristics and conditions of a site determine the feasibility of installing a given system at that site. For example, an absorption system can only be installed in an area with a slope of <12 percent, and a septic tank should be installed outside a flood zone and in an area not in proximity to the coast. It should be noted that while the feasibility of disposal systems are typically constrained by site conditions, treatment systems can generally be installed at any site independent of site conditions (WRRC, 2008).

For each of the properties (TMKs) containing OSDS in the Upcountry Maui study area, we assessed the feasibility of each of the upgrade options considered, using geospatial data corresponding to the constraints. Publicly available spatial data for OSDS, TMKs, terrain slope, coastline, streams, and flood zones were obtained from the Hawaii Statewide GIS Program Data Portal (http://geoportal.hawaii.gov/; see Table 4 for dataset details). Data representing each of the site conditions were attributed to each OSDS point datum. A series of conditional statements were then applied in order to filter OSDS points by the constraints of a given system (Table), to determine whether a given upgrade option was feasible for the site conditions of each OSDS.

Table 3. Constraints of system options. Y: Option is feasible, N: Option is not feasible/permitted; HAR 11-62; [1]These are included as options in the HAR 11-62, but require additional review and approval. [2] ATU-N/DN and absorption systems used together with UV disinfection are assumed to be permitted for TMKs that are located < 50 feet from a body of water.

Options Category	Site Conditions/Constraints Options	High water table	Small Lot Size	Slow Soil Percolation Rate	High Topographic Slope	In Flood Zone	Near Inland or Coastal Waters
Treatment	Septic Tank	Y	Y	Y	Y	N	Y if >50 ft away
Treatment	ATU, N or N/DN	Y	Y	Y	Y	N	Y if >50 ft away[2]
Disposal	Absorption Systems (Bed/Trench)	Y if >3 ft	Y if >minimum absorption area required by HAR	Y if 60 to 1 min/in	Y if <12% (Trench used if 8% <slope <12%)	N	Y if >50 ft away[2]
Disposal	Seepage Pit	Y if >3 ft	Y	Y if 60 to 1 min/in	Y if ≥ 12% and absorption system not feasible	N	Y if >50 ft away
Treatment	Chlorine Disinfection	Y	Y	Y	Y	N	Y if >50 ft away
Treatment	UV Disinfection	Y	Y	Y	Y	N	Y
Disposal	Presby Advanced Enviro-Septic and De-Nyte	Y	Y if >minimum absorption area required by HAR	Y if 60 to 1 min/in	Y	N	Y if >50 ft away
Approval Required[1]	Evapotranspiration	Y	Y	Y	Y if <12%	N	Y if >50 ft away
Approval Required[1]	Recirculating Sand Filter	Y	Y	Y	Y	N	Y if >50 ft away
Innovative Technologies	Constructed Wetland	Y if >3 ft	Y	Y	Y if <12%	N	Y if >50 ft away

	Site Conditions/Constraints	**High water table**	**Small Lot Size**	**Slow Soil Percolation Rate**	**High Topographic Slope**	**In Flood Zone**	**Near Inland or Coastal Waters**
Options Category	**Options**						
Innovative Technologies	Drip Irrigation	Y	Y if >minimum absorption area required by HAR	Y	Y	N	Y if >50 ft away
Innovative Technologies	Eliminite	Y	Y	Y	Y	N	Y if >50 ft away
Innovative Technologies	NITREX	Y	Y	Y	Y	N	Y if >50 ft away
Emerging Technologies	Recirculating Gravel Filter System (WA)	Y	Y	Y	Y	N	Y if >50 ft away
Emerging Technologies	Passive Treatment Units (medium and high treatment) (FL)	Y	Y	Y	Y	N	Y if >50 ft away
Emerging Technologies	Disposal by Layered Soil Treatment (“Layer Cake”) Systems (MA)	Y if >3 ft	Y	Y	Y if <12%	N	Y if >50 ft away
Emerging Technologies	Disposal by Nitrification/Denitrification Biofilter (NY)	Y	Y	Y	Y	N	Y if >50 ft away
Alternative Toilets	Compost/Incinerating/ Nano-Membrane Toilets	Y	Y	Y	Y	Y	Y
Sewering	Decentralized/Centralized	Y	Y	Y	Y	Y	Y

Table 4. Geo datasets used in feasibility evaluation

Constraint	Dataset	Geoprocessing
Slope	Hawaii Statewide DEM 5-meter	ArcMap Spatial Analyst Toolbox: Slope tool
Streams (distance from)	Streams (from DLNR, Division of Aquatic Resources)	Near tool; generates distance of each TMK from stream polylines
Coastline	Coastlines MHI (from Office of Planning, State of Hawaii)	Polygon to Polyline Conversion tool. Near tool; generates distance of each TMK from coastline polylines
Lot size	Parcel/TMK maps for Neighbor Islands (from Statewide GIS Program, Office of Planning, State of Hawaii)	Calculate geometry: Area
Area available for absorption-type systems	Parcel/TMK maps for Neighbor Islands (from Statewide GIS Program, Office of Planning, State of Hawaii)	Calculate geometry: Area. Subtract house size: • For lots V5000 sf: house ≤50% lot size • For lots >5000 sf: house = 3000 sf
Flood zone	FEMA Special Flood Hazard Areas for the State of Hawaii	Spatial Join: • Join features: flood data (field of interest: FLD_ZONE) • Target features: OSDS • Screening: FLD_ZONE ≠ “x” (areas outside the 1-percent annual chance floodplain and areas protected from the 1-percent annual chance flood by levees”

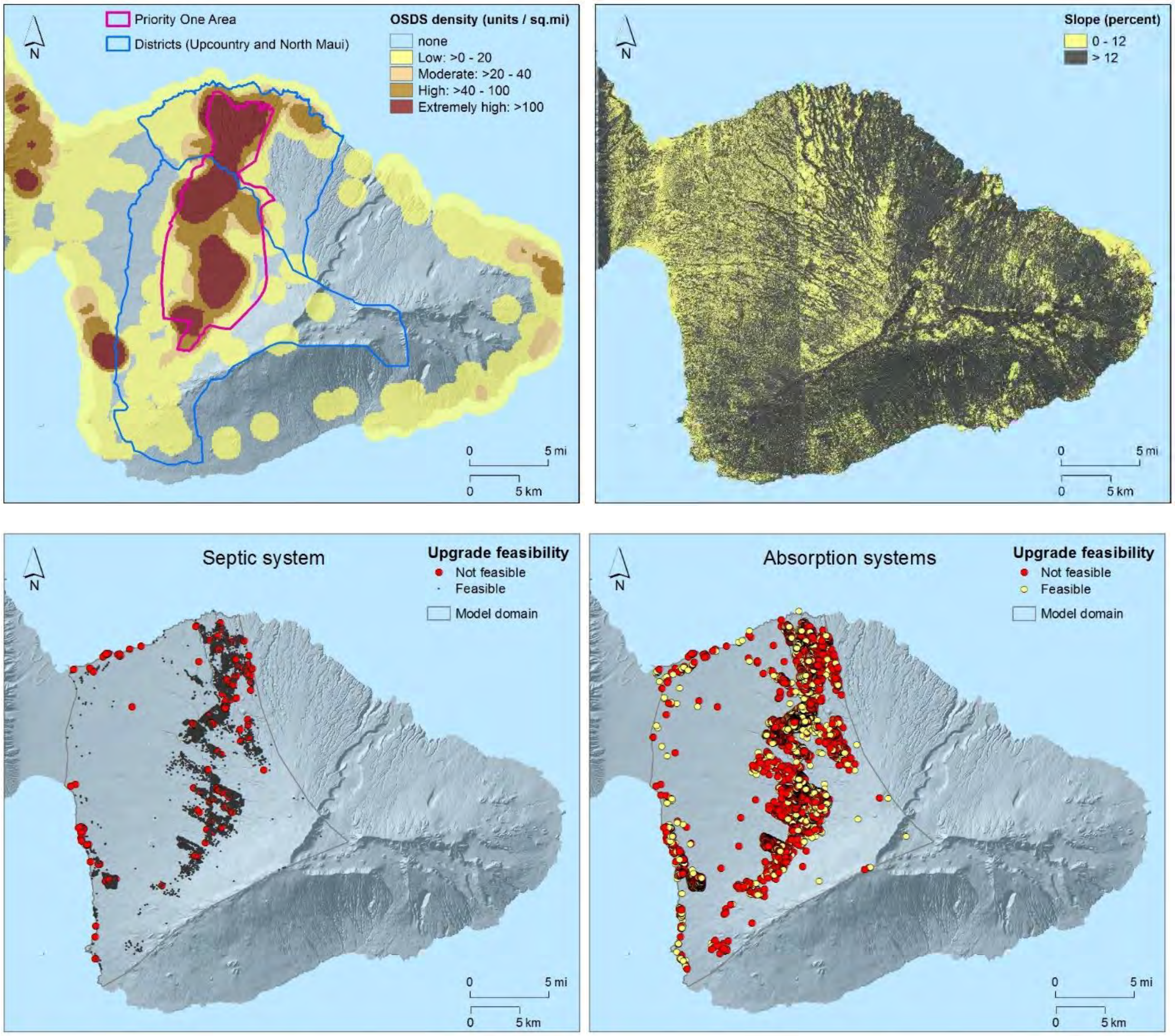

Figure 2. Disposal options evaluated were constrained by the site limitations.

Additional Concerns/Considerations related to technical options

Some options present technical considerations that are quite specific, and outside of the technical review. For instance, households with alternative (zero-discharge: composting or nano/Gates) toilets will also have to deal with other wastewater flows (other than toilets). Household wastewater consists of black water and gray water. According to the Guidelines for the Reuse of Gray Water (HDOH Wastewater Branch, 2009), black water is defined as wastewater discharged from toilets, urinals, and food preparation sinks (kitchen sinks). Gray water is defined as wastewater discharge from: showers and bathtubs, hand-washing lavatories, sinks (not used for disposal of hazardous, toxic materials food preparation, or food disposal), and clothes-washing machines (excluding wash water with human excreta, e.g., diapers). Gray water reuse is not currently permitted in the County of Maui, and the current

HDOH Guidelines require a wastewater treatment system. As stated in the Guidelines, a gray water reuse system must have an overflow pathway to the county sewer system or an individual wastewater treatment system. Thus, there are two issues for current cesspool systems that upgrade to zero-discharge toilets: 1) kitchen sink water is considered black water that would still require an OSDS, and 2) all gray water systems require an overflow pathway for flows in excess of that needed for in-yard reuse to prevent overflow/spills. It is possible that the overflow issue (2) could be handled by a seepage pit (converted cesspool). However, the kitchen sink blackwater issue (1) would necessitate a change in the guidelines in order remove the need for an approved OSDS system (cesspool upgrade). A gray water system is simply a storage tank and an irrigation system and does not include any type of “treatment” for removal of items washed down the kitchen sink. Thus, the sticking point is that kitchen sink use would have to be strictly controlled (including banning in-sink grinders) or else the gray water tank would end up rapidly accumulating every manner of ground up materials discharged and these materials would be subject to biodegradation, septic conditions, odors, etc. The most practical solution would be source control – but this would require a fairly major change in human behaviour and that may not happen with the necessary reliably. Maui County would also have to adopt a rule allowing gray water systems.

Stakeholders were concerned that many of the geographically extensive options would either not fit on the properties or require destruction of gardens, many of which provide sustenance and income to Upcountry Maui residents. Nearly all of the properties in the study area have enough space for one or more alternative cesspool upgrade systems, but nearly all do require significantly more space than cesspools. However, these systems are all located underground and do not preclude co-location of gardens on top if necessary. If a resident had a health concern in such a situation, a raised-bed garden with an impermeable bottom liner could be utilized.

Step 5. Alternatives

Alternatives are treatment+disposal options packaged together that could be implemented across the study area. Creating and evaluating a range of well-defined internally coherent alternatives (or packages of management and policy actions) is central to good decision-making. Good alternatives should be collaborative to ensure the full range of stakeholder priorities are captured in the alternatives developed and evaluated. To support this process, we undertook alternatives development in two phases.

In the initial phase, using feedback from stakeholder consultations, the project team developed simple alternatives that allowed stakeholders to explore “what if” scenarios without needing to specify exact design details, and a set of alternatives based on several discussions with stakeholders that captured the suite of options available (see Appendix II), and ensured options relevant to the full range or stakeholders were incorporated. In the second phase, to ensure stakeholder needs were addressed, we conducted a facilitated alternative development workshop (combined in person and online) with the stakeholder group. The workshop included 13 participants, including members of the upcountry Maui community associations, Maui County Council, Maui County Farm Bureau, Agricultural Working Group, and Hawaii Department of Health. The University of Hawaii Institutional Review Board advised that human subjects clearance was not required for this process, however we handed out informational sheets to all participants explaining the purpose and approach of the project, with contact information should participants feel the need to follow up with the Principal Investigators or UH’s IRB.

In the stakeholder workshops we conducted two focused alternative development activities, where we worked with groups of stakeholders to develop alternatives. The two activities, (1) Bookends, and (2) Visioning, are described below. Notes from this process are provided in Appendix III.

1. Bookends: To explore the implications of focusing on each objective, we asked three groups of stakeholders to think of and define a strategy that they believed would perform ‘AMAZINGLY’, for each objective, with no consideration of other implications – a modified application of a “bookends” approach (Gregory 2012). Subsequently participants were asked to consider how they thought the selected strategy or strategies would perform against other criteria and with that in mind, to consider whether other options might perform equally well for the objective under consideration, but better against other objectives.

2. Visioning: We asked stakeholders to construct alternatives for two situations (A and B) below. Participants were asked to focus on ‘out-of the-box’ options, and to identify and record risks, challenges or barriers, rather than dismissing ideas due to perceived barriers or novelty.
    A. Everybody wins: Here we asked participants to build on the first activity to identify solutions that might improve performance against all objectives, identify potential

barriers or reasons why a solution may not perform well against all criteria, and then focus on how they might be overcome, or what other options or tweaks might perform better across the board.

B. Funding potential: Here we asked participants to focus on options that would reduce or remove costs to the homeowner or leverage opportunities for other funding.

Subsequent to these activities, the project team developed a set of 38 alternatives that captured the full decision space (see Table 5). To construct these alternative, options were screened for feasibility (as per methods described in “Constraints”) to inform the spatial allocation of options within alternatives, such that only options screened as feasible for a given site could be selected for that site. Alternative development included consideration of options that would be implemented under a range of feasibility constraints. The results of the screening process for each alternative for each TMK are shown in Table 6. A few things can be highlighted from Tables 5 and 6 as follows:

- Alt4B (septic tank + seepage pit) has the least nitrogen removal at only 10%. Other septic tank Alts have nitrogen removal efficiencies of 47% to 98%
- The Alts that incorporate ATUs with nitrification only, have removals from 53% to 71% (plus a zero-discharge option (ET) which gives 100% removal)
- The Alts that incorporate ATUs with nitrification + denitrification, have removals from 50% to 71%. These could also add ET for 100% removal.
- The data set that was used for this study includes 11,956 TMKs in the study area, however, only 8,540 have OSDSs and of those, there are 6,198 that have cesspools. These numbers are somewhat different than the DOH references (10,040 OSDSs and 7,400 cesspools)
- The maximum slope constraint of 12% affects absorption disposal systems for many of the TMKs with cesspools. Absorption disposal systems can only be used on 3,394 of the TMKs. For the other 2,804 TMKs with cesspools, the existing cesspool can be cleaned and converted into a seepage pit (Alt4B). Thus, for septic tank Alts, the fallback option is Alt4B (septic tank + seepage pit), and for ATU Alts, the fallback option is Alt16 (ATU-N/DN + disinfection + seepage pit).
- Sewering Makawao will result in closure of 1,712 cesspools
- Sewering the remainder of Pukalani will result in closure of 1,217 cesspools
- Sewering both Pukalani and Makawao will result in 2,929 cesspools

Table 5. Alternatives considered

Code	Name	Description
1	Septic Tank to Absorption System: 47% Reduction	47% uniform reduction in N (mg/L) outputs at each Household.
2	Septic Tank to Constructed Wetland: 53% Reduction	53% uniform reduction in N (mg/L) outputs at each Household.
3	Septic Tank to RSF to Drip Irrigation: 69% Reduction	69% uniform reduction in N (mg/L) outputs at each Household.
4	Septic Tank to RSF to Seepage Pit: 47% Reduction	47% uniform reduction in N (mg/L) outputs at each Household.
4B	Septic Tank to Seepage Pit: 10% Reduction	10% uniform reduction in N (mg/L) outputs at each Household.
5	Septic Tank to Eliminite to Absorption System: 80% Reduction	80% uniform reduction in N (mg/L) outputs at each Household.
6	Septic Tank to Presby: 78% Reduction	78% uniform reduction in N (mg/L) outputs at each Household.
7	Septic Tank to NITREX to Absorption System: 98% Reduction	98% uniform reduction in N (mg/L) outputs at each Household.
8	Septic Tank to Recirculating Gravel Filter System to Absorption System: 84% Reduction	84% uniform reduction in N (mg/L) outputs at each Household.
9	Septic Tank to "Layer Cake": 55% Reduction	55% uniform reduction in N (mg/L) outputs at each Household.
10	Septic Tank to Lined/Sequence D/DN Biofilter: 91% Reduction	91% uniform reduction in N (mg/L) outputs at each Household.
11	ATU-N to Absorption System: 53% Reduction	53% uniform reduction in N (mg/L) outputs at each Household.
12	ATU-N/DN to Absorption System: 71% Reduction	71% uniform reduction in N (mg/L) outputs at each Household.
13	ATU-N to Constructed Wetland: 58% Reduction	58% uniform reduction in N (mg/L) outputs at each Household.
14	ATU-N to ET: 100% Reduction	100% uniform reduction in N (mg/L) outputs at each Household.
15	ATU-N to Disinfection to Drip Irrigation: 71% Reduction	71% uniform reduction in N (mg/L) outputs at each Household.
16	ATU-N/DN to Disinfection to Seepage Pit: 50% Reduction	50% uniform reduction in N (mg/L) outputs at each Household.
17	Passive FL Units (medium, in-ground): 71% Reduction	71% uniform reduction in N (mg/L) outputs at each Household.
18	Passive FL Units (high) to Absorption System: 91% Reduction	91% uniform reduction in N (mg/L) outputs at each Household.

19	High Impact	The 20% worst offenders (by N flux) upgrade to best N reduction option.
20	Private Company pays for installation, then fees	Decentralised Treatment Units are installed in very high density areas. Elsewhere: the cheapest feasible traditional option (i.e. cheapest from alts 1-18 is applied). Regulatory changes require any new developments above same density (or lower) to incorporate.
21	O&M borne by users (cost of O&M)	
22	Fed infrastructure fund + State + Maui County - Fees = same as rest of Maui	
23	Private Company pays for installation, then fees	Decentralised Treatment Units are installed in very high density areas. Elsewhere: the a very effective option is applied (Membrane Bioreactor). Regulatory changes require any new developments above same density (or lower) to incorporate .
24	O&M borne by users (cost of O&M)	
25	Fed infrastructure fund + State + Maui County - Fees = same as rest of Maui	
26	Private Company pays for installation, then fees	Sewer all sites in MAKAWAO. Estimate costs based on roughly the capcaity needed based on that volume/ density + a guess at how much extra might appear in build out.
27	O&M borne by users (cost of O&M)	
28	Fed infrastructure fund + State + Maui County - Fees = same as rest of Maui	
29	Private Company pays for installation, then fees	Sewer all sites in Pukalani not already on sewer. Estimate costs based on rough costs of upgrades.
30	O&M borne by users (cost of O&M)	
31	Fed infrastructure fund + State + Maui County - Fees = same as rest of Maui	
32	Private Company pays for installation, then fees	Sewer all sites in Makawao + Pukalani not already on.
33	O&M borne by users (cost of O&M)	
34	Fed infrastructure fund + State + Maui County - Fees = same as rest of Maui	
35	Well head treatment: 0% Reduction	No change in groundwater nitrogen concentration. Water is drinkable at tap. User pays (no cost to householders for sewer, but there would be a cost passed on to those who use the water).
36-38	Composting Toilet (1-3): 100% Reduction	Everyone gets a composting toilet (as for 1-19). 1. Modify grey water rules and have grey

		water system overflow into existing system.
		2. Modify grey water rules and have grey water system overflow into cesspool or existing unit
		3.Modify grey water rules and have grey water system overflow into the minimum feasible solution - seepage pit.

[1] If the alternative disposal option was not feasible, the second choice was the same alternative treatment with an absorption system, and the third choice was the same alternative treatment with a seepage pit. About 150 TMKs are located less than 50 feet from a body of water. The upgrade option for these TMKs is ATU N/DN with UV disinfection and an absorption system.

Table 6. Summary results of alternatives screening

Alt #	Alternative	TMKs					Type of Upgrade		
		# of TMKs Total in Area	# of TMKs with OSDSs	# of TMKs with Cesspools	# of TMKs with cesspools Upgraded	# of TMKs connected to Sewer	a	b	c
0	Baseline conditions with cesspools	11,956	8,540	6,198	6,198	0	N/A	N/A	N/A
1	Septic Tank to Absorption System: 47% Reduction	11,956	8,540	6,198	6,198	0	Alt1 3394	Alt4B 2804	N/A
2	Septic Tank to Constructed Wetland: 53% Reduction	11,956	8,540	6,198	6,198	0	Alt2 3394	Alt4B 2804	N/A
3	Septic Tank to RSF to Drip Irrigation: 69% Reduction	11,956	8,540	6,198	6,198	0	Al3 6198	N/A	N/A
4	Septic Tank to RSF to Seepage Pit: 47% Reduction	11,956	8,540	6,198	6,198	0	Al4 6198	N/A	N/A
4B	Septic Tank to Seepage Pit: 10% Reduction (1.5 BR; 70 gal/person)	11,956	8,540	6,198	6,198	0	Al4B 6198	N/A	N/A
4B_HI	Septic Tank to Seepage Pit: 10% Reduction (2/BR; 100 gal/person)	11,956	8,540	6,198	6,198	0	Al4B 6198	N/A	N/A
4B_LO	Septic Tank to Seepage Pit: 10% Reduction (1/BR; 70 gal/person)	11,956	8,540	6,198	6,198	0	Al4B 6198	N/A	N/A
4B_Census	Septic Tank to Seepage Pit: 10% Reduction (2010 census/no. BR; 100 gal/person)	11,956	8,540	6,198	6,198	0	Al4B 6198	N/A	N/A
5	Septic Tank to Eliminite to Absorption System: 80% Reduction	11,956	8,540	6,198	6,198	0	Alt5 3394	Alt4B 2804	N/A
6	Septic Tank to Presby: 78% Reduction	11,956	8,540	6,198	6,198	0	Alt6 3394	Alt4B 2804	N/A
7	Septic Tank to NITREX to Absorption System: 98% Reduction	11,956	8,540	6,198	6,198	0	Alt7 3394	Alt4B 2804	N/A
8	Septic Tank to Recirculating Gravel Filter System to Absorption System: 84% Reduction	11,956	8,540	6,198	6,198	0	Alt8 3394	Alt4B 2804	N/A
9	Septic Tank to "Layer Cake": 55% Reduction	11,956	8,540	6,198	6,198	0	Alt9 3394	Alt4B 2804	N/A
10	Septic Tank to Lined/Sequence D/DN Biofilter: 91% Reduction	11,956	8,540	6,198	6,198	0	Alt10 3394	Alt4B 2804	N/A
11	ATU-N to Absorption System: 53% Reduction	11,956	8,540	6,198	6,198	0	Alt11 3394	Alt16 2804	N/A
12	ATU-N/DN to Absorption System: 71% Reduction	11,956	8,540	6,198	6,198	0	Alt12 3394	Alt16 2804	N/A
13	ATU-N to Constructed Wetland: 58% Reduction	11,956	8,540	6,198	6,198	0	Alt13 3394	Alt16 2804	N/A
14	ATU-N to ET: 100% Reduction	11,956	8,540	6,198	6,198	0	Alt14 3394	Alt16 2804	N/A
15	ATU-N to Disinfection to Drip Irrigation: 71% Reduction	11,956	8,540	6,198	6,198	0	Al15 6198	N/A	N/A
16	ATU-N/DN to Disinfection to Seepage Pit: 50% Reduction	11,956	8,540	6,198	6,198	0	Alt16 2804	Alt12 3394	N/A
17	Passive FL Units (medium) to Absorption System: 71% Reduction	11,956	8,540	6,198	6,198	0	Alt17 3394	Alt16 2804	N/A
18	Passive FL Units (high) to Absorption System: 91% Reduction	11,956	8,540	6,198	6,198	0	Alt18 3394	Alt16 2804	N/A
19A	High impact: Septic Tank to Presby: 78% Reduction (highest mass reduction in alt 1-18)	11,956	8,540	6,198	1,839	0	Alt6 1023	Alt4B 816	N/A
19B	High Impact: ATU-N to ET: 100% Reduction (smallest area with >5 mg/L in alt 1-18)	11,956	8,540	6,198	1,871	0	Alt14 992	Alt16 847	N/A
20-21-22	Sewer Makawao, ST to Presby (cheapest option)	11,956	8,540	6,198	4,329	1,712	Alt6 2311	Alt4B 2383	Alt12 123
23A-24A-25A	Sewer Pukalani, ATU-N to ET (smallest area with >5 mg/L in alt 1-18) where possible	11,956	8,540	6,198	4,824	1,217	Alt16 2320	Alt14 2870	N/A
23B-24B-25B	Sewer Pukalani, ST to Presby (highest mass reduction in alt 1-18) where possible	11,956	8,540	6,198	4,824	1,217	Alt6 2948	Alt4B 2320	N/A
26-27-28	Sewer Makawao only, no cesspool upgrades	11,956	8,540	6,198	4,329	1,712	N/A	N/A	N/A
29-30-31	Sewer Pukalani only, no cesspool upgrades	11,956	8,540	6,198	6,198	1,217	N/A	N/A	N/A
32-33-34	Sewer Makawao & Pukalani, no other upgrades	11,956	8,540	6,198	6,198	2,929	N/A	N/A	N/A
35	Wellhead treatment (results same as base model)	11,956	8,540	6,198	6,198	0	N/A	N/A	N/A
36-37-38	Compost toilets, no effluent N	11,956	8,540	6,198	6,198	0	N/A	N/A	N/A

Step 6. Estimating consequences

Costs

For each cost objective (**Objectives 1 and 2**) we estimated both capital costs and operation and maintenance costs over a standardized 60-year time horizon. Capital costs for equipment were based on manufacturer/vendor price quotes and catalogues. Detailed itemized installation costs for equipment, labor, and professional services (engineering, plumbing, electrician) were based on discussions with contractors and service providers with many years of experience installing all types of on-site systems in Hawaii. Costs for equipment were based on quotes from Hawaii-based vendors and representatives.

Costs are based on the size of the OSDS system required for the number of bedrooms for each TMK at a rate of 200 gallons per day (gpd) per bedroom. Individual systems are limited by DOH rules to 1,000 gpd each (5 bedrooms). Size requirements for septic tanks, ATUs, absorption systems, and seepage pits were determined according to the requirements in HAR 11-62 Wastewater Systems. For other types, we used industry standard sizing criteria and unit costs. The size of the absorption systems is dependent upon soil percolation rates. The DOH WWBranch pulled a large set of permits for several areas of Upcountry Maui and we were able to determine typical percolation rates by area as follows:

- Haiku (15 to 30 min/inch)
- Kula (10 to 15 min/inch)
- Makawao (15 to 20 min/inch)
- Pukalani (15 min/inch)
- Design value used for all TMKs: 20 min/inch

This gives an area requirement of 175 square feet per bedroom assuming that plastic dome infiltrator units are used which receive a 17% area reduction. The values for estimated capital costs include labor, materials, equipment, mobilization, installation, contractor’s overhead and profit, and construction contingencies. Operation and maintenance costs include electricity, maintenance inspections, and tank pumping/hauling/disposal, considered for a 60-year lifetime of the system, including replacements as necessary. Variations in cost may occur due to site conditions such as soil type (e.g., excavation in rock), site isolation or accessibility, or slope.

Table shows the costs estimated for site work associated with OSDS installation. Additional costs will be incurred for each system including permit fee ($100), engineering fees ($4,000), plumber connection fee ($500), and sometimes electrician connection fee ($500). Table shows the costs for equipment/materials for treatment and disposal options for systems sized for one to five bedrooms. The costs for ATUs are based on vendor quotes from Hawaii firms/reps: International Wastewater Technologies, OESIS, WaiponoPure, FujiClean and Presby for which there is a fairly large range for 1 bedroom to 5-bedroom sized units. We used reasonable values rather than only the least expensive and this gave values of $9,000 for 1BR to $15,000 for 5BR. Note, it is possible to get a small unit for $5000 and a 5BR size unit for $10,000, however, we assumed that not everyone will choose these least-cost options. The costs for septic tanks have a larger range of costs based on the material of construction. There are only two sizes for septic tanks 1,000 gallons (1-4BR) and 1,250 gallons (5BR). Concrete tanks range from $3,500-4,500, FRP tanks cost $2600-3,300, and some light plastic units can be purchased for around $1,500. However, the light units are not considered durable enough to last for 60 years as used in this study. We assumed a range of $3000 to $4,500 for these tanks.

Table 9 shows the total installed costs for each individual treatment and disposal system which includes equipment, additional fees, and site work. Table 2 (above) shows the annual operation and maintenance costs for the OSDS options as well as the replacement interval. Operation costs include electricity which is based on approximately 100W continuous draw and electricity cost of $0.35/kWh. Maintenance costs include annual pumping ($250) and inspection ($150). Systems must be completely replaced after either 30- or 60-years thus incurring the full installation cost again at that time. Table 10 shows the installed costs for each alternative combination of treatment and disposal systems. Table shows the total installation cost for Upcountry Maui for each alternative by summation of the cost for each TMK based upon the number of bedrooms. The data are arranged in lowest to highest capital cost which range from a low of $18 million to a high of $264 million. We calculated the net present cost (NPV) of initial installation, replacements in the future, and annual operation and maintenance of all the cesspool upgrades for a 60-year period (also in Table), in 2018 dollars. We used two discount factors reflecting the private cost of capital (5% home equity loan rate) and a rate reflective of public sector investment (2.8%) (OMB 2016). In both cases, we applied an annual inflation rate of 1.8% (based on Real GDP for Hawaii's economy, March 2017; dbedt.hawaii.gov). For the 2.8% discount rate, the NPV ranges from $22 million to $785 million. For the 5% discount rate, the range is from $20 million to $551 million.

For this project, we did not provide a range of costs for any systems or Alts, instead, we provide a single best estimate for the purchase/installation/operation/maintenance of each system under typical local conditions. Site-specific, non-standard conditions, such as locally poor soils, unknown underground utilities, undocumented structures, the need for removal of large trees, necessity to place systems in traffic bearing areas, contractor availability/scarcity, etc. could increase costs substantially. The amounts of these increases can be predicted only with detailed engineering analysis of each property, including site visits, records searches, soil tests, etc. that will be required for each property as part of the normal design/permitting process. It is estimated that costs could increase by up to 50% in the worst case. It is also possible that costs could decrease in the future as cesspool replacements ramp up to large numbers, additional contractors emerge, new technologies become common, and volume discounts become possible.

Cost Efficiency

We calculated the cost efficiency (CE; **Objective 6**, as the difference in nitrogen concentration from baseline (Benefit, B, in kg nitrate) divided by the cost of the upgrades (C, NPV in $USD2018) i.e. a modified Cost-Benefit Analysis, then ranked the options.

Equity

For objectives related to equity (**Objectives 7,8**), we evaluated equity within the Upcountry Maui community by calculating the number of households implicated in each alternative (which can be compared to the number of households in the entire community), and across the broader community of Maui by looking at the difference between the per annum costs borne by the Maui households for the alternative vs. the standard sewage fees a Maui household pays.

Costs Summary

Tables 7, 8, 9, and 10 present the costs calculated in this study. Several findings can be highlighted as follows:

- Sitework to install treatment systems costs about $6,000, and sitework to install a disposal system plus close/convert a cesspool costs about $4,000.
- Installed costs for septic tanks are $15,000-$17,000 and for ATUs are $22,000-$30,000 for 1BR - 5BR size units.
- Composting toilets cost $2,200 each, installed. The new nano/gates toilets are still several years away, however, it is likely that these toilets will be priced similar or possibly lower than composting toilets
- Installed costs for absorption disposal systems are $4,000 - $7,000 for 1BR - 5BR size systems (this assumes an average of 175 sf/BR).
- Drip irrigation disposal systems cost $8,000-$9000 and Evapotranspiration systems which are zero-discharge disposal systems cost $5,000-$9,000 for 1BR - 5BR size systems
- Installed costs for gray water systems are $4,000-$5000 for 1BR - 5BR size systems
- Total installed costs for treatment and disposal at a typical 3BR home depend on the type of system:
  - Septic tank-based systems where good N removal (>60%) is not required can cost $21,000 to $25,000.
  - The lowest cost package system ($16,000) is septic tank plus seepage pit which is suitable only where absorption is not feasible (due to slope, soil)
  - Septic tank-based systems with high N removal (80-98%) cost $25,000-$33,000.
  - ATU based systems mostly cost from $27,000 to $32,000, with two expensive systems that are over $40,000.
- Costs for installing the various upgrade alternatives in all 6,198 TMKs with cesspools (and thereby meeting the cesspool ban) range from $102M to $165M for septic tank-based systems and from $191M to $231M for ATU-based systems. The total

cost for upgrading to composting toilets is between these two ranges at $186M (these systems include replacing all toilets, adding a gray water system, and upgrading the cesspool to a seepage pit).

- Costs for several alternatives that do not upgrade all cesspools (do not meet ban) such as wellhead treatment, addition of sewers only in Pukalani/Makawao, and upgrading only the highest nitrogen emitters, are lower, ranging from $18M-$96M

Table 7 Cesspool upgrade site work cost estimate

Cost Item	ATU or Septic Tank	Absorption System	Cesspool Closure	Cesspool Conversion
Clearing and grubbing including small trees (landscaper) including haul away	1000	incl	0	0
Tree removal (larger trees) cut and hauk away and grind the stump ($1000+) per tree depending on size. Try to avoid.	0	0	0	0
Reseed grass and other replanting by landscaper	500	incl	0	0
Excavation and backfill: back hoe at $1500 per day w/operator and haul away excess, one day for tank plus one day for absorption system. If require mini excavator due to access issues, requires 4 days at $750 per day	1500	1500	750	0
Granualar bed/backfill material delivered at $20/cu yd	300	600	750	0
Shoring for excavation: Aluminum: $800-1500 per week delivered and picked-up	1000	0	0	0
Rebuild fence or wall: Wood or moss rock, 8 ft; $500 (carpenter) to $1500 for moss rock wall	750	incl	0	0
Vibrator for compaction: $100/day	150	150	0	0
Laborer to help with installation at $150/day	750	incl	0	0
Water for tank install: Use house water if can at $0; if water truck (1000 gal) at $1000	0	0	0	0
Cesspool pump out (500), cesspool clean (500), cesspool percolation test (1000)	0	0	500	2000
Total cost	**5950**	**2250**	**2000**	**2000**

Table 8 Costs for equipment/materials for OSDS treatment and disposal systems

	OSDS Treatment and Disposal Systems	Equipment and Materials				
		1BR	2BR	3BR	4BR	5BR
Treatment Options	ATU-N	$9,000	$9,000	$10,500	$12,000	$15,000
	ATU-N/DN	$10,500	$10,500	$12,000	$13,000	$17,000
	Septic Tank	$3,000	$3,500	$3,500	$4,500	$4,500
	Passive Biofilters (in-ground, medium, FL)	$8,600	$11,300	$12,500	$14,700	$15,900
	Passive Biofilters (in-ground, high, FL)	$11,100	$12,800	$14,000	$16,200	$17,400
	Composting toilets (also use for incinerating)	$2,200	$2,200	$4,400	$4,400	$6,600
Disposal Options	Absorption System (bed or trench)	$1,500	$2,200	$2,800	$3,400	$4,900
	Constructed Wetland	$4,000	$5,000	$6,000	$8,000	$10,000
	Disinfection	$1,000	$1,000	$1,000	$1,000	$1,000
	Drip Irrigation	$4,900	$5,000	$5,800	$5,900	$6,000
	Seepage Pit (new)	$6,400	$10,400	$14,400	$18,400	$22,400
	Evapotranspiration	$3,000	$4,000	$5,000	$6,000	$7,000
	NITREX ®	$5,800	$7,400	$8,200	$10,000	$10,800
	Presby Advanced Enviro-Septic & De-Nyte ®	$3,300	$4,700	$6,200	$7,700	$9,200
	Recirculating Sand Filter	$3,000	$3,000	$6,000	$6,000	$6,000
	Eliminite ®	$8,000	$8,000	$8,000	$8,000	$8,000
	Layered Soil Treatment System (MA)	$6,000	$6,000	$6,000	$6,000	$6,000
	Gray Water system	$1,600	$2,300	$2,300	$2,300	$2,300

Table 9 Total installed costs for individual OSDS treatment and disposal systems

	OSDS Treatment and Disposal Systems	Total Installed Cost including Fees				
		1BR	2BR	3BR	4BR	5BR
Treatment Options	ATU-N	$22,000	$22,000	$23,500	$25,000	$28,000
	ATU-N/DN	$23,500	$23,500	$25,000	$26,000	$30,000
	Septic Tank	$15,500	$16,000	$16,000	$17,000	$17,000
	Passive Biofilters (in-ground, medium, FL)	$21,100	$23,800	$25,000	$27,200	$28,400
	Passive Biofilters (in-ground, high, FL)	$24,100	$25,800	$27,000	$29,200	$30,400
	Composting toilets (also use for incinerating)	$2,800	$2,800	$5,600	$5,600	$8,400
Disposal Options	Absorption System (bed or trench)	$3,750	$4,450	$5,050	$5,650	$7,150
	Constructed Wetland	$6,250	$7,250	$8,250	$10,250	$12,250
	Disinfection	$2,000	$2,000	$2,000	$2,000	$2,000
	Drip Irrigation	$7,900	$8,000	$8,800	$8,900	$9,000
	Seepage Pit (new)	$8,650	$12,650	$16,650	$20,650	$24,650
	Evapotranspiration	$5,250	$6,250	$7,250	$8,250	$9,250
	NITREX ®	$8,050	$9,650	$10,450	$12,250	$13,050
	Presby Advanced Enviro-Septic & De-Nyte ®	$5,550	$6,950	$8,450	$9,950	$11,450
	Recirculating Sand Filter	$5,250	$5,250	$8,250	$8,250	$8,250
	Eliminite ®	$10,250	$10,250	$10,250	$10,250	$10,250
	Layered Soil Treatment System (MA)	$8,250	$8,250	$8,250	$8,250	$8,250
	Gray Water system	$4,100	$4,800	$4,800	$4,800	$4,800

Table 10 Total installed costs for treatment plus disposal systems for Alternatives 1-18

Alt	Description	1BR	2BR	3BR	4BR	5BR
Alt1	Septic Tank to Absorption System: 47% Reduction	$19,250	$20,450	$21,050	$22,650	$24,150
Alt2	Septic Tank to Constructed Wetland: 53% Reduction	$21,750	$23,250	$24,250	$27,250	$29,250
Alt3	Septic Tank to RSF to Drip Irrigation: 80% Reduction	$28,650	$29,250	$33,050	$34,150	$34,250
Alt4	Septic Tank to RSF to Seepage Pit: 47% Reduction	$20,750	$21,250	$24,250	$25,250	$25,250
Alt 4B	Septic Tank to Seepage Pit: 10% Reduction	$15,500	$16,000	$16,000	$17,000	$17,000
Alt5	Septic Tank to Eliminite to Absorption System: 80% Reduction	$29,500	$30,700	$31,300	$32,900	$34,400
Alt6	Septic Tank to Presby: 78% Reduction	$21,050	$22,950	$24,450	$26,950	$28,450
Alt7	Septic Tank to NITREX to Absorption System: 98% Reduction	$27,300	$30,100	$31,500	$34,900	$37,200
Alt8	Septic Tank to Recirculating Gravel Filter System to Absorption System: 84% Reduction	24500	25700	29300	30900	32400
Alt9	Septic Tank to "Layer Cake": 55% Reduction	$23,750	$24,250	$24,250	$25,250	$25,250
Alt10	Septic Tank to Lined/Sequence D/DN Biofilter: 91% Reduction	23750	24250	24250	25250	25250
Alt11	ATU-N to Absorption System: 53% Reduction	$25,750	$26,450	$28,550	$30,650	$35,150
Alt12	ATU-N/DN to Absorption System: 71% Reduction	$27,250	$27,950	$30,050	$31,650	$37,150
Alt13	ATU-N to Constructed Wetland: 58% Reduction	$28,250	$29,250	$31,750	$35,250	$40,250
Alt14	ATU-N to ET: 100% Reduction	$27,250	$28,250	$30,750	$33,250	$37,250
Alt15	ATU-N to Disinfection to Drip Irrigation: 82% Reduction	$31,900	$32,000	$34,300	$35,900	$39,000
Alt16	ATU-N/DN to Disinfection to Seepage Pit: 50% Reduction	$25,500	$25,500	$27,000	$28,000	$32,000
Alt17	Septic Tank to Passive FL Units (medium, in ground): 71% Reduction	$36,600	$39,800	$41,000	$44,200	$45,400
Alt18	Septic Tank to Passive FL Units (high) to Absorption System: 91% Reduction	$43,350	$46,250	$48,050	$51,850	$54,550

Table 11 Total installed cost and total net present value (NPV) for Alternatives 1 through 38, with ranking lowest-highest based on installed cost

Alt	Description	Total Installation Cost ($M)	Rank	NPV, 60 years, 2.8% Discount Factor ($M)	Rank	NPV, 60 years, 5% Discount Factor ($M)	Rank
35	Wellhead treatment (results same as base model)	$18.0	1	$38.8	2	$30.4	2
29-30-31	Sewer Pukalani only, no cesspool upgrades	$18.2	2	$22.1	1	$20.5	1
26-27-28	Sewer Makawao only, no cesspool upgrades	$55.6	3	$60.9	3	$58.7	3
19A	High impact: Septic Tank to Presby: 78% Reduction (highest mass reduction in alt 1-18)	$59.9	4	$118	5	$94.4	5
32-33-34	Sewer Makawao & Pukalani, no other upgrades	$73.9	5	$82.9	4	$79.3	4
19B	High Impact: ATU-N to ET: 100% Reduction (smallest area with >5 mg/L in alt 1-18)	$95.9	6	$250	9	$185	7
Alt4B	Septic Tank to Seepage Pit: 10% Reduction	$102	7	$221	6	$173	6
Alt1	Septic Tank to Absorption System: 47% Reduction	$124	8	$245	8	$196	8
23B-24B-25B	Sewer Pukalani, ST to Presby (highest mass reduction in alt 1-18) where possible	$133	9	$274	11	$242	11
Alt9	Septic Tank to "Layer Cake": 55% Reduction	$134	10	$329	13	$250	13
Alt10	Septic Tank to Lined/Sequence D/DN Biofilter: 91% Reduction	$134	11	$329	14	$250	14
Alt6	Septic Tank to Presby: 78% Reduction	$137	12	$278	12	$221	10
Alt2	Septic Tank to Constructed Wetland: 53% Reduction	$138	13	$348	15	$261	15
Alt4	Septic Tank to RSF to Seepage Pit: 47% Reduction	$147	14	$380	16	$285	16
Alt8	Septic Tank to Recirculating Gravel Filter System to Absorption System: 84% Reduction	$153	15	$410	19	$306	19
20-21-22	Sewer Makawao, ST to Presby (cheapest option)	$157	16	$274	10	$245	12
Alt5	Septic Tank to Eliminite to Absorption System: 80% Reduction	$162	17	$385	18	$293	18
Alt7	Septic Tank to NITREX to Absorption System: 98% Reduction	$165	18	$382	17	$292	17
36-37-38	Compost toilets, no effluent N	$186	19	$228	7	$210	9
Alt11	ATU-N to Absorption System: 53% Reduction	$191	20	$528	20	$385	20
Alt12	ATU-N/DN to Absorption System: 71% Reduction	$196	21	$538	21	$393	21
Alt16	ATU-N/DN to Disinfection to Seepage Pit: 50% Reduction	$196	21	$538	21	$393	21
Alt14	ATU-N to ET: 100% Reduction	$198	23	$560	24	$407	23
Alt13	ATU-N to Constructed Wetland: 58% Reduction	$204	24	$631	27	$450	27
Alt3	Septic Tank to RSF to Drip Irrigation: 80% Reduction	$213	25	$756	28	$531	28
23A-24A-25A	Sewer Pukalani, ATU-N to ET (smallest area with >5 mg/L in alt 1-18) where possible	$229	26	$584	26	$435	25
Alt15	ATU-N to Disinfection to Drip Irrigation: 82% Reduction	$231	27	$785	29	$551	29
Alt17	Septic Tank to Passive FL Units (medium, in ground): 71% Reduction	$236	28	$542	23	$415	24
Alt18	Septic Tank to Passive FL Units (high) to Absorption System: 91% Reduction	$264	29	$570	25	$443	26

Nitrogen Reduction with groundwater model

We obtained a DOH-developed baseline groundwater model (See Appendix IV: Groundwater Model) representative of nitrogen concentration in Upcountry Maui aquifers (aquifer nutrient loading). The purpose of the numerical groundwater flow and transport modeling was to test the consequences of the 38 cesspool conversion alternatives. The groundwater flow model that was used, MODFLOW 2005, is an international standard for simulating groundwater flow. A modular three-dimensional multi-species transport model, MT3DMS, was used to simulate movement of nitrogen due to groundwater flow. This groundwater model was used to calculate reductions in groundwater nitrate concentrations resulting from the reduction in nitrogen input for the 38 alternatives shown in Table 5, and these reductions were then evaluated with the **Objectives 3, 4, 5** in Table 1.

Baseline Groundwater Model Findings

A baseline model using a groundwater and transport model (Appendix IV) was prepared to represent existing nitrogen levels. The modeled area is larger than the Priority One area (**Error! Reference source not found.**) in order for more accurate simulations that are not influenced by boundary conditions. Table 12 shows the nitrogen inputs into the model; it includes the assumptions of 1.5 persons per bedroom, 70 gallons per person, and an N concentration of 87 mg/L. The total number of bedrooms in the study area is 30,750 and the subset of those that are on properties with cesspools are 22,908. The total nitrogen load from OSDSs is 1064.9 kg/day and the total flow rate is 3.23 million gallons per day (MGD) from all OSDSs, with 2.4 MGD and 793 kg-N/day coming from cesspools. These values just discussed are the baseline to which all the cesspool upgrade alternatives are compared, and they are based on the DOH model calibration to data collected from wells. We considered the effects of these assumptions by considering some higher and lower values. Table 12 also shows that if the load is calculated from the HAR 11-62 design standard (2 persons/BR and 100 gal/person), then the loads are almost double (1551 kg/d instead of 793 kg/d from cesspools) which could be a worst case for the existing level of development. However, the study area is not “built out” and additional properties could be developed which would add to the nitrogen load. The 2010 Census data indicates a study area population of 30,900, which is very close to an average of 1.0 persons per bedroom. Assuming that the 22, 908 bedrooms in TMKs with cesspools each have one person, the N concentration is 87 mg/L, and the average flow per person is 100 gal/d, then the cesspool load would be 756 kg/d which is pretty close to the “calibrated” model value (793 kg/d). This indicates that the calibrated model can be considered reasonable.

In the baseline model the highest underlying groundwater concentration in the modeled area is 13.8 mg/L (Table 14 and Figure 3). There are 8,972 acres with concentrations above 5 mg/L, and 991 acres with concentrations above 10 mg/L (Table 14 and Figure 4). Historical sugarcane and OSDSs contribute the majority (56%) of nitrate in the baseline model (Table 13 and Figure 5) while OSDSs contribute 33% (note: cesspools are 24.3% and other OSDSs are 8.7%).

Table 12 Nitrogen loading values used in the model

Alt4B	Persons/BR	Flow/person	N Conc	Bedrooms	Load kg/d
Baseline Total	1.5	70	87	30,750	1,064.9
Baseline Cesspools	1.5	70	87	22,908	793
Baseline Other	1.5	70	87		272
High Estimate Total	2	100	87	30,750	1,995.3
High Estimate Cesspools	2	100	87	22,908	1551
High Estimate Other	2	100	87		444
Low Estimate Total	1	70	87	30,750	698.4
Low Estimate Cesspools	1	70	87	22,908	529
Low Estimate Other	1	70	87		170
2010 Census Estimate Total	1	100	87	30,900	1,019.3
2010 Census Estimate Cesspools	1	100	87	22,908	756
2010 Census Estimate Other	1	100	87		263

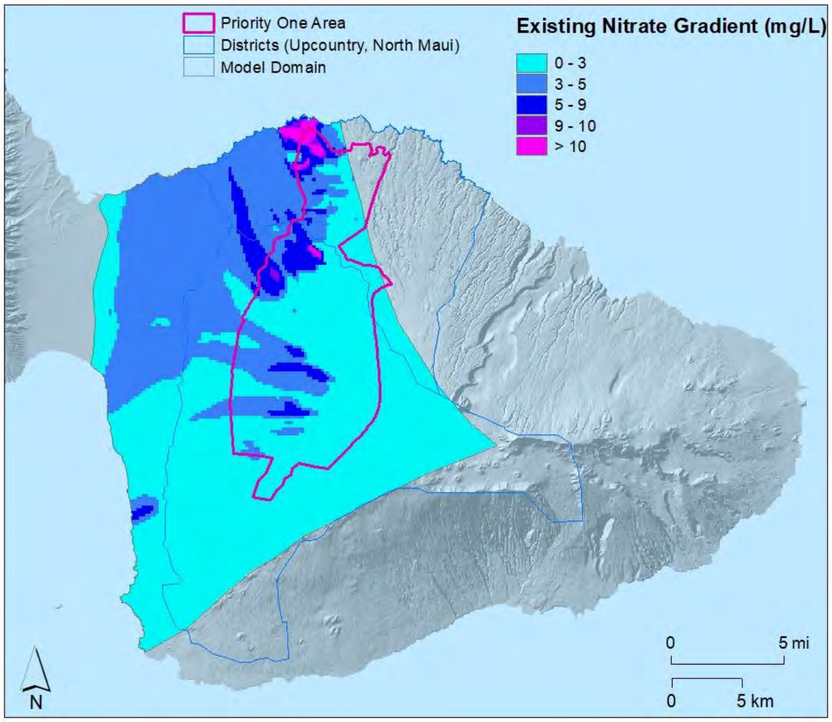

Figure 3. Map groundwater concentrations for baseline model

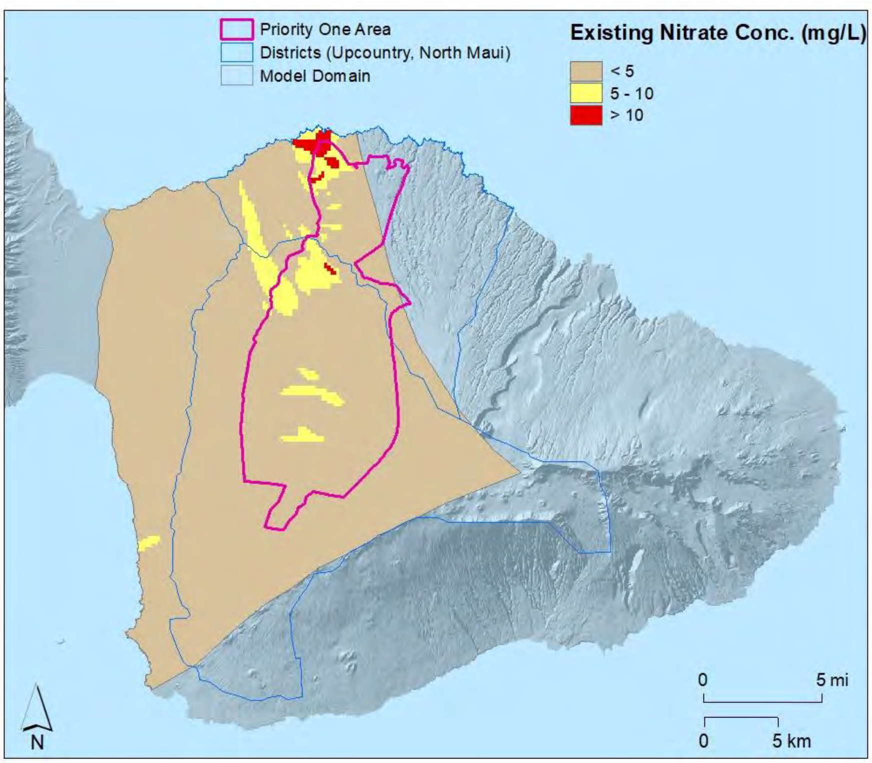

Figure 4. Areas above 5 and 10 mg/L in baseline model

Table 13. Summary of Base Groundwater Model Findings

Source	Mass Flux (kg/d)	Percent Flux
OSDS	1,064.8	33%
Historical Pineapple	67.2	2.1%
Historical Sugar Cane	1,813.9	56%
Pukalani Golf Course Recycle Water	3.5	0.11%
Golf Course (recycled water not applied)	7.8	0.24%
Haliimaile and Pukalani Wastewater Treatment Plant infiltration ponds/beds	19.1	0.59%
Natural/Background (including ranchlands)	287.5	8.8%
Total Flux	3,263.7	100

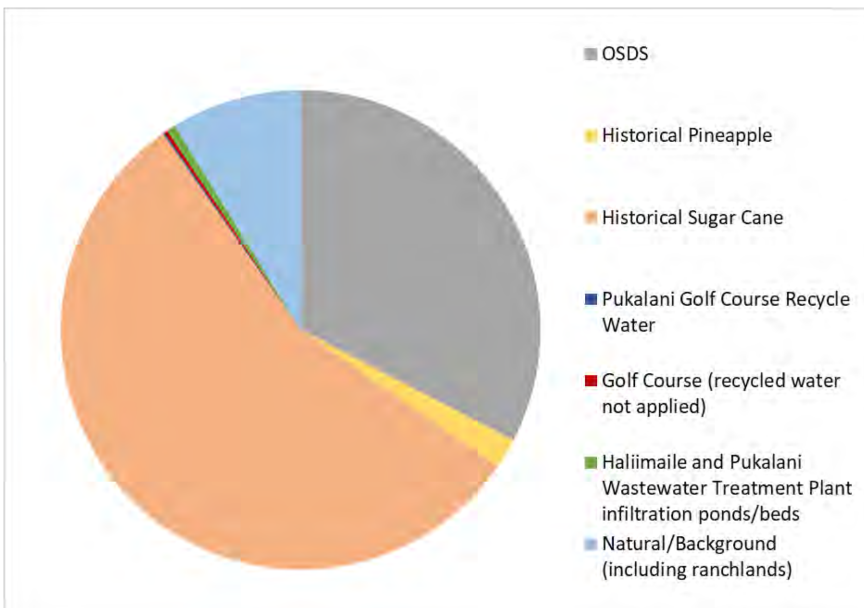

Figure 5. Pie Chart showing a summary of the contribution of each potential nitrate source across the entire area of study according to the baseline model

Groundwater Model Results for Upgrade Alternatives

Table 14 shows the modeled effects of the cesspool upgrade alternatives. For each alternative, it shows the baseline N load, the reduced load due to treatment, the amount of reduction (in kg and in %), the baseline maximum groundwater concentration, the reduced maximum groundwater concentration, and the areas with concentrations above 5 mg/L and 10 mg/L. Figures showing the areas affected for each alternative are shown in Appendix V (Figures AP5-1 through AP5-27). Several highlights can be described for the information in Table 14 and Figures AP5-1 to AP5-27 as follows:

- The status quo situation results in 991 acres of the study area having nitrate concentrations in excess of 10 mg/L, thus making wells in these areas unusable for drinking water unless treatment systems are installed. Adding wellhead treatment might sound easy, however, due to drinking water regulations, other area wells may also be required to provide treatment if they are part of the same "system." Also, an additional nearly 8,000 acres would have groundwater with "high" nitrate levels between 5.0 and 9.9 mg/L.

- There are 6 alternatives which include septic tanks for treatment that eliminate the areas with >10 mg/L of nitrate (Alts 3, 7, 8, 10, 17, 18) and there are 6 which do not achieve this goal of keeping **all** of the groundwater safe for drinking purposes.
- All 6 of the ATU alternatives (Alts 11, 12, 13, 14, 15, 16) achieve the goal of keeping **all** of the groundwater safe for drinking purposes.
- The sewer-only alternatives for Makawao and Pukalani (Alts 26-34) do **not** significantly decrease the areas of unusable groundwater and essentially continue the status quo.
- The alternatives (Alts 19A and 19B) which only address the worst offenders (20% with highest N discharge) do not quite eliminate the areas >10 mg/L of nitrate, but they do reduce these areas by about 90% to between 109 to 129 acres. If the criteria were changed to the worst 25 or 30% offenders (exact value not determined in this study), then **all** of the groundwater could be improved to <10 mg/L of N.
- Composting toilets which could achieve zero-discharge of nitrogen to the groundwater would achieve the goal of keeping **all** of the groundwater safe for drinking purposes.

Step 7. Consider Trade-offs

The final step in the SDM process is to confront the trade-offs across all objectives and all alternatives. We facilitate this analysis by displaying results in a summarized strategy evaluation matrix (Table 15).

Table 14**.** Change in nitrate mass flux due to each alternative; and the areas with groundwater concentrations greater than 5 and 10 mg/L for each alternative

Alt #	Alternative	Mass Flux				Maximum Concentration			Areas	
		Baseline Mass Flux (kg/d)	Resulting Mass Flux (kg/d)	Delta Mass Flux	Mass Flux Reduction	Baseline Max Conc. (mg/L)	Modeled Alt. Max Conc. (mg/L)	Max Conc. Reduction	Area > 5 mg/L (acres)	Area > 10 mg/L (acres)
0	Baseline conditions with cesspools	1064.8	N/A	N/A	N/A	13.7	N/A	N/A	8,972	991
1	Septic Tank to Absorption System: 47% Reduction	1064.8	676.0	388.7	37%	13.7	11.3	17%	4,173	109
2	Septic Tank to Constructed Wetland: 53% Reduction	1064.8	648.1	416.6	39%	13.7	11.1	19%	3,764	76
3	Septic Tank to RSF to Drip Irrigation: 69% Reduction	1064.8	499.3	565.5	53%	13.7	7.8	43%	1,497	0
4	Septic Tank to RSF to Seepage Pit: 47% Reduction	1064.8	676.0	388.7	37%	13.7	11.3	17%	2,689	0
4B	Septic Tank to Seepage Pit: 10% Reduction (1.5 BR; 70 gal/person)	1064.8	1029.0	35.8	3%	13.7	12.7	7%	7,210	610
4B_HI	Septic Tank to Seepage Pit: 10% Reduction (2/BR; 100 gal/person)	1995.3	1823.3	172.0	9%	23.8	22.0	8%	26,237	4250
4B_LO	Septic Tank to Seepage Pit: 10% Reduction (1/BR; 70 gal/person)	698.4	638.2	60.2	9%	8.7	8.0	8%	1,813	0
4B_Census	Septic Tank to Seepage Pit: 10% Reduction (2010 census/no. BR; 100 gal/person)	1019.3	931.4	87.9	9%	12.4	11.5	8%	5,661	86
5	Septic Tank to Eliminite to Absorption System: 80% Reduction	1064.8	530.2	534.5	50%	13.7	10.1	26%	2,707	7
6	Septic Tank to Presby: 78% Reduction	1064.8	429.0	635.8	60%	13.7	10.2	26%	2,813	7
7	Septic Tank to NITREX to Absorption System: 98% Reduction	1064.8	447.9	616.8	58%	13.7	9.4	31%	1,912	0
8	Septic Tank to Recirculating Gravel Filter System to Absorption System: 84% Reduction	1064.8	513.8	551.0	52%	13.7	9.9	27%	2,547	0
9	Septic Tank to "Layer Cake": 55% Reduction	1064.8	640.2	424.6	40%	13.7	11.0	20%	3,706	68
10	Septic Tank to Lined/Sequence D/DN Biofilter: 91% Reduction	1064.8	480.7	584.0	55%	13.7	9.6	30%	2,183	0
11	ATU-N to Absorption System: 53% Reduction	1064.8	638.5	426.3	40%	13.7	9.1	33%	2,332	0
12	ATU-N/DN to Absorption System: 71% Reduction	1064.8	560.1	504.7	47%	13.7	8.5	38%	1,857	0
13	ATU-N to Constructed Wetland: 58% Reduction	1064.8	613.7	451.1	42%	13.7	8.9	35%	2,213	0
14	ATU-N to ET: 100% Reduction	1064.8	429.4	635.3	60%	13.7	7.8	43%	787	0
15	ATU-N to Disinfection to Drip Irrigation: 71% Reduction	1064.8	484.4	580.4	55%	13.7	7.8	43%	1,380	0
16	ATU-N/DN to Disinfection to Seepage Pit: 50% Reduction	1064.8	560.1	504.7	47%	13.7	8.5	38%	1,857	0
17	Passive FL Units (medium) to Absorption System: 71% Reduction	1064.8	560.1	504.7	47%	13.7	8.5	38%	1,857	0
18	Passive FL Units (high) to Absorption System: 91% Reduction	1064.8	468.6	596.1	56%	13.7	7.9	42%	1,048	0
19A	High impact: Septic Tank to Presby: 78% Reduction (highest mass reduction in alt 1-18)	1064.8	778.9	285.9	27%	13.7	11.8	14%	4,125	129
19B	High Impact: ATU-N to ET: 100% Reduction (smallest area with >5 mg/L in alt 1-18)	1064.8	780.6	284.1	27%	13.7	12.0	12%	4,051	109
20-21-22	Sewer Makawao, ST to Presby (cheapest option)	1064.8	352.0	712.8	67%	13.7	7.5	45%	817	0
23A-24A-25A	Sewer Pukalani, ATU-N to ET (smallest area with >5 mg/L in alt 1-18) where possible	1064.8	359.2	705.6	66%	13.7	7.8	43%	703	0
23B-24B-25B	Sewer Pukalani, ST to Presby (highest mass reduction in alt 1-18) where possible	1064.8	363.3	701.5	66%	13.7	7.5	45%	752	0
26-27-28	Sewer Makawao only, no cesspool upgrades	1064.8	842.4	222.3	21%	13.7	13.7	0%	7,139	926
29-30-31	Sewer Pukalani only, no cesspool upgrades	1064.8	898.3	166.5	16%	13.7	13.7	0%	6,238	991
32-33-34	Sewer Makawao & Pukalani, no other upgrades	1064.8	675.9	388.9	37%	13.7	13.7	0%	4,386	926
35	Wellhead treatment (results same as base model)	1064.8	1064.8	0.0	0%	13.7	13.7	0%	8,972	991
36-37-38	Compost toilets, no effluent N	1064.8	0.0	1064.8	100%	13.7	6.3	54%	2	0

Table 15. Strategy evaluation table. Each row represents an alternative, while each column is an objective. Each objective is color-coded with a 2 -point color gradient from yellow (worst), to green (best). QTY denotes the number of OSDS systems upgraded in each alternative.

	Objective Number -->	**O1**	**O2**	**O3**	**O4**	**O5**	**O6**	**O7.**	**O8.**	**O9.**	**O10.**	**Policy Screen**
Alt #	Alternative	Alt Total Cost 2.8% DF	Cost per HH for 2.8%	Area > 10 mg/L (acres)	Mass Flux Reduction (%)	Area >5 mg/L (acres)	CE index (1=best)	% of total households (OSDS) in community affected	Diff from Maui mean ($/year)	Meets design criteria already?	Maintenance burden	Meets cesspool ban?
N/A	Base Model	NA	NA	991	37%	8972	NA	0%	NA	Yes, ALL	low	Yes
1	Septic Tank to Absorption System: 47% Reduction	$244,632,700	$39,470	109	39%	4173	0.21	52%	-290	Yes, ALL	low	Yes
2	Septic Tank to Constructed Wetland: 53% Reduction	$347,737,298	$56,105	76	53%	3764	0.16	52%	-114	Yes, ALL	moderate	Yes
3	Septic Tank to RSF to Drip Irrigation: 69% Reduction	$755,938,758	$121,965	0	37%	1497	0.10	52%	611	Yes, ALL	moderate	Yes
4	Septic Tank to RSF to Seepage Pit: 47% Reduction	$380,120,136	$61,329	0	50%	2689	0.14	52%	-51	Yes, ALL	moderate	Yes
4B	Septic Tank to Seepage Pit: 10% Reduction	$221,398,213	$35,721	610	60%	7210	0.02	52%	-350	Yes, ALL	low	Yes
5	Septic Tank to Eliminate to Absorption System: 80% Reduction	$385,017,741	$62,120	7	58%	2707	0.18	52%	-29	Yes, ALL	moderate	Yes
6	Septic Tank to Presby: 78% Reduction	$278,420,839	$44,921	7	52%	2813	0.30	52%	-221	Yes, ALL	low	Yes
7	Septic Tank to NITREX to Absorption System: 98% Reduction	$382,298,144	$61,681	0	40%	1912	0.21	52%	-30	Yes, ALL	low	Yes

	Objective Number -->	O1	O2	O3	O4	O5	O6	O7.	O8.	O9.	O10.	Policy Screen
Alt #	Alternative	Alt Total Cost 2.8% DF	Cost per HH for 2.8%	Area > 10 mg/L (acres)	Mass Flux Reduction (%)	Area >5 mg/L (acres)	CE index (1=best)	% of total households (OSDS) in community affected	Diff from Maui mean ($/year)	Meets design criteria already?	Maintenance burden	Meets cesspool ban?
8	Septic Tank to Recirculating Gravel Filter System to Absorption System: 84% Reduction	$257,486,428	$41,543	0	55%	2547	0.28	52%	6	Yes, ALL	moderate	Yes
9	Septic Tank to "Layer Cake": 55% Reduction	$329,170,222	$53,109	68	40%	3706	0.17	52%	-143	Yes, ALL	low	Yes
10	Septic Tank to Lined/Sequence D/DN Biofilter: 91% Reduction	$194,802,972	$31,430	0	47%	2183	0.40	52%	-143	Yes, ALL	low	Yes
11	ATU-N to Absorption System: 53% Reduction	$528,144,567	$85,212	0	42%	2332	0.11	52%	219	Yes, ALL	high	Yes
12	ATU-N/DN to Absorption System: 71% Reduction	$538,108,994	$86,820	0	60%	1857	0.12	52%	241	Yes, ALL	high	Yes
13	ATU-N to Constructed Wetland: 58% Reduction	$631,249,165	$101,847	0	55%	2213	0.09	52%	395	Yes, ALL	high	Yes
14	ATU-N to ET: 100% Reduction	$560,110,309	$90,370	0	47%	787	0.15	52%	279	Yes, ALL	high	Yes
15	ATU-N to Disinfection to Drip Irrigation: 71% Reduction	$784,859,709	$126,631	0	47%	1380	0.10	52%	666	Yes, ALL	high	Yes
16	ATU-N/DN to Disinfection to Seepage Pit: 50% Reduction	$538,108,994	$86,820	0	56%	1857	0.12	52%	241	Yes, ALL	high	Yes
17	Passive FL Units (medium) to Absorption System: 71% Reduction	$541,943,660	$87,438	0	67%	1857	0.12	52%	299	Yes, ALL	low	Yes

	Objective Number -->	O1	O2	O3	O4	O5	O6	O7.	O8.	O9.	O10.	Policy Screen
Alt #	Alternative	Alt Total Cost 2.8% DF	Cost per HH for 2.8%	Area > 10 mg/L (acres)	Mass Flux Reduction (%)	Area >5 mg/L (acres)	CE index (1=best)	% of total households (OSDS) in community affected	Diff from Maui mean ($/year)	Meets design criteria already?	Maintenance burden	Meets cesspool ban?
18	Passive FL Units (high) to Absorption System: 91% Reduction	$570,130,010	$91,986	0	67%	1048	0.14	52%	374	Yes, ALL	moderate	Yes
19A	High impact: Septic Tank to Presby: 78% Reduction (highest mass reduction in alt 1-18)	$116,490,319	$63,344	129	67%	4125	0.33	15%	24	Yes, ALL	low	Yes
19B	High Impact: ATU-N to ET: 100% Reduction (smallest area with >5 mg/L in alt 1-18)	$250,244,508	$133,749	109	21%	4051	0.15	16%	832	Yes, ALL	high	Yes
20	Sewer Makawao, ST to Presby (cheapest option) where possible	$273,558,867	$45,284	0	21%	817	0.35	51%	-140	In theory, but major engineering required	low to homeowners, high to society	Yes
21	Sewer Makawao, ST to Presby (cheapest option) where possible	$273,558,867	$45,284	0	21%	817	0.35	51%	-140	In theory, but major engineering required	low to homeowners, high to society	Yes

	Objective Number -->	O1	O2	O3	O4	O5	O6	O7.	O8.	O9.	O10.	Policy Screen
Alt #	Alternative	Alt Total Cost 2.8% DF	Cost per HH for 2.8%	Area > 10 mg/L (acres)	Mass Flux Reduction (%)	Area >5 mg/L (acres)	CE index (1=best)	% of total households (OSDS) in community affected	Diff from Maui mean ($/year)	Meets design criteria already?	Maintenance burden	Meets cesspool ban?
22	Sewer Makawao, ST to Presby (cheapest option) where possible	$273,558,867	$45,284	0	16%	817	0.35	51%	-140	In theory, but major engineering required	low to homeowners, high to society	Yes
23A	Sewer Pukalani, ATU-N to ET (smallest area with >5 mg/L in alt 1-18) where possible	$584,279,863	$96,719	0	16%	703	0.16	51%	384	In theory, but major engineering required	high	Yes
24A	Sewer Pukalani, ATU-N to ET (smallest area with >5 mg/L in alt 1-18) where possible	$584,279,863	$96,719	0	16%	703	0.16	51%	384	In theory, but major engineering required	high	Yes
25A	Sewer Pukalani, ATU-N to ET (smallest area with >5 mg/L in alt 1-18) where possible	$584,279,863	$96,719	0	37%	703	0.16	51%	384	In theory, but major engineering required	high	Yes

	Objective Number -->	O1	O2	O3	O4	O5	O6	O7.	O8.	O9.	O10.	Policy Screen
Alt #	Alternative	Alt Total Cost 2.8% DF	Cost per HH for 2.8%	Area > 10 mg/L (acres)	Mass Flux Reduction (%)	Area >5 mg/L (acres)	CE index (1=best)	% of total households (OSDS) in community affected	Diff from Maui mean ($/year)	Meets design criteria already?	Maintenance burden	Meets cesspool ban?
23B	Sewer Pukalani, ST to Presby (highest mass reduction in alt 1-18) where possible	$274,004,340	$45,357	0	37%	752	0.34	51%	-149	In theory, but major engineering required	low to homeowners, high to society	Yes
24B	Sewer Pukalani, ST to Presby (highest mass reduction in alt 1-18) where possible	$274,004,340	$45,357	0	37%	752	0.34	51%	-149	In theory, but major engineering required	low to homeowners, high to society	Yes
25B	Sewer Pukalani, ST to Presby (highest mass reduction in alt 1-18) where possible	$274,004,340	$45,357	0	0%	752	0.34	51%	-149	In theory, but major engineering required	low to homeowners, high to society	Yes
26	Sewer Makawao only, no cesspool upgrades elsewhere	$60,854,128	$35,546	926	100%	7139	0.48	14%	-244	In theory, but major engineering required	low to homeowners, high to society	In sewered area

	Objective Number -->	O1	O2	O3	O4	O5	O6	O7.	O8.	O9.	O10.	Policy Screen
Alt #	Alternative	Alt Total Cost 2.8% DF	Cost per HH for 2.8%	Area > 10 mg/L (acres)	Mass Flux Reduction (%)	Area >5 mg/L (acres)	CE index (1=best)	% of total households (OSDS) in community affected	Diff from Maui mean ($/year)	Meets design criteria already?	Maintenance burden	Meets cesspool ban?
27	Sewer Makawao only, no cesspool upgrades elsewhere	$60,854,128	$35,546	926	100%	7139	0.48	14%	-244	In theory, but major engineering required	low to homeowners, high to society	In sewered area
28	Sewer Makawao only, no cesspool upgrades elsewhere	$60,854,128	$35,546	926	100%	7139	0.48	14%	-244	In theory, but major engineering required	low to homeowners, high to society	In sewered area
29	Sewer Pukalani only, no cesspool upgrades elsewhere	$22,089,239	$18,151	991	NA	6238	1.00	10%	-535	In theory, but major engineering required	low to homeowners, high to society	In sewered area
30	Sewer Pukalani only, no cesspool upgrades elsewhere	$22,089,239	$18,151	991	NA	6238	1.00	10%	-535	In theory, but major engineering required	low to homeowners, high to society	In sewered area

	Objective Number -->	**O1**	**O2**	**O3**	**O4**	**O5**	**O6**	**O7.**	**O8.**	**O9.**	**O10.**	**Policy Screen**
Alt #	Alternative	Alt Total Cost 2.8% DF	Cost per HH for 2.8%	Area > 10 mg/L (acres)	Mass Flux Reduction (%)	Area >5 mg/L (acres)	CE index (1=best)	% of total households (OSDS) in community affected	Diff from Maui mean ($/year)	Meets design criteria already?	Maintenance burden	Meets cesspool ban?
31	Sewer Pukalani only, no cesspool upgrades elsewhere	$22,089,239	$18,151	991	27%	6238	1.00	10%	-535	In theory, but major engineering required	low to homeowners, high to society	In sewered area
32	Sewer Makawao and Pukalani, no cesspool upgrades elsewhere	$82,943,366	$28,318	926	27%	4386	0.62	24%	-365	In theory, but major engineering required	low to homeowners, high to society	In sewered area
33	Sewer Makawao and Pukalani, no cesspool upgrades elsewhere	$82,943,366	$28,318	926	66%	4386	0.62	24%	-365	In theory, but major engineering required	low to homeowners, high to society	In sewered area
34	Sewer Makawao and Pukalani, no cesspool upgrades elsewhere	$82,943,366	$28,318	926	66%	4386	0.62	24%	-365	In theory, but major engineering required	low to homeowners, high to society	In sewered area

	Objective Number -->	**O1**	**O2**	**O3**	**O4**	**O5**	**O6**	**O7.**	**O8.**	**O9.**	**O10.**	**Policy Screen**
Alt #	Alternative	Alt Total Cost 2.8% DF	Cost per HH for 2.8%	Area > 10 mg/L (acres)	Mass Flux Reduction (%)	Area >5 mg/L (acres)	CE index (1=best)	% of total households (OSDS) in community affected	Diff from Maui mean ($/year)	Meets design criteria already?	Maintenance burden	Meets cesspool ban?
35	Wellhead treatment (results same as base model)	$38,842,349	$0	991	66%	8972	0.00	0%	NA	Yes	low to homeowners, high to society	No
36	Compost toilets, no effluent N	$227,927,752	$27,441	0	66%	2	0.62	69%	-395	No	high	No
37	Compost toilets, no effluent N	$227,927,752	$27,441	0	66%	2	0.62	69%	-395	No	high	No
38	Compost toilets, no effluent N	$227,927,752	$27,441	0	66%	2	0.62	69%	-395	No	high	No

Interpretation of results

The aim of this research was to use evidence to help design nutrient pollution solutions that will reduce the most pollution at the least cost, while considering equity. We identified and compared alternatives including various types of cesspool upgrades and installation of sewers. To achieve the largest pollution reduction possible at the lowest cost, we examined (i) how alternative management practices may influence groundwater nitrogen levels and at what cost; and (ii) where nutrient reductions would be most beneficial to meet both water quality regulations/objectives, and other social goals. We interpret the results of the analysis and provide specific recommendations below.

Comparison across objectives.

As illustrated in the Strategy Evaluation Table (Table5), some alternatives perform better at each one of the individual objectives:

1 Cost.

The 60-year NPV is lowest for the partial sewering Pukalani only alternative ($22.1 million at 2.8% discount rate), followed by wellhead treatment ($38.8 million), sewering Makawao ($60.9 million) and sewering both. The lowest cost partial sewering and wellhead treatment alternatives do not perform well in terms of other objectives, and do not meet the cesspool ban. Adding cesspool upgrades to these partial sewering projects raised the total cost by 300% (e.g., $274 million combined for Pukalani or Makawao partial sewering with septic tanks + Presby disposal). Upgrading the worst offenders to a septic tank to Presby or ATU-N to ET are the least expensive of the upgrade-only alternatives (A19A and 19B, $118/$250 million, which target the worst 20% of polluters). The least expensive alternatives that upgrade all the cesspools are Alt4B (septic tanks to seepage pits, $221 million), Alt1 (septic tanks to absorption beds, $245 million), Alt6 (septic tank to Presby, $274 million), Alt9 and Alt10 (septic tank to layer cake or lined sequence DN biofilter, both are $329 million). Alternatives that include ATUs are all over $500 million because these systems have power requirements, greater maintenance requirements, and have lifespans of 30 years (unlike septic tanks with 60-yr life), thus requiring the expense of a replacement during the 60-yr analysis period. Applying a higher discount rate does not change the relative ranking of the alternatives, although the costs are slightly lower in most cases.

2 Cost per household.

Least cost per household are the partial sewering only with upgrading of other cesspools ($18-35.5k; A26-34), and the composting toilets ($27k; A36-38) alternatives. Partial sewering plus low cost option (septic tank plus Presby) is about $45k, and advanced option (ATU-N to ET) runs about $100k (A20-25). Targeting the worst polluters (A19A, B) would cost the households $63-133k, depending on the system choice. The range of per household cost for the various individual alternatives (A1-18) is $31-133k over the 60-year time horizon.

3 Drinking water standard.

The nitrate-N standard of <10 mg/l is not achieved in several alternatives, including the partial sewering Makawao and Pukalani with no conversion for the other cesspools (A26-35) (when nearly 1,000 acres will be above the 10 mg/l standard), the alternatives that just address the 20% worst emitters (Alt19A/19B) which leave 109-129 acres above the standard, as well as some of the lowest cost alternatives that replace all cesspools (Alt4B, Alt1, Alt2, Alt9, and two others that are very close Alt5 and Alt6). Alternatives that do meet the drinking water standard for the entire area and also meet the cesspool ban include Alt3, Alt7, Alt8, and Alt10-Alt18, which are the more expensive alternatives with ATUs.

4 Flux reduction.

Max flux reduction was highest with compost toilets (A36-38), but would require a blackwater system for kitchen sink waste and change in laws. Partially sewering Makawao and Pukalani with no cesspool upgrades elsewhere (A32-34) results in 37% reduction in flux; partially sewering Makawao or Pukalani and converting all other cesspools to either ATU or septic results in 66-67% reduction in flux (A20-25). Looking at individual solutions, some achieve slightly lower results, e.g., ST + Presby (60%; A6), ST to NITREX to absorption system (58%; A7), ATU-N to ET (60%; A14).

5 Risk.

The area that is >5mg/l is lowest in the options that partially sewer Pukalani and convert cesspools to ATU-N + ET or Septic tank + Presby elsewhere (703 and 752 acres remain above 5mg/l; A23-25); similar results are obtained if partially sewering Makawao coupled with septic tank to Presby everywhere where possible (A20-22), or convert all cesspools to ATU-N with ET (787; A14). All the other individual alternatives leave much larger areas contaminated (1,000 to 4,000 acres).

6 Cost efficiency.

(B/C, or N flux reduction per dollar spent over 60 years). Rank of the highest bang for buck is (1) partially sewering only Pukalani (A29-31), (2) partially sewering Makawao and Pukalani (A32-34), then (3) partially sewering only Makawao (A26-28), all with no cesspool upgrades anywhere. The most cost-efficient option amongst those that address (most) cesspools is septic tank to Presby (19A). Notably, wellhead treatment has zero cost-efficiency because it delivers no environmental benefit to the fundamental objective of reducing nitrogen flux to the aquifer.

7 Equity – Community.

Why should I have to pay if I am not the problem? From one perspective, equity can be considered to be that the cost is borne by those who are the most egregious emitters, and thus the fewest people bear the cost for reducing nitrogen. Alternatives 19A and B – where only the

20% worst emitters of effluent, and the sewer alternatives without additional upgrades, affect the fewest people.

Why should I have to pay when my neighbors aren't? Equity could also be considered as the number of households implicated in each alternative, where a higher number would spread the cost across more of the community. There are quite a few options where nearly everyone is involved.

8 Equity – Maui wide.

Why should I have to pay more than other people on Maui for my household waste disposal? The average annual cost of sewer fees paid by other residents of Maui is $816 per household. The cost to individual households from the alternatives considered would be $240-535 below this average (for the sewering only alternatives), $395 less (composting), and $300 less - $6 more (individual septic systems). However, ATUs, passive units, combined sewer-ATU alternatives can cost from $220 more up to double what the average household spends on waste disposal over the 60-year time horizon.

9 Design standards.

Only a few of the alternatives have existing design standards for wastewater treatment and disposal systems including alternatives 1, 6, 11, 12, 16, 19A/B, 20-21-22, 23B-34. Some of the other alternatives do not have design standards, but can be approved without them including wetlands, drip irrigation, and ET systems. The other systems do not have design standards, which will require the state to develop design standards before they can be approved and installed (Alts 5, 7, 8, 9, 10, 17, 18). This represents a time delay and likely additional costs. Wellhead treatment does not address the cesspool issue at all; sewering would require major engineering.

10 Maintenance burden.

The lowest maintenance burden is associated with some of the septic tank options. The partial sewering options (with no cesspool upgrades) pose a low maintenance burden to the homeowners once they are hooked up, but transfers this burden to society through the required operation and maintenance of the centralized system.

A comment on the cesspool ban.

Alternatives 1-25 meet the cesspool ban, however, options 26-34 only meet the ban in the sewered areas, and the wellhead treatment does not meet the ban. The composting toilets may meet the ban, if the cesspools are decommissioned or turned into seepage pits for kitchen sink water only (which would require changes in current regulations).

Towards decisions about alternatives

The final decision-making power is in the hands of landowners, the state legislature, and DOH, not the decision analysts. The approach taken in this study can support more transparent decision-making by clearly identifying objectives, how each alternative performs, and trade-offs, but the ultimate decisions rely on normative judgments that are the responsibility of public officials. The next step towards making a decision is to decide which objectives are most important, and how much the achievement of certain objectives can be given up in order to achieve other objectives. This normative weighting of objectives is beyond the scope of this analysis. Notably, there are techniques in decision science to elicit weights to make some objectives more important, which may be something the DOH wants to engage in as they move forward. That said, we are able to pull out some highlights and present a few illustrative scenarios where there are key trade-offs.

Table 15 is called a strategy evaluation table and it is designed to serve as a decision aid. The color scheme in Table 15 helps identify alternatives that perform well across many objectives (lots of green), or poorly (lots of yellow). A mix of colors illustrates trade-offs across objectives presented by a given alternative. The table can be used to evaluate individual alternatives, or compare across alternatives.

The first cut can be alternatives that perform poorly across multiple objectives (many yellow cells), and should thus not be considered – such as well-head treatment (Alt 35), which fails to decrease groundwater risk, and consequently also has zero cost-effectiveness.

We can highlight some alternatives that seem to be winners (i.e., they meet most objectives, illustrated by lots of green). The strategy evaluation table (reveals an obvious winner, composting toilets, which meets the fundamental objectives of reducing cost, impact, and risk, while ensuring equity, but it does not meet the cesspool ban nor comply with current regulations. There are also significant technical and social hurdles to overcome, which we did not address in this analysis. We discuss these in our recommendations section.

A number of septic tank alternatives (Alt 6, 8, 10, 19A) perform well across multiple objectives, as do the sewering Makawao (or Pukalani) combined with septic tank to Presby where possible alternatives (Alt 20-22, 23B-25B). The key difference between these alternatives is the risk of exceeding 5 and 10mg/l nitrate standards, which is quite a bit higher in the former. This may or not be an acceptable risk. The sewering plus upgrade alternatives (Alt 20-25) all eliminate the area at risk of >10mg/L, but leave 700-800 acres susceptible to >5mg/L. All these alternatives will cost around $250 million to install, operate, and maintain for the next 60 years. Notably, in the sewering alternatives, more advanced upgrades to the cesspools outside the sewage area (Alt 20-22 upgrade cesspools with the cheapest option where possible) do not deliver much additional benefit, but cost quite a bit more. And alternatives that only sewer the neighborhoods without attending to the cesspools at all are the cheapest alternatives, both overall and per household, but they result in potentially unacceptable risk to aquifers, low flux reduction benefits, and do not meet the ban.

If decision makers are hoping to get the most nitrogen reduction benefit per dollar spent, then sewering Pukalani with no cesspool upgrades elsewhere are the best alternatives (Alt 29-31), but as the yellow cells indicate, the area at risk of being >5mg/L or >10mg/L nitrate is quite high (~6000 and ~1000 acres, respectively), it does not meet the ban, the mass flux reduction is quite low (16%), and only a small number (10%) of households in the area would be participating in the solution, although the cost per affected household would be quite low ($18k). This would also be the selection if decision makers want the cheapest solution.

If decision makers cannot allow any area to reach >10mg/l, then many alternatives are eliminated. The lowest cost alternative to meet the 10mg/l standard will cost $227 million over the 60-year project timeframe. Relatively low-cost septic tank-based alternatives (8, 10) meet this standard, at a much cheaper cost per household than the sewering alternatives (Alt 20-25), which have similar overall costs. Another benefit of the septic-based alternatives is more households in the community participate (increasing equity), though the sewering alternatives reduce nitrogen flux more.

Only composting toilets (at $228million) will ensure that all the area meets the more strict 5mg/l standards; the next best will restrict exceedance to 703 acres at a cost of $584million (Alt 23A-25A sewering Pukalani and installing ATUs with ET where possible), or 752 acres at a cost of $274million (Alt 23B-25B sewering Pukalani and installing septic tank to Presby where possible). All of these alternatives meet the cesspool ban.

Alternatives that target the TMKs with the highest nitrogen contributions (Alt 19A and 19B) would cost $116 and $250 million, but the additional cost for 19B does not buy much result. 19B is far less cost-effective than 19A. Both these alternatives reduce the area at risk of over 10mg/L to about 100 acres, and only affect ~15% of households, which may be perceived as attractive or inequitable, depending on the perspective. These alternatives meet the cesspool ban.

Notably, most alternatives will cost less per annum over the lifetime of the upgrade than other Maui residents pay. Some of the sewering alternatives would have the Upcountry households paying about $500/year less than the average wastewater disposal cost, though others are $400/year more. This offers a potential opportunity for cost recovery by charging residents across the county equally for municipal wastewater services. Some alternatives have residents paying similar costs as the average Maui household (Alt 7-8), while others would have them pay far more.

Recommendations

General

Aquifers that are designated as potable should be maintained in that state and preserved for current and future use to the extent that is feasible via source control. In the case of Upcountry Maui, the only feasibly controllable source is OSDSs, which constitute approximately one third of the total nitrogen inputs which includes cesspools (24%). Cesspool upgrade alternatives that preserve the groundwater for potable use are those that minimally provide nitrate-N concentrations <10 mg/L for 100% of the land area. This results in a subset of acceptable alternatives. Some DoH reports aim to maintain all groundwater nitrate-N concentrations below 5 mg/L. Notably, because the non-cesspool sources are very large, no alternatives evaluated here, even zero-discharge, can achieve that objective.

Further investigations

We recommend to investigate inputs of chloramine into drinking water and thus emissions via cesspools, and, if appropriate, incorporate it into the groundwater model.

Small cluster sewer systems were not investigated in this study because they require a more involved design process that is too expensive and time consuming for this project and would normally be done by a professional A/E design firm. The process would include dividing up neighborhoods into drainage sub-basins, predicting flows, finding land to locate treatment and disposal facilities, and establishing mini sewer districts to collect fees, procure easements, procure operator services, apply for and maintain government permits, etc. It is recommended that such a study be conducted as there are examples of such system solutions on the mainland. It is also recommended to investigate the cost of centralized sewering of the entire community including a WWTP and a disposal system.

We recommend to pilot study and then develop design standards for passive denitrifying absorption systems (Alts 9, 10, 17, 18) as well as pilot study of Nitrex and Eliminite and Presby (with De-nyte) for the same purpose.

We recommend to extend the study of alternatives 19A/B to determine how many more TMKs would have to be included (in addition to the worst 20%) to achieve zero acres of >10mg/L nitrate and to find the cost.

We recommend to conduct composting toilet study, including literature, current practice data from mainland, and pilot studies in Hawaii to gain familiarity, experience maintenance issues, determine pathogen risks in compost, acceptable handling practices, and develop regulatory standards including permitting and maintenance requirements.

Program management and efficiency

We recommend resources be dedicated to program management, as upgrading 88,000 cesspools will require each to go through the approval process which includes review and approval of test data and design submittals from engineers, and keeping of records. This will be a huge task that would require several additional staff. In addition, it will become even more important for the DOH to implement a more comprehensive life-cycle type management program for OSDSs. We recommend to determine a framework and the required DOH staffing to regulate all the OSDSs including upgraded cesspools in order to ensure public health is protected in the state.

We recommend to develop design standards for drip irrigation systems and ET systems to make approval of such systems routine instead of one-off design for each property as is the current situation.

Financing

We recommend to investigate financing options for completing any alternative program of upgrades. Every effort should be made to capitalize on economies of scale. Financing options would include individual homeowner pays, state/federal grants, state tax credits, privatization of individual systems similar to rooftop solar systems, County owning/operating all individual systems, Community association formation followed by assessment for capital costs and billing of O&M costs, public-private partnerships, and other options.

Legislation and administrative actions

Based on the investigations recommended above, write legislation to facilitate gray water, composting toilets, drip irrigation, ET systems, passive denitrifying absorption systems, program management including issuing OSDS permits and associated requirements, and financing methods. Composting toilets in fact achieve the fundamental objective of reducing nitrogen pollution to the groundwater, but do not comply with current regulations. Composting toilets also would require homeowners to take an active and regular role in their own sewage treatment (clean bulking agent has to be added to the units regularly and dirty compost removed and discarded with refuse) which may not be realistic on a large scale. Depending on the cost of the future “Gates” toilets (not yet on the market and no cost data available), which function the same as the composting toilets yet require less homeowner maintenance, this may become an important option to consider and allow by law.

One concern about exclusively relying on the ban to control cesspools is that it does not specify what technologies to use, instead, as our analysis highlight, most homeowners will have multiple options, each with its own costs and nitrogen removal efficiencies. Criteria are needed to guide homeowner choices to ensure that sufficient nitrogen is removed, such that cumulatively all groundwater is maintained with <10mg/l of nitrate. We therefore strongly recommend that DoH develop such criteria.

The cesspool ban has regulatory efficiency, and proffers a mechanism for the DoH to engage with all homeowners in any funding and technical assistance. While on its face the ban seems equitable as all homeowners have to comply equally, there may be solutions that have greater economic efficiency and/or environmental benefits that better achieve the fundamental objective of the ban (i.e., cost-effectively reducing nitrogen inputs into drinking water sources and sensitive waters). For example, our analysis revealed that the objective of 10mg/l can be achieved by targeting only certain areas and/or certain cesspools. This suggests that a systems perspective would improve outcomes, i.e., when the fundamental objective can be met by intervening in part of the system, these areas are targeted and exemptions to the ban might be considered for remaining households.

Any solution that differentially impacts some homeowners would raise equity concerns. Indeed, in some scenarios, some homeowners might be faced with installing an even more expensive system than they would have if they were just responsible for upgrading individually, because the more elaborate system would remove much more nitrogen and thereby achieve system goals more efficiently. Any system-scale solution would, of course, require subsidizing homeowners who upgrade. We recommend that DoH adopt a systems perspective, and design collective solutions and creative funding mechanisms to improve the economic efficiency.

Conclusions

The project achieved all objectives, namely, it: 1) identified a suite of cesspool replacement options, 2) developed a range of management alternatives to upgrade cesspools that incorporate feasibility, 3) analyzed environmental benefit of each alternative; 4) enumerated costs of the alternatives; and 5) provided recommendations on the alternatives relative to cost, environmental benefit, and stakeholder-identified objectives. The approach to evaluate the utility of proposed actions via a participatory and structured decision making process was successful in engaging a diverse set of stakeholders over a sustained period, bringing agency officials, academic experts, and the public together to integrate social values and science. As such, the project achieved its strategic goals to build a framework for academic-agency collaboration, and to pilot a collaborative decision-making framework with communities. The project team hopes that this framework will provide pay-offs for agency decision making far into the future, leading to decisions that are more transparent, robust, and publicly accepted. We recommend committing to a participatory and structured decision making process for future environmental problems.

Stakeholders strongly challenged the prioritization of Upcountry Maui cesspools. The 2017 report spurred strong public pushback, and subsequent response to comments published by DoH only addressed some of the concerns. This project tried to handle these objections by highlighting concerns that the stakeholders raised in various sections throughout the report. That said, most were outside the scope of this analysis. We recommend continuing a good faith process of responding to stakeholder concerns and claims with science, where appropriate, and open communication. We understand that the DoH is constrained by legal mandate, but we furthermore recommend that, insofar as it is possible, future prioritization processes follow the structured decision-making framework piloted here. We believe this would lead to more economically efficient, equitable, and socially acceptable outcomes.

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Appendix I: Stakeholder group

Table S1. Stakeholder group

Stakeholders	Department/Agency/Company	Title/Position
Agawa, Shayne	Maui Dept. of Environmental Mgmt	Deputy Director
Baisa, Gladys	formerly Maui County Water Supply	former Director
Baltizar, Brendan		Farmer
Blumenstein, Eva	Maui Dept. of Water Supply	Planning Director
Coleman, Stuart	Surfrider	HI Islands Manager
Jacintho, William	Maui Cattlemen's Association	President
Kau, Helene	Maui County Water Supply	Deputy Director
Mayer, Dick	UH Maui, Retired	Economics Professor
Meidell, Scott	Real Estate and Land Management	Senior Vice President
Nakagawa, Eric	Maui Dept. of Environmental Mgmt	Division Chief
Nakahata, Mae	HC&S/A&B	Farmer
Niles, Annette	Maui Cattlemen's Association	Rancher
Nishoka, Miles	Hawaii Dept. of Health	Cesspool Coordinator
O'Keefe, Sean	HC&S	Environmental Manager
Pang, Lorrin	Hawaii Dept. of Health	Maui District Health Officer
Pearson, Jeff	Maui County Water Supply	Director
Pruder, Sina	Hawaii Dept. of Health	Chief, Wastewater Branch
Reynolds, Christin	One World One Water	Water advocate
Seto, Joanna	Hawaii Dept. of Health	Chief, Safe Drinking Water Branch
Strand, Darren	A&B	Pineapple
Sugimura, Yukilei	Maui County Council	Councilmember
Thompson, Theresa	Maui Cattlemen's Association	Rancher
Thomson, Richelle	Maui County	Corporation Counsel
Uehara, Norris	Hawaii Dept. of Health	Pollution Prevention Section Supervisor
Watanabe, Warren		Farmer

Appendix II: Options

1. Introduction

This Appendix describes the treatment and disposal technologies that are considered in the main report. The following sections are summarized from the “Onsite Wastewater Treatment Survey and Assessment” report (Water Resources Research Center and Engineering Solutions, Inc., 2008). Therefore, citations of the material are not repeated throughout. For more details, please reference the report.

2. Importance of Nitrification and Denitrification

The main pollutant of concern from sewage dispersed on-site is the fully oxidized form of nitrogen (nitrate, NO_3^-) because it is high mobile in the subsurface (does not sorb). Thus it readily travels to underlying groundwater. Nitrogen in raw wastewater is present as a combination of organic-bound N and ammonia (reduced forms). These are converted aerobically via ammonification (Org-N -> NH_3) and then nitrification converts the NH_3 into nitrate. In order to remove nitrate from the water, denitrification is required – which converts nitrate into nitrogen gas which is released to the atmosphere and is inert (non-GHG).

3. Wastewater Treatment Methods

The following describes various on-site wastewater treatment methods that have been reviewed for adaptability in Upcountry Maui. These technologies convert household wastewater constituents into endproducts which then must be disposed into the ground via a separate disposal system. Section 3, describes the TREATMENT methods and Section 4 describes the DISPOSAL methods.

3.1. Aerobic Treatment Unit-w/Nitrification

An aerobic treatment unit (ATU) is an individual wastewater system that is designed to retain solids, aerobically decompose organic matter over time, and allow effluent to discharge into an approved disposal system. There are many types of ATUs, and the following will describe the most commonly used: suspended-growth flow-through ATUs and combined attached and suspended growth ATUs. ATUs also typically include primary treatment plus biological secondary treatment in different compartments. These units typically include nitrification.

3.1.1. Suspended-Growth Flow-Through ATU w/Nitrification

A suspended-growth flow-through ATU is a biological treatment system where microorganisms are kept in suspension by mixing air with wastewater influent and concentrated underflow or sludge (from a clarifier) in an aeration tank (Figure AP2-1). If there is no integral primary settling basin, a separate septic tank or pre-loader should be installed upstream of the ATU. The purpose of this additional tank is to remove readily settleable solids and floating matter that will reduce suspended solids loading.

From the aeration tank, the mixture is passed into a secondary clarifier, where microorganisms settle to the bottom, forming a layer of sludge. The clarified liquid effluent is passed to a disposal system. Some of the sludge solids in the settling basin will decompose, while the remainder accumulates and must periodically be removed (pumped out) and properly/legally disposed of offsite.

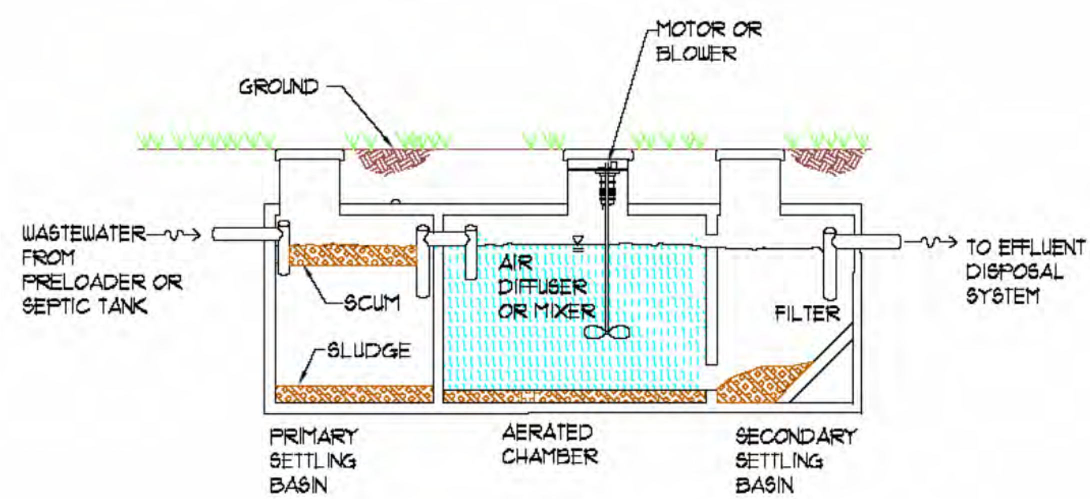

Figure AP2-1 Schematic of Suspended-Growth Flow-Through ATU

Advantages

- This type of ATU can achieve effluent quantity of BOD concentrations of 5-25 mg/L and TSS concentrations of 5-25 mg/L. This is equivalent to the standard “secondary” treatment level specified in the Federal Clean Water Act for publically-owned wastewater treatment plants across the USA.
- Since the biological process takes place in a aerobic environment where free oxygen is available, complete nitrification of ammonia is able to occur in the ATU.

Limitations

- Consideration should be given to determine how best to use available grades to allow gravity flow from the preloader (if present) to the ATU to the disposal system.
- Power is required to operate the blowers, pumps, controls, and monitoring and alarm systems in the ATU.
- Denitrification does not occur due to absence of an anaerobic environment. Therefore, effluent quantities of nitrate-N range from 10 to 60 mg/L. Because this type of ATU

alone cannot remove nitrogen, the pairing with a denitrifying disposal method may be necessary.

- ATUs are sensitive to high and low temperatures, heavy loading of solids, toxic chemicals (including chemical cleansers), power failures, and large influent flow variability.

Trained professionals should inspect the system every four to six months, along with sludge/scum pumping, as needed.

3.1.2. Combined Attached and Suspended Growth ATU w/Nitrification

This setup allows microorganisms to form a slime layer on the surface of submerged or semi-submerged media (Figure AP2-2). Wastewater is treated as it passes over the media. The system is similar to the suspended-growth flow-through ATU, except that the aerated chamber contains submerged media.

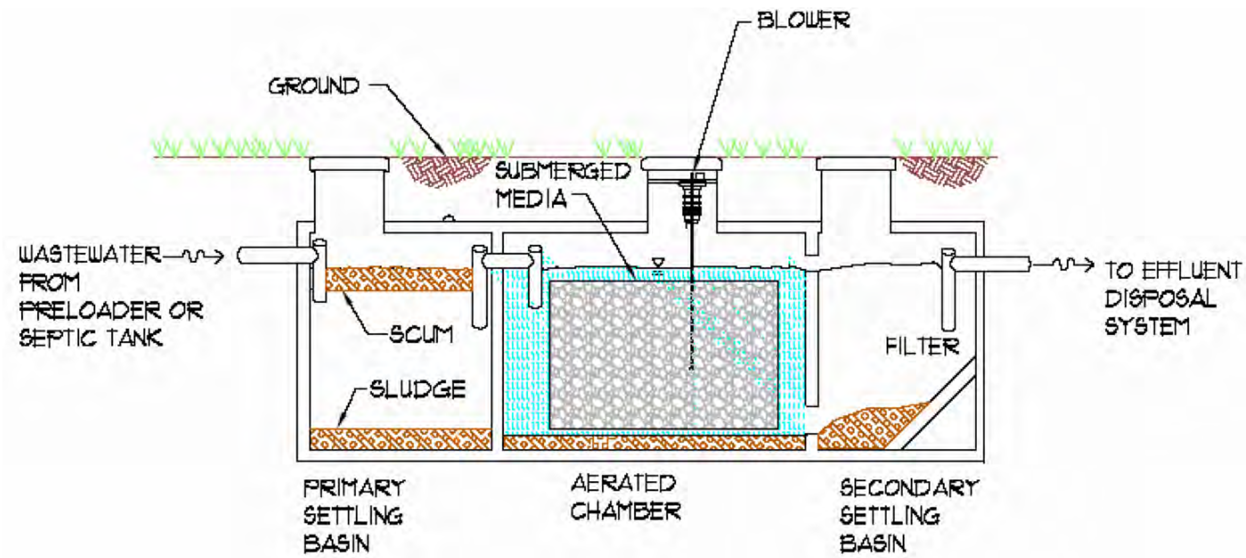

Figure AP2-2 Schematic of Combined Attached and Suspended Growth ATU

Advantages

- This type of ATU can achieve effluent quantity of BOD concentrations of 5-25 mg/L and TSS concentrations of 5-25 mg/L.
- Since the biological process takes place in a aerobic environment where free oxygen is available, complete nitrification of ammonia is able to occur in the ATU.

Limitations

- Consideration should be given to determine how best to use available grades to allow gravity flow from the preloader (if present) to the ATU to the disposal system.

- Power is needed to operate the blowers, controls, and monitoring and alarm systems in the ATU.
- Denitrification does not occur due to absence of an anaerobic environment. Therefore, effluent quantities of nitrate-N range from 10 to 60 mg/L. Because this type of ATU alone cannot remove nitrogen, the pairing with a denitrifying disposal method may be necessary.
- ATUs are sensitive to high and low temperatures, heavy loading of solids, toxic chemicals (including chemical cleansers), power failures, and large influent flow variability.

Trained professionals should inspect the system every four to six months, along with sludge/scum pumping, as needed.

3.2. Aerobic Treatment Unit-Nitrification/Denitrification

Some ATUs include both nitrification and denitrification capabilities. Flow-through varieties include a recirculation pump tp return nitrified water to the front of the system where it mixes with raw wastewater under anaerobic conditions and it is held to allow denitrification. Another tpe of system is the sequencing batch reactor (SBR) described below.

3.2.1. Sequencing Batch Reactor ATU w/Nitrification and Denitrification

In a SBR type ATU, all the aerobic, anaerobic, and clarifying processes occur within a single tank. The operating sequence includes at least the four following steps (Figure AP2-3), which can be cycled several times per day (e.g. one cycle every 4 hours):

1. Fill: tank is filled with raw wastewater to a predetermined volume.
2. Aeration: air is added for mixing and suspension of the microorganisms and the wastewater and for microbial oxidation of the waste including conversion of N into nitrate via nitrification;
3. Settle: aeration is turned off and the microorganisms/sludge settles to the tank bottom; concurrently, the contents become anaerobic which allows denitrification of the nitrate into nitrogen gas;
4. Decant: clarified portion is decanted as effluent. Cycle repeats.

These ATUs are designed to operate continuously using a control system of times, level sensors, and microprocessors.

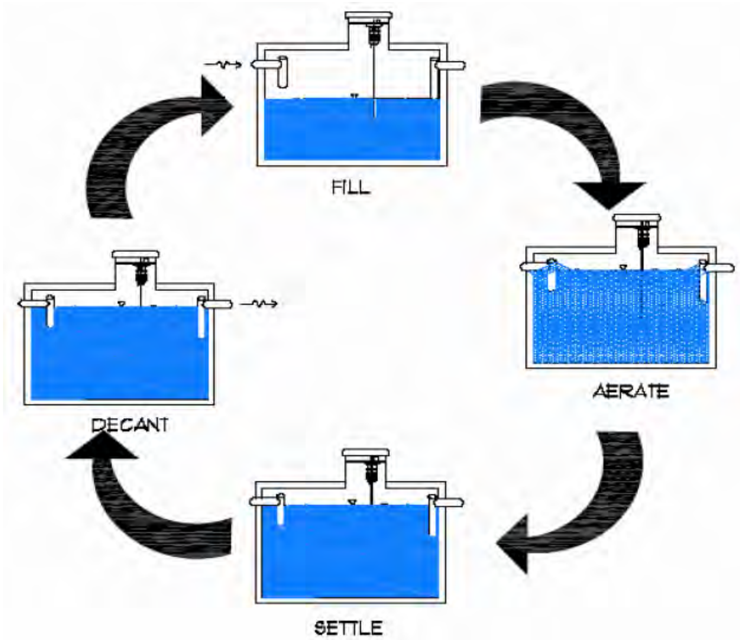

Figure AP2-3 Cycles of an SBR-type ATU

Advantages

- This type of ATU that can achieve effluent quantity of BOD concentrations of 5-25 mg/L and TSS concentrations of 5-25 mg/L.
- An SBR can provide both nitrification and denitrification through cycles of an aeration step and settling and decanting steps.
- Up to 50% of influent nitrogen can normally be removed (or possibly higher under ideal conditions).

Limitations

- Consideration should be given to determine how best to use available grades to allow gravity flow from the preloader (if present) to the ATU to the disposal system.
- Power is needed to operate the blowers, controls, and monitoring and alarm systems in the ATU.
- Accumulated sludge and scum must be removed on a regular basis to prevent carryover of these materials into the downstream disposal system.
- ATUs are sensitive to high and low temperatures, heavy loading of solids, toxic chemicals (including chemical cleansers), power failures, and large influent flow variability.

Trained professionals should inspect the system every four to six months, along with sludge/scum pumping, as needed.

3.3. Septic Tank

A septic tank serves as both a settling and skimming tank and partial anaerobic treatment. The baffles in the tank cause solids settle to the bottom and create a layer of sludge, while fats, oils, grease, and other floatables rise to the top and create a layer of scum (Figure AP2-4). Based on Hawaii's design requirements, a screen should also be installed on the effluent end to enhance solids removal and prevent clogging of the downstream disposal system. If high quality effluent is desired, a septic tank could be used to pretreat wastewater prior to a secondary treatment step, such as an ATU.

Figure AP2-4 Septic Tank with Two Chambers (United States Environmental Protection Agency, 2018)

Advantages

- Power is not required to operate a septic tank.

Limitations

- Accumulated sludge and scum must be removed on a regular basis to prevent carryover of these materials into downstream processes.

Maintenance costs are based on periodic pumping of solids and scum, as well as cleaning the effluent filter.

4. Wastewater Disposal Methods

The following describes various on-site wastewater disposal methods that have been reviewed for adaptability in Upcountry Maui. These systems are required to follow after the wastewater treatment step.

4.1. Absorption Systems

Absorption systems are designed to percolate liquids into the ground in consideration of the hydraulic permeability of the soil media. The percolation area is measured as the summation of the bottom area of all the trenches. These systems are generally shallow and are in the aerobic soil layer which provides oxidation of organic wastes and nitrification. The extent of such treatment is dependent upon the characteristics of the native soil, the loading rate, and other factors which can cause treatment to vary from 0% to as high as 90%. The absorption system also provides filtration of suspended solids and microorganisms.

4.1.1. Absorption Trenches and Gravel-less Systems

This disposal system is a subsurface wastewater infiltration system with trenches typically between 18 and 36 inches wide and 3 to 5 feet below grade (Figure AP2-5). Gravel-less trenches use materials such as plastic dome-shaped segmented chambers as substitutes for the traditional method of gravel bedding. This modification retains structural stability and hydraulic flow, while reducing the costs for gravel fill.

As wastewater percolates out of the trench, oxygen transfer from the air can maintain aerobic conditions in the trench.

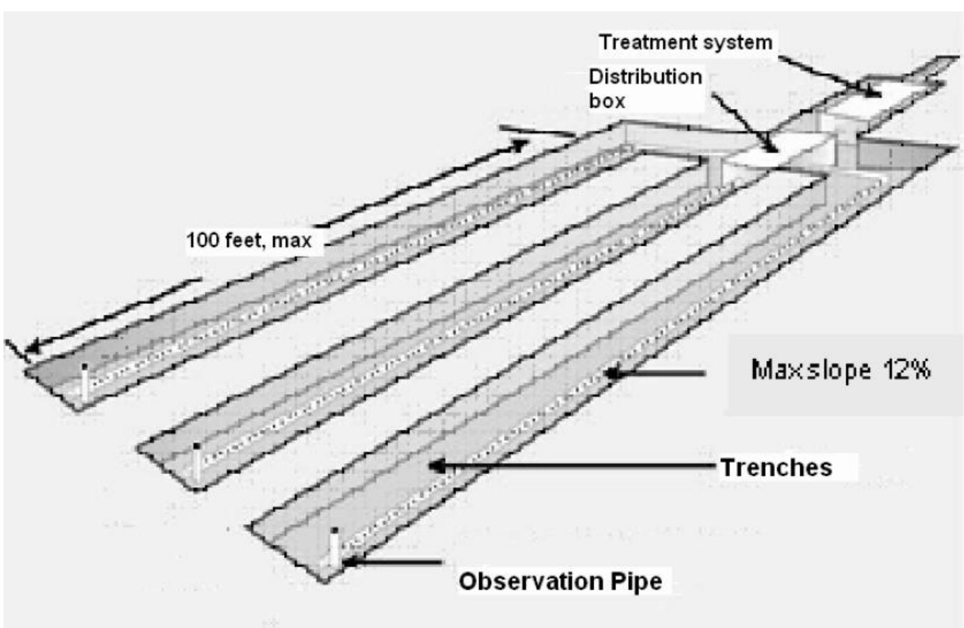

Figure AP2-5 Trench Disposal System

Advantages

- When used downstream of a septic tank, absorption trenches can achieve levels of less than 30 mg/L of BOD, 30 mg/L of TSS, and 13 CFU/100 mL of fecal coliform.
- When deployed downstream of an ATU, absorption trenches can achieve levels of 4 mg/L of BOD, 1 mg/L of TSS, and 13 CFU/100 mL of fecal coliform.
- No power is required and maintenance is generally not possible.

Limitations

- Trenches should not be used in terrain where the natural slope is too steep (>12% in HI).
- These systems cannot be used if groundwater is too close to the surface (minimum vertical separation of three feet is desirable)
- Large amounts of land may be needed, since the effective absorption area is at the bottom of each trench.
- Root intrusion can adversely impact trench performance.
- Overloading, rainfall, or unsuitable soils may cause contaminants to spill out into the surrounding soil, or surface water.

Periodic inspection of observation ports (if provided) can be used to determine whether water is accumulating in the trenches instead of percolating out. Upstream processes must be properly maintained to prevent excessive solids coming in and causing clogging of the voids in soil and adversely impacting the functionality of the absorption trench.

4.1.2. Absorption Beds

These are subsurface wastewater infiltration systems with beds at least three feet wide. They are similar to absorption trenches, but the area for disposal is excavated and a layer of gravel is installed with the distribution pipe on top (Figure AP2-6). An absorption trench system has a distinct section of undisturbed soil between the absorption trenches whereas the bed-type system is continuous. The percolation area is the area of the bottom of the absorption bed.

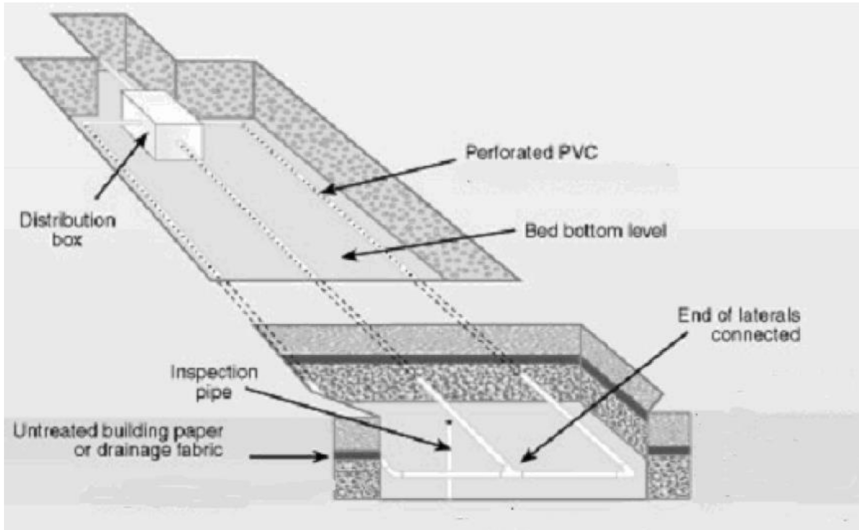

Figure AP2-6 Absorption Bed Disposal System

Advantages

- Same as absorption trenches.

Limitations

- Same as absorption trenches.

4.2. Seepage Pit

A seepage pit is similarly constructed to a cesspool, but it receives treated wastewater, whereas a cesspool receives untreated wastewater. These systems are generally constructed from reinforced concrete rings, with a diameter of 8 or 10 feet and a height of 2 feet, that are stacked in order to achieve the depth required (usually 15-30 ft). Each ring has large openings in the sides and looks like Swiss cheese. A concrete lid with a 4-inch inspection port is placed on top. Water percolates out from the sides and the bottom of the unit into the surrounding soil. The effective percolation area is measured as the pit sidewall area.

Advantages

- Seepage pits are the simplest and most compact method to percolate water into the ground.
- They are viable options when the available land area is insufficient for absorption beds or trenches, the terrain is steep, or when an impermeable layer overlies more suitable soil.
- These units can be maintained (accumulated solids from poorly-functioning upstream treatment units can be accessed and pumped out) unlike absorption trenches/beds.

Limitations

- Seepage pits generally cannot provide the same level of treatment as absorption bed and trench systems, but there have been few studies.

Proper functioning of a seepage pit relies heavily on maintenance of the upstream treatment process. This prevents clogging of the seepage pit. Otherwise, periodic pumping of any accumulated sludge will be required.

4.3. Disinfection

Disinfection is the killing of pathogens in wastewater. It is a form of additional treatment that is not often incorporated into OSDS systems and is placed here with disposal systems even though it is not a form of disposal. Most ATUs have the option of adding disinfection if desired by the owner or required due to proximity of the system to either groundwater or surface water. There are two main methods of disinfection: chlorination and ultraviolet (UV) light disinfection.

4.3.1. Chlorination

Chlorine is a powerful oxidizing chemical frequently used for disinfection of water or wastewater. Its common forms include chlorine gas, solid or liquid chlorine (calcium hypochlorite and sodium hypochlorite), and chlorine dioxide. Powder or tablets of solid hypochlorite are the form that can be used in onsite treatment systems. All forms of chlorine are toxic and corrosive, and require careful handling and storage.

Advantages

- The main advantages of chlorine are ready availability, low cost, and effectiveness against a wide range or pathogenic organisms. Chlorine can reduce fecal coliforms by 99 to 99.99% and can continue to exist as a residual in wastewater effluent.

Limitations

- Chlorine chemicals need to be stored and handled carefully.

A tablet system will require tablet storage and replenishments, inspection, and repair of system components as needed.

4.3.2. UV Disinfection

UV disinfection employs mercury-type lamps separated from the water by a quartz sleeve contained in a flow through stainless-steel reaction vessel (pipe). UV light acts as a physical disinfection agent due to the germicidal properties of UV in the range of 240 to 270 nanometers. The radiation penetrates the cell wall of microorganisms and causes cellular mutations that prevent reproduction. Effectiveness of UV disinfection depends on the clarity of the treated wastewater, UV intensity, time of exposure, and reactor configuration.

Advantages

- UV successfully inactivates most bacteria, viruses, spores, and cysts.
- In contrast to chlorine chemicals, this method does not involve handling or storing of hazardous or toxic chemicals.

Limitations

- A continuous power supply is required to operate the UV bulbs.
- Periodic cleaning of the quartz sleeves is required to ensure transmission of the UV radiation into the wastewater (monthly minimally).
- Bulbs must be replaced (typically annually)
- UV treatment is rendered ineffective in wastewater with low clarity due to bacteria being shielded by high turbidity and total suspended solids.

4.4. Presby Advanced Enviro-Septic and De-Nyte System

The Advanced Enviro-Septic® Treatment System is a network of 10-foot long pipes for further treating and percolating septic tank effluent. It consists of special pipes embedded in a specific type of System Sand. The pipes contain ridges, perforations with skimmers, geotextile fabric, green plastic fiber mat, and Bio-Accelerator® fabric. These work together to treat wastewater as depicted in Figure AP2-7 (Presby Environmental, 2018). Without using any electricity or replacement media, the Advanced Enviro-Septic® system can remove BOD, TSS, and provide full ntrification. Coupled with the add-on De-Nyte® unit, conversion of nitrate to nitrogen gas is possible (Figures AP2-8 and AP2-9) (Presby Environmental, 2018). Interconnected De-Nyte® cells can be placed 6 to 12 inches below the Advanced Enviro-Septic® system. These cells capture and treat nitrified wastewater using patented denitrification products (Presby Environmental, 2018).

Figure AP2-7 Presby Advanced Enviro-Septic® Treatment System (Presby Environmental, 2018)

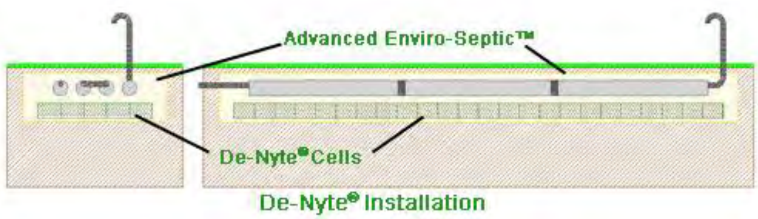

Figure AP2-8 Presby Advanced Enviro-Septic® Treatment System and De-Nyte® for Nitrogen Removal (Presby Environmental, 2018)

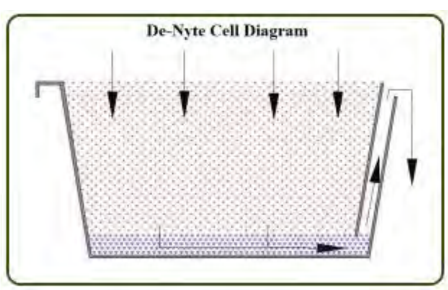

Figure AP2-9 Presby De-Nyte® Cell (Presby Environmental, 2018)

Advantages

- With De-Nyte®, total nitrogen removal is expected to be up to 75%.
- Passive system that does not need electricity. There are no moveable parts and no replaceable media.
- Enhanced treatment and disposal of wastewater are combined in this system.

Limitations

- This technology is relatively new to Hawaii, so a robust inspection and sampling program would be necessary.

Virtually no maintenance of the system is needed, but routine inspections and pumping of the upstream septic tank will be necessary.

5. Approval Required under Hawaii Administrative Rules

5.1. Evapotranspiration

Evapotranspiration (ET) combines direct evaporation and plant transpiration for wastewater disposal. Pretreated effluent (usually an ATU) is conveyed to a porous bed containing water-tolerant plants (Figure AP2-10). Wicking, or capillary action, draws water to the surface, where it is either taken up by the plants and transpired, or evaporated from the surface. Effluent that is not transpired or evaporated will percolate from the bottom of the bed. This type of system is known as evapotranspiration-infiltration (ETI).

These systems can also be designed with an underlying impermeable liner for a "zero-discharge" system. In this case, disposal is strictly dependent on evaporation and plant transpiration. Additionally, the liner allows the system to be placed above an Underground Injection Control (UIC) line or where there is shallow groundwater or proximate surface water such as a stream, lake or the ocean.

Other components that are typically included are drip or distribution lines, flushing or filtering mechanism, controller to automate dosing cycles, distribution pump, and alternating ET beds.

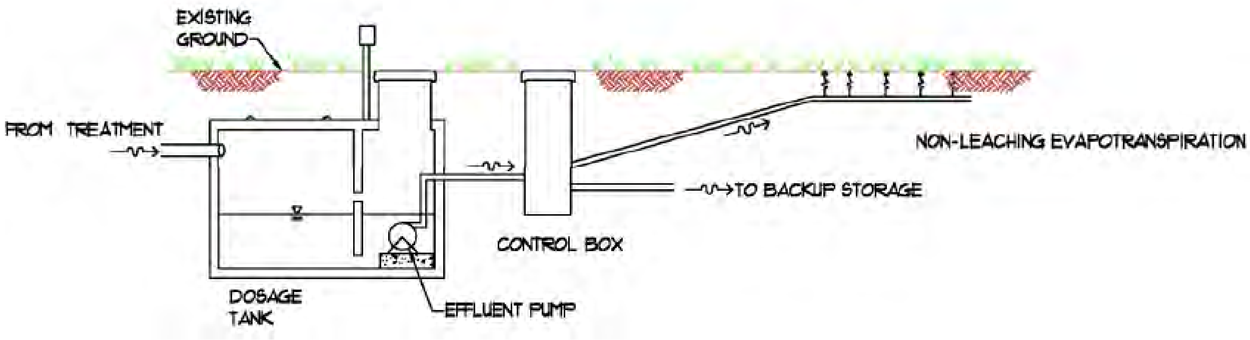

Figure AP2-10 Profile of Typical ET System

Advantages

- If an impermeable liner is included for a "zero-discharge" system, then 100% nitrogen removal is achieved.

Limitations

- Large surface areas are needed for year-round disposal. The size is controlled by a water balance based on rainfall and pan evaporation rates
- ET systems are more effective in arid climates where evaporation rates are much higher than precipitation rates.
- Recordkeeping of lysimeter (soil pore water sampler) data is required to ensure proper functioning.

O&M tasks will include simple inspection of observation wells, electrical costs for pumping, as needed, minor landscaping, and maintaining upstream processes to avoid overflow of solids into the ET bed.

5.2. Recirculating Sand Filter

Treated effluent is pressure distributed (such as by spray nozzles) to the top of a bed of sand, which is biologically treated as it percolates through (Figures AP2-11 and AP2-12). Carbon oxidation nitrification and denitrification can all occur. A portion of the water is pumped back to the pump chamber or the treatment process, and another portion passes on to a dispersal system such as drip irrigation or a seepage pit. The nitrate in the recirculated water undergoes denitrification under anaerobic conditions (Barnstable County Department of Health and Environment, 2018).

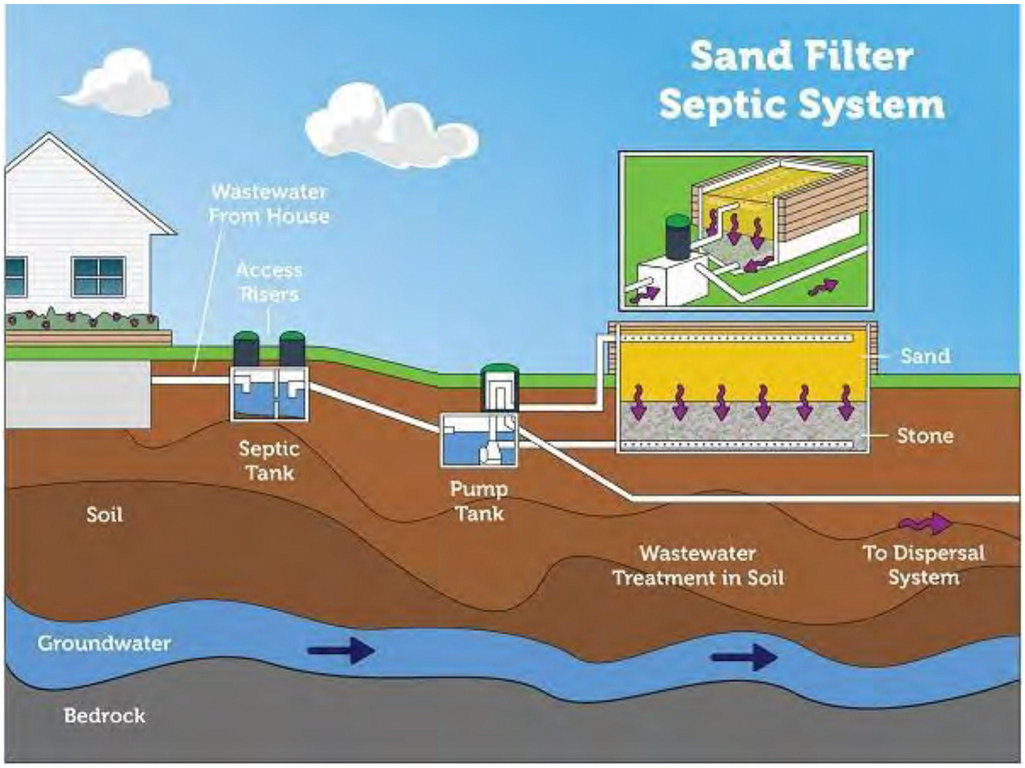

Figure AP2-11 RSF with Primary Treatment by Septic Tank (United States Environmental Protection Agency, 2018)

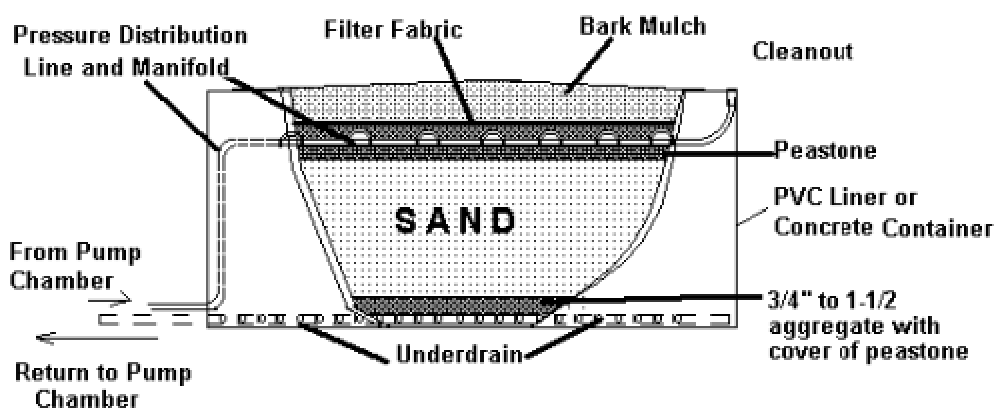

Figure AP2-12 Profile of RSF

Advantages

- RSFs can remove up to 50% total nitrogen.

Limitations

- Large land area may be required.
- Filters need to be covered to protect against odor, debris, algae fouling, and precipitation.
- A pump is needed for recirculating the wastewater.

Operational costs include electricity and labor. The filter should be inspected every 3 to 4 months, and the top layer of the filter media should be removed and replaced periodically.

6. Innovative Technologies

6.1. Constructed Wetland

A constructed wetland recreates the processes that occur in their natural environment. They may have visible water pools, however, those used as OSDSs typically keep wastewater flow beneath the media surface. This limits potential contact with wastewater and associated public health concerns. In general, the constructed wetland is an earthen basin or cell containing microorganisms, porous media, and plants (Figure AP2-13). The influent may be gravity-fed or pressure-dosed. The wastewater flows through the wetland and undergoes filtration, nitrification, denitrification, and adsorption. Longer detention times help to improve quality of the leaving effluent (Texas A&M AgriLife Extention Service).

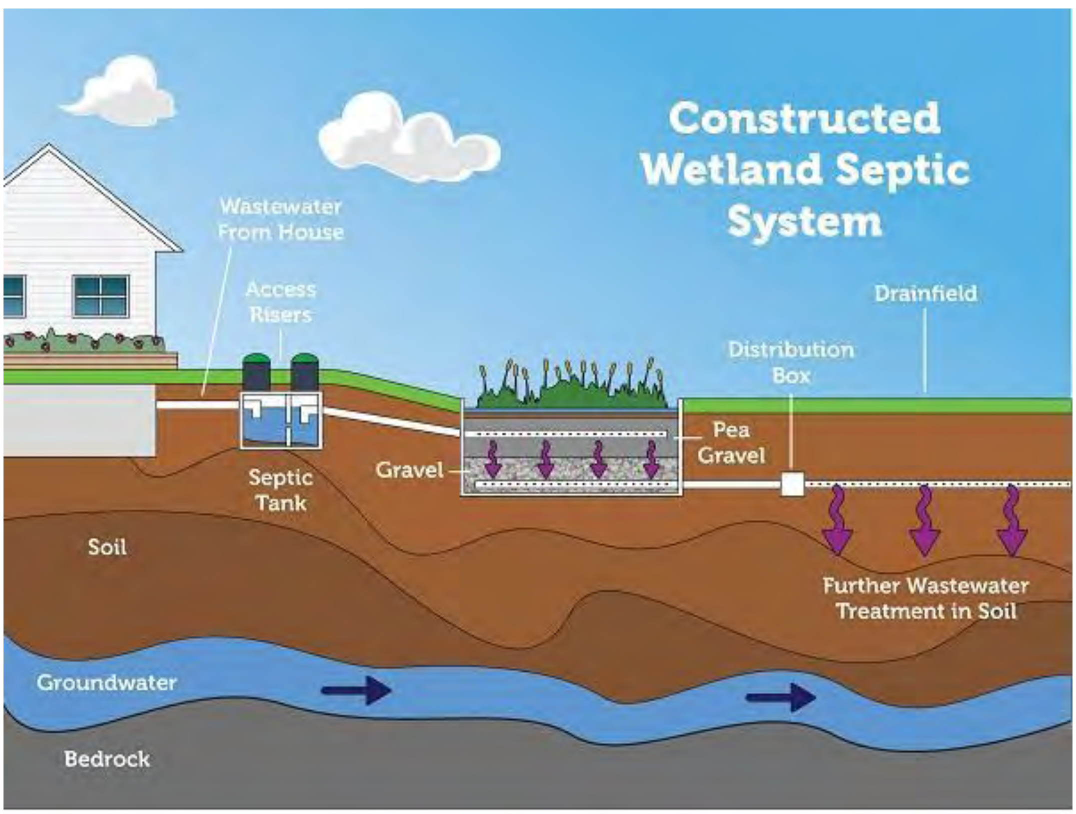

Figure AP2-13 Constructed Wetland with Primary Treatment by Septic Tank (United States Environmental Protection Agency, 2018)

Advantages

- A constructed wetland provides suitable conditions for denitrification to occur.
- Power is not required to operate a wetland.

Limitations

- Large land area may be required.
- It is important to maintain an even cross-sectional flow throughout the constructed wetland.
- The water level should be maintained in the cell during low- or no-flow periods so that the plants do not die.

The constructed wetland should be properly maintained to prevent surface ponding. Frequent inspection of the vegetation, inlet distributor, liner, berms or retaining walls, pumps, if present, and drainfield is required.

6.2. Drip Irrigation

This method of wastewater disposal uses a pump dosed system of pipes containing emitters (generally spaced every 12 inches) to deliver treated wastewater into the shallow root zone of the soil for dispersal (Figures AP2-14 and AP2-15). This allows for rates to be slow and controlled, as the dispersal system serves as both a slow rate biofilter and an ET system. The loading rate depends on soil characteristics, such as permeability, rainfall, evaporation, evapotranspiration rates, and level of nutrients (Sinclair, Rubin, & Otis, 1999).

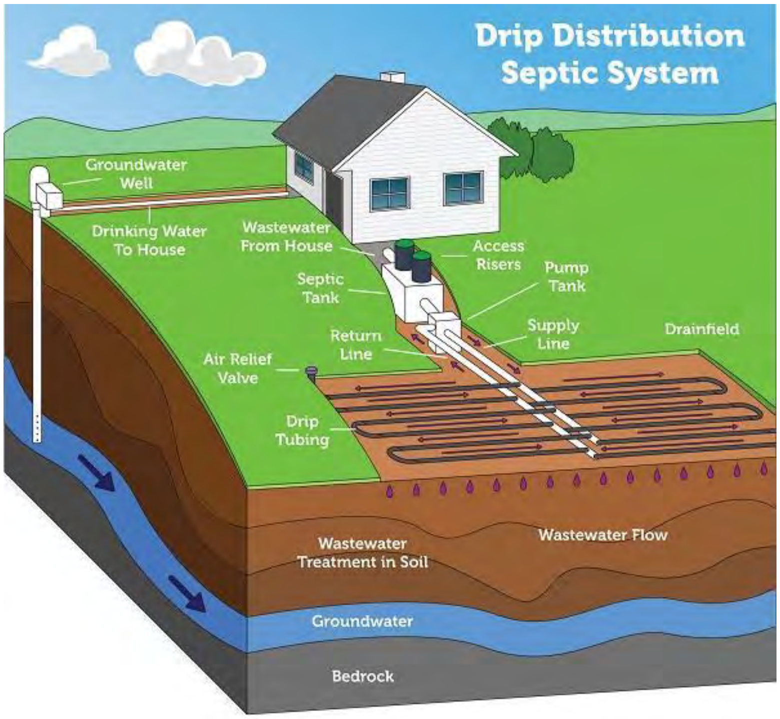

Figure AP2-14 Drip Irrigation System Shown with Septic Tank Treatment (United States Environmental Protection Agency, 2018)

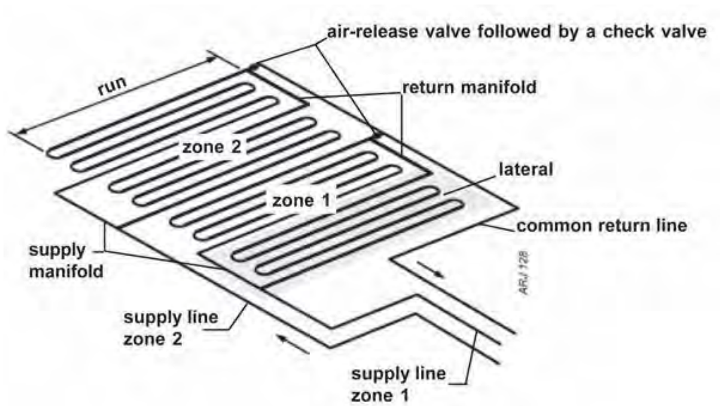

Figure AP2-15 Drip Irrigation Zones (Jarrett, 2008)

Advantages

- Reliable alternative for areas with low permeability, seasonal high water tables, or severe slopes.
- Ability to control dose/rest cycles allows for even spacing or dosing of effluent and facilitates wastewater infiltration by spreading it spatially and temporally.

Limitations

- In some cases, a large dose tank is needed to accommodate timed dose delivery to the drip absorption area.

6.3. Eliminite

This is a denitrifying septic system with two 1,500-gallon concrete tanks. As depicted in Figure AP2-16, the Eliminite system uses patented, proprietary treatment media called MetaRocks® to remove nitrogen. MetaRocks® provide a surface for nitrifying and denitrifying bacteria to thrive. The first 1,500-gallon tank is used as a septic tank, and the second tank has two chambers to house the MetaRocks® and provide BOD, TSS, and nitrogen removal. The Eliminite system is followed by a disposal system such as absorption or seepage pit. (Buzzards Bay Coalition, West Falmouth Village Association, Barnstable County Department of Health and the Environment, 2017) (Eliminite, Inc., 2018).

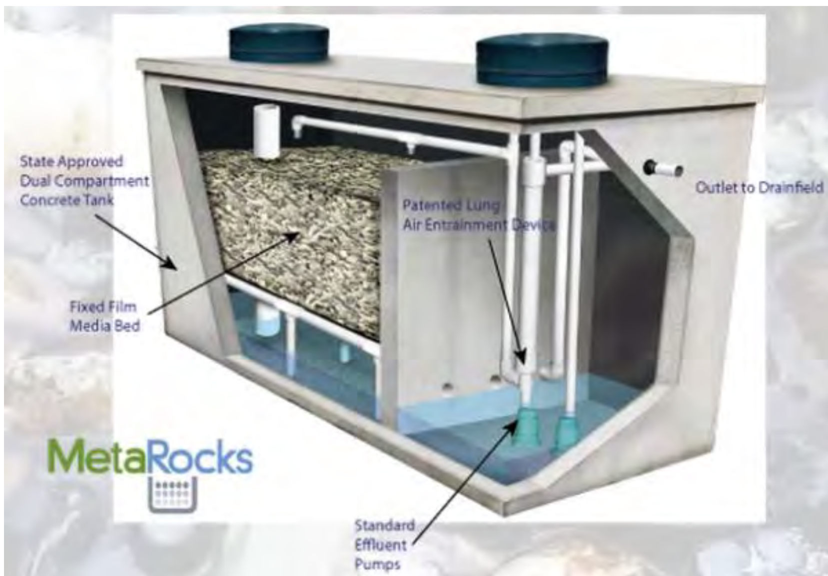

Figure AP2-16 Nitrogen Reduction by Eliminite's MetaRocks® (Eliminite, Inc., 2018)

Advantages

- Average total nitrogen removal is expected to be 62%.
- If a home already has a 1,500-gallon septic tank, then only one additional treatment tank is needed.

Limitations

- Pump operation and electrical power are needed.
- This technology is new to Hawaii, so a robust inspection and sampling program would be necessary.

6.4. NITREX

NITREX™ reactive media is contained in a tank that receives nitrified wastewater effluent. As depicted in Figure AP2-17, a typical setup includes wastewater sequentially passing through a septic tank, a nitrifying sand filter, the NITREX™ denitrifying filter tank, and then an absorption bed or trench for disposal. The NITREX™ media can also be placed in a lined excavation instead of a tank. The sand filter serves as a necessary nitrification step so that the NITREX™ can perform denitrification on nitrate-rich effluent (Lombardo Associates, Inc., 2018).

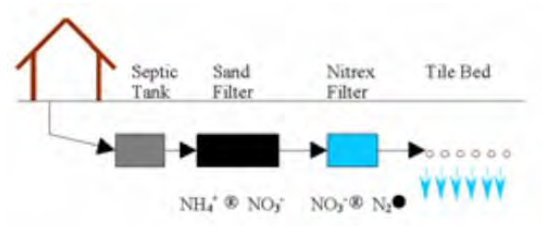

Figure AP2-17 Nitrogen Reduction by NITREX™ Filter (Lombardo Associates, Inc., 2018)

Advantages

- Average total nitrogen removal is expected to be up to 97%.
- There is no pumping or chemical addition requirement.
- The NITREX™ media has an expected performance period of 50 years.

Limitations

- This technology is new to Hawaii, so a robust inspection and sampling program would be necessary.

Virtually no maintenance of the system is needed, but routine inspections and pumping of the upstream septic tank will be necessary.

7. Emerging Technologies for Wastewater Treatment and Disposal

Various alternative methods have been investigated via extensive studies in other states. While these have been tested in limited setups and show potential in usability and effectiveness, their adaptability to Hawaii in general and Upcountry Maui conditions specifically, need to be assessed. Based on their promising results in preliminary studies, they are included as cesspool conversion options. Assumptions for site constraints and costing are based on the test study conditions and may vary significantly for Upcountry Maui.

7.1. Passive Nitrogen Reduction

The Washington State Department of Health and the University of Washington, Florida Department of Health, Barnstable County Department of Health, the New York State Center for

Clean Water Technology and Stony Brook University completed investigations of systems that operate relatively passively, with limited reliance on pumping, controls, and forced aeration (Hazen and Sawyer, 2014). Section 7.1.1 includes the technologies developed in Washington. The following Sections 7.1.2, 7.1.3, 7.1.4, and 7.1.5 describe methods based on full-scale prototype systems tested by the Florida Department of Health. Section 7.1.6 introduces another passive system designed by Barnstable County Department of Health. Sections 7.1.7 and 7.1.8 include setups by the New York State Center for Clean Water Technology and Stony Brook University that are currently being tested. Section 7.1.9 presents a selection of proprietary methods developed by onsite wastewater system manufacturers.

7.1.1. Recirculating Gravel Filter Systems

Each of these systems is based on a two-step process:

1) Under aerobic conditions, the effluent undergoes nitrification.
2) Under anaerobic conditions, denitrification occurs (Washington State Department of Health and University of Washington Civil and Environmental Engineering Department, 2012).

7.1.1.1. Recirculating Gravel Filter with Vegetated Woodchip Bed System

This system would be placed following a septic tank. Effluent could be transferred to an absorption bed or trench. There are three zones in this system, with effluent continually circulated through the first two zones. With each circulation cycle, a portion of the nitrified effluent is released to the third zone for denitrification. The different zones are denoted by numbers in circles in Figure AP2-18.

Zone 1: The septic tank effluent flows into the recirculating tank. As the effluent level rises in the tank, a float activates a timer to control a pump. The pump sends timed doses of effluent to the recirculating gravel filter in Zone 2.

Zone 2: The wastewater flows down through the gravel, and ammonia is converted to nitrate. The nitrified effluent exits through a slotted pipe at the bottom and about 80% flows back to the recirculating tank in Zone 1 with 20% flowing to Zone 3.

Zone 1 (repeated cycle): The nitrified effluent from Zone 2 mixes with additional septic tank effluent. Serving as a carbon source for bacteria, the septic tank effluent allows for some denitrification to occur here. The effluent is then pumped to Zone 2 to repeat the process.

Zone 3: This is a vegetated woodchip bed with constant submergence of the woodchips to create an anoxic zone. The bed can also be described as an anoxic subsurface constructed wetland. Denitrification occurs as the effluent flows horizontally through the bed. Plants such as cattails can also provide increased nitrate removal, as well as provide another carbon source. Finally, effluent from this zone would be transferred to a water level control basin and then a leach field (absorption bed or trench) (Washington State Department of Health and University of Washington Civil and Environmental Engineering Department, 2012).

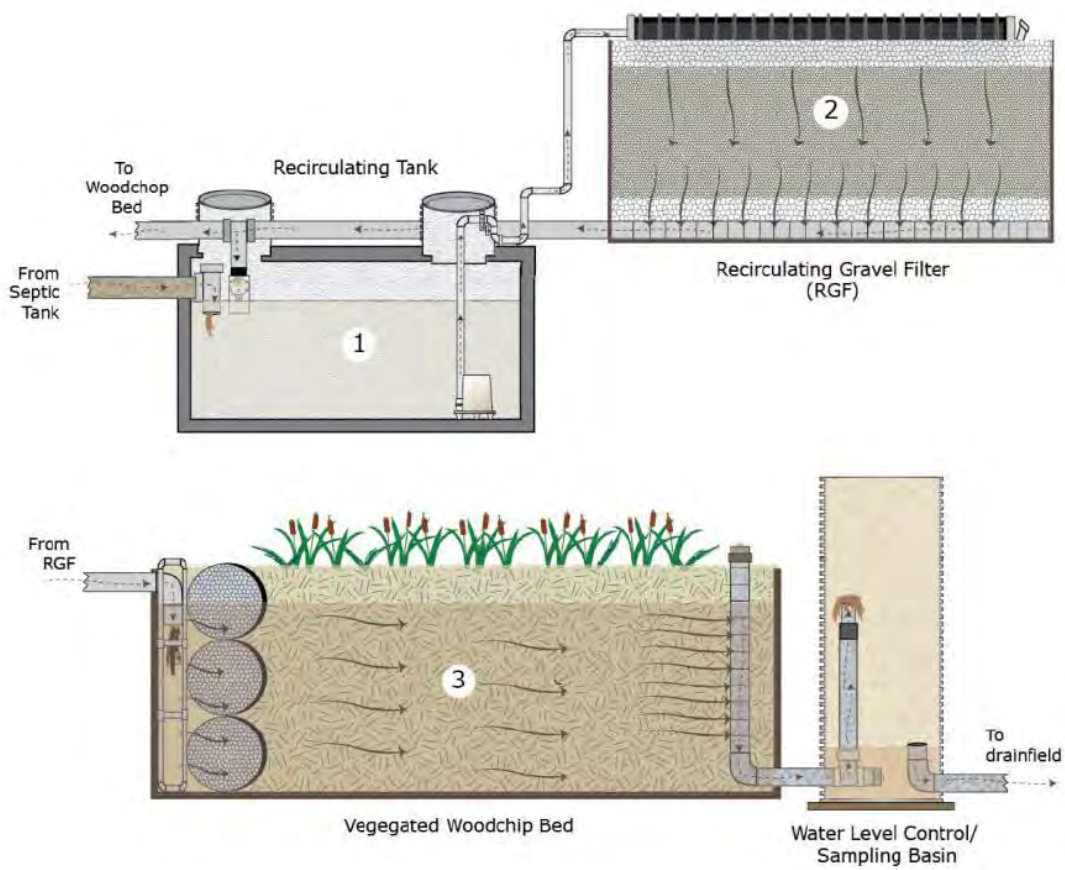

Figure AP2-18 Recirculating Gravel Filter with Vegetated Woodbed System (Washington State Department of Health and University of Washington Civil and Environmental Engineering Department, 2012)

Advantages

- Average total nitrogen removal was 92%.
- Local materials may be used for the woodbed media.

Limitations

- Pump operation and electricity are needed for the recirculation system.

Routine inspections should include the pump and control panel, adequacy of dosage frequency, and effluent filter on the septic tank outlet. The septic tank should also be maintained to ensure proper functioning of the subsequent treatment and disposal steps (Washington State Department of Health and University of Washington Civil and Environmental Engineering Department, 2013).

7.1.1.2. Enhanced Recirculating Gravel Filter System

This system is also designed to follow a septic tank and discharge to an absorption bed or trench. It can also be described of as a recirculating vertical-flow constructed wetland. As shown in Figure AP2-19, nitrification is to take place in the oxygen-rich top layer, and denitrification is to take place in the oxygen-free bottom layer. There are three zones, as shown by the numbers in circles in Figure AP2-19.

Zone 1 (beginning cycle): Septic tank effluent enters a mixing chamber at the bottom of the filter system. This chamber contains an anoxic gravel layer and organics in the wastewater are oxidized. The effluent continues to travel upwards through a slotted pipe, entering Zone 2.

Zone 2: This is a recirculating basin with a level-activated timer that controls a pump to send times doses to the filter bed in Zone 3.

Zone 3: In this oxygen-rich zone, wastewater is distributed into an oyster shell layer, which serves as a food source for Zone 3 bacteria. The wastewater continues to percolate down into a fine gravel layer, where nitrification occurs. The nitrified effluent then passes through a slotted pipe and is pumped back to the mixing chamber in Zone 1.

Zone 1 (repeated cycle): The mixing chamber now contains septic tank effluent and nitrified effluent. This mixture continues into the anoxic gravel layer in Zone 2 and denitrification occurs under these circumstances.

Zone 2 (repeated cycle): The process is repeated with doses sent to Zone 3, and as the recirculating tank fills to a certain level, the denitrified effluent is discharged to a leach field (absorption bed or trench) (Washington State Department of Health and University of Washington Civil and Environmental Engineering Department, 2012).

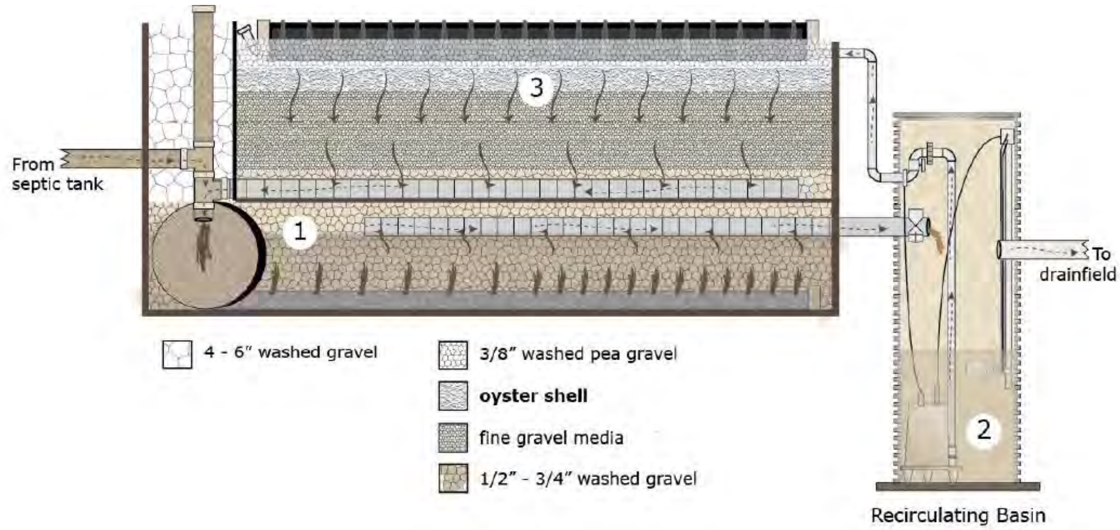

Figure AP2-19 Enhanced Recirculating Gravel Filter System (Washington State Department of Health and University of Washington Civil and Environmental Engineering Department, 2012)

Advantages

- Average total nitrogen removal was 82%.
- Local materials may be used for media.

Limitations

- Pump operation and electricity are needed for the recirculation system.
- Clogging occurred in the anoxic zone feed distribution piping. Further studies are needed for methods to prevent this.

Routine inspections should include the pump and control panel, adequacy of dosage frequency, and effluent filter on the septic tank outlet. The septic tank should also be maintained to ensure proper functioning of the subsequent treatment and disposal steps (Washington State Department of Health and University of Washington Civil and Environmental Engineering Department, 2013).

7.1.1.3. Vegetated Recirculating Gravel Filter System

This is similar to the enhanced recirculating gravel filter system, with nitrification occurring in the oxygen-rich top layer and denitrification occurring in the oxygen-free bottom layer. There are three zones, as shown in Figure AP2-20. Denitrification takes places after a complete cycle and effluent flows a second time through Zone 1.

Zone 1(beginning cycle): The system receives septic tank effluent. The effluent enters a gravelless chamber at the bottom of the filter system and then continues into the gravel layer of the anoxic Zone 1. Organics are oxidized, and wastewater travels horizontally across to an outlet pipe leading to Zone 2.

Zone 2: This is a recirculating basin with a level-activated time that controls a pump to send timed doses of effluent to the filter bed in Zone 3.

Zone 3: Wastewater is distributed into the oxygen-rich root zone of this vegetated bed. The effluent percolates down through a fine gravel layer, where nitrification occurs. The effluent then flows across a liner and down into an uncovered portion of the bottom gravel layer at the inlet end of the filter in Zone 1.

Zone 1 (repeated cycle): Here, the septic tank effluent and nitrified effluent from Zone 3 mix together and horizontally flow back through the anoxic gravel layer for denitrification to occur.

Zone 2 (repeated cycle): The process is repeated in the recirculating basin, and when it fills to a certain level, the denitrified effluent discharges to an absorption bed or trench (Washington State Department of Health and University of Washington Civil and Environmental Engineering Department, 2012).

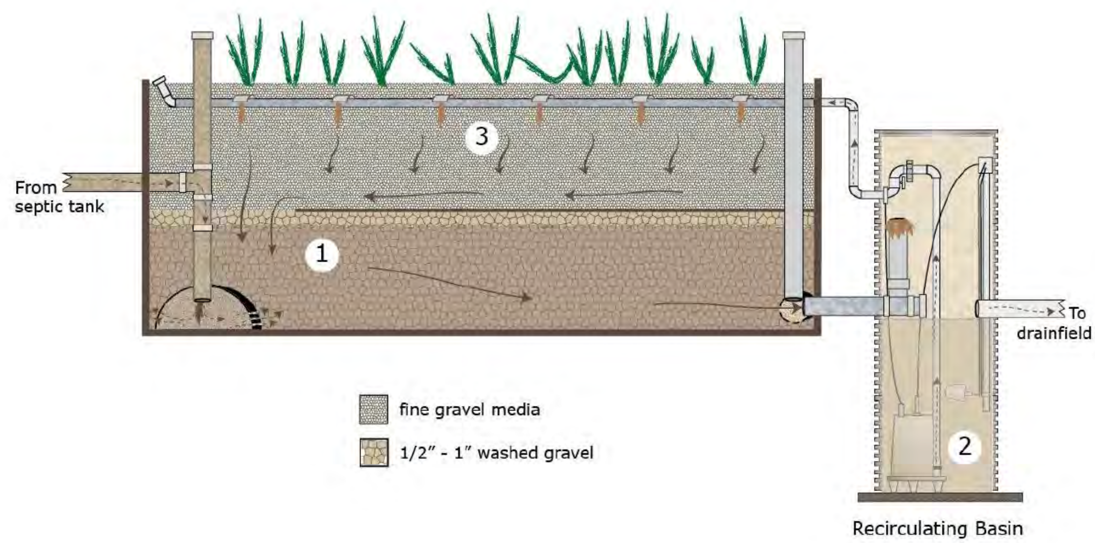

Figure AP2-20 Vegetated Recirculating Gravel Filter System (Washington State Department of Health and University of Washington Civil and Environmental Engineering Department, 2012)

Advantages

- Average total nitrogen removal was 69%.
- Local materials may be used for media.

Limitations

- Pump operation and electricity are needed for the recirculation system.
- Clogging due to plant root growth occurred in orifices of the aerobic bed distribution system. Therefore, plant selection is an important consideration.
- Clogging also occurred in the anoxic zone effluent line, but this was addressed using a filter.

Routine inspections should include the pump and control panel, adequacy of dosage frequency, and effluent filter on the septic tank outlet. The septic tank should also be maintained to ensure proper functioning of the subsequent treatment and disposal steps (Washington State Department of Health and University of Washington Civil and Environmental Engineering Department, 2013).

7.1.2. Treatment by In-Tank Unsaturated Biofilter with Recirculation and Disposal by Soil Treatment Unit

This method is an in-tank approach that treats septic tank effluent with a Stage 1 unsaturated biofilter with recirculation to a recirculation tank, and a soil treatment unit, such as an absorption trench or bed (Figure AP2-21). Stage 1 is a porous media biofilter that is unsaturated, allowing for nitrification to occur. Media that was used in the studies included expanded clay, sand, and oyster shells. Septic tank effluent is applied to the top of the media, resulting in a downward percolation of wastewater over and through the porous media biofilter bed. Due to nitrification, most of the wastewater nitrogen is converted to nitrate (Hazen and Sawyer, 2015).

With recirculation back to an anoxic holding tank, the nitrate-rich effluent is mixed with incoming wastewater. This provides favorable conditions for denitrification, prior to the disposal step (Hazen and Sawyer, 2015).

Advantages

- Total nitrogen removal is expected to be 50 to 70% prior to discharge to the disposal unit.
- Local materials may be used for biofilter media.

Limitations

- Pump operation and electricity are needed for the recirculation system.

Routine inspections (twice a year is required by Florida code) include pump operation and electrical connections, hydraulic inspection, flushing and cleaning of distribution lines, biofilter media life, and the recirculation system. The septic tank should also be maintained to ensure proper functioning of the subsequent treatment and disposal steps.

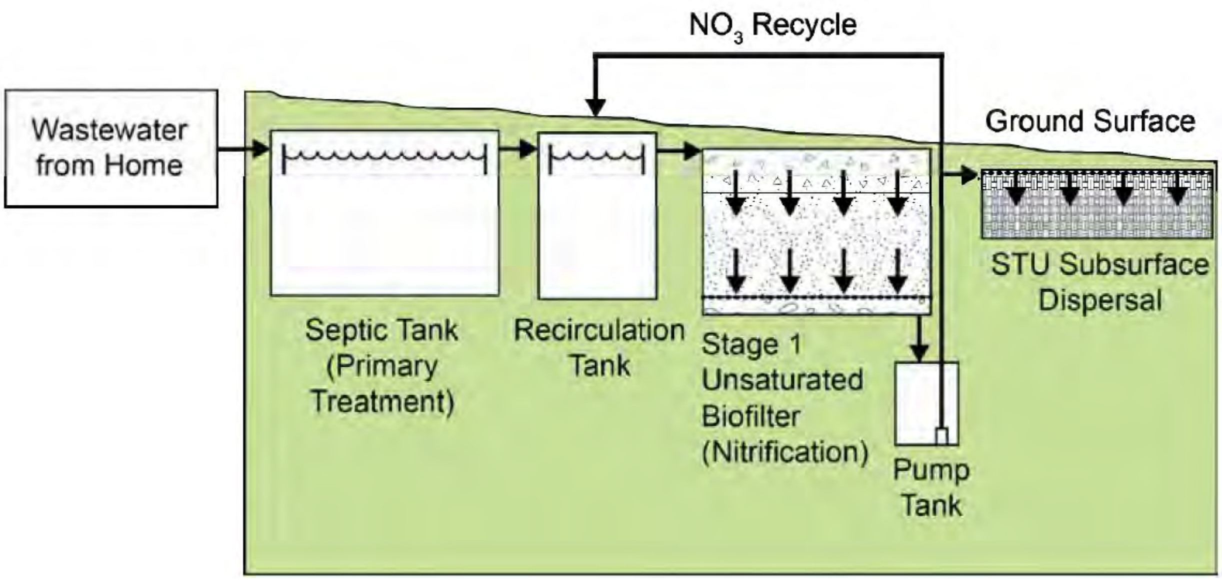

Figure AP2-21 Treatment by In-Tank Stage 1 Unsaturated Biofilter with Recirculation and Disposal by Soil Treatment Unit (Hazen and Sawyer, 2015)

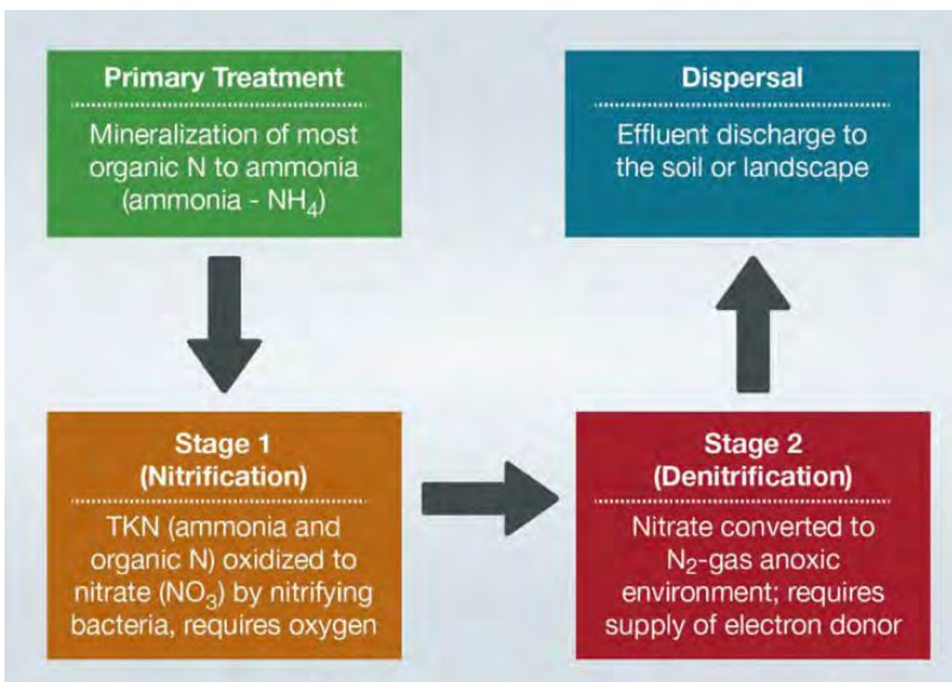

Figure AP2-22 Two-Stage Biofiltration Systems for Nitrogen Reduction (Hazen and Sawyer, 2015)

7.1.3. Treatment by In-Ground Unsaturated Biofilter in Native Soil Underlain by Saturated Biofilter in Liner and Disposal by Overflow into Surrounding Soil

Similar to the previously described system, this is an in-ground (non-tank confined) variation that treats septic tank effluent which is dosed at low pressure to an in-ground Stage 1 unsaturated biofilter in native soil. The Stage 1 biofilter is underlain by a Stage 2 lignocellulosic biofilter in a lined bed. The effluent is allowed to overflow the liner into surrounding soil. As shown in Figure AP2-23, nitrification occurs in Stage 1. Afterwards, the nitrate-rich water travels to the Stage 2 biofilter, which is saturated and therefore an anoxic environment suitable for denitrification. Studies have identified fine sand and lignocellulosic materials from woody plants as candidate media for Stage 2. Elemental sulfur was also tested as a media, although this type of media is more difficult to obtain and manage.

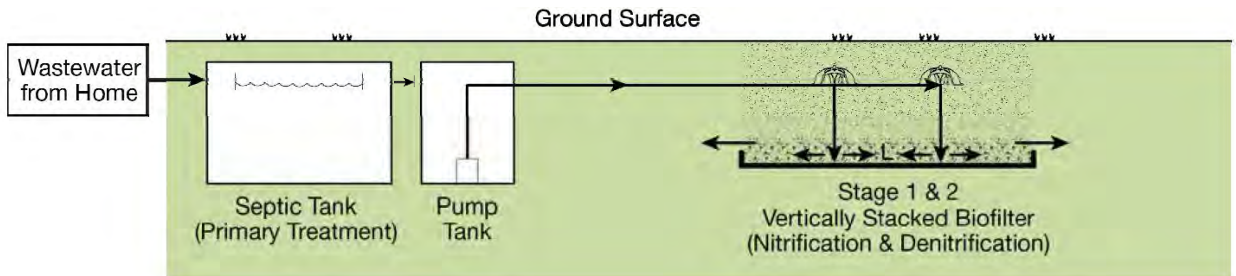

Figure AP2-23 Treatment by In-Ground Unsaturated Biofilter in Native Soil Underlain by Saturated Biofilter in Liner and Disposal by Overflow into Surrounding Soil (Hazen and Sawyer, 2015)

Advantages

- Total nitrogen removal is expected to be 50 to 70% prior to discharge from the system into the underlying soil for percolation disposal.
- Local materials may be used for biofilter media.

Limitations

- Pump operation and electricity are needed for the low pressure dosing system.

Routine inspections (twice a year is required by Florida code) include pump operation and electrical connections, hydraulic inspection, flushing and cleaning of distribution lines, biofilter media life, and the recirculation system. The septic tank should also be maintained to ensure proper functioning of the subsequent treatment and disposal steps.

7.1.4. Treatment by Single Pass or Recirculating Unsaturated Biofilter and Saturated Biofilter and Disposal by Soil Treatment Unit

This system also treats septic tank effluent via secondary treatment in a Stage 1 unsaturated biofilter and Stage 2 saturated biofilter. The denitrified effluent is then disposed of in an absorption bed or trench.

The Stage 1 biofilter hydraulics can be either single pass or recirculation (Figures AP2-23, AP2-24, and AP2-25). In Figure AP2-23, the pump tank can be run either with single pass or with a recycle stream for internal recirculation to spray nozzles located above the surface of the Stage 1 media. If topography allows for flow through the biofilters by gravity, then the system can be setup as in Figure AP2-24.

The Stage 2 biofilters can contain single or dual media, such as lignocellulosic/sand mixture and elemental sulfur.

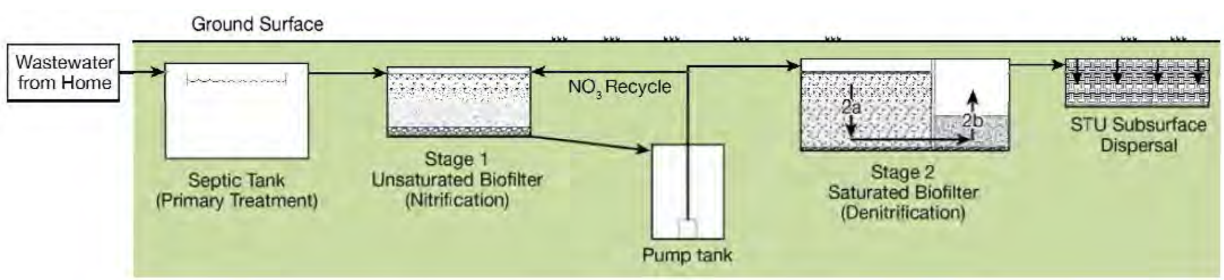

Figure AP2-23 Treatment by Recirculating Unsaturated Biofilter and Saturated Biofilter and Disposal by Soil Treatment Unit (Hazen and Sawyer, 2015)

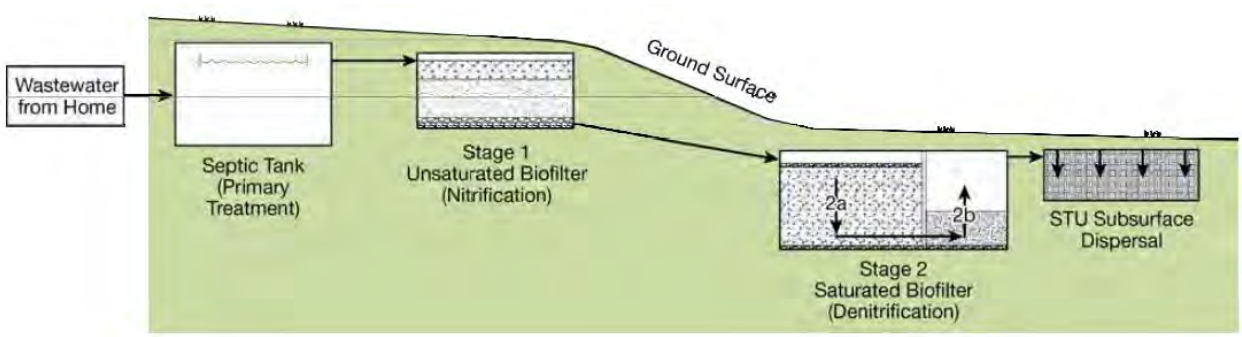

Figure AP2-24 Treatment by Gravity-Flow Single Pass Unsaturated Biofilter and Saturated Biofilter and Disposal by Soil Treatment Unit (Hazen and Sawyer, 2015)

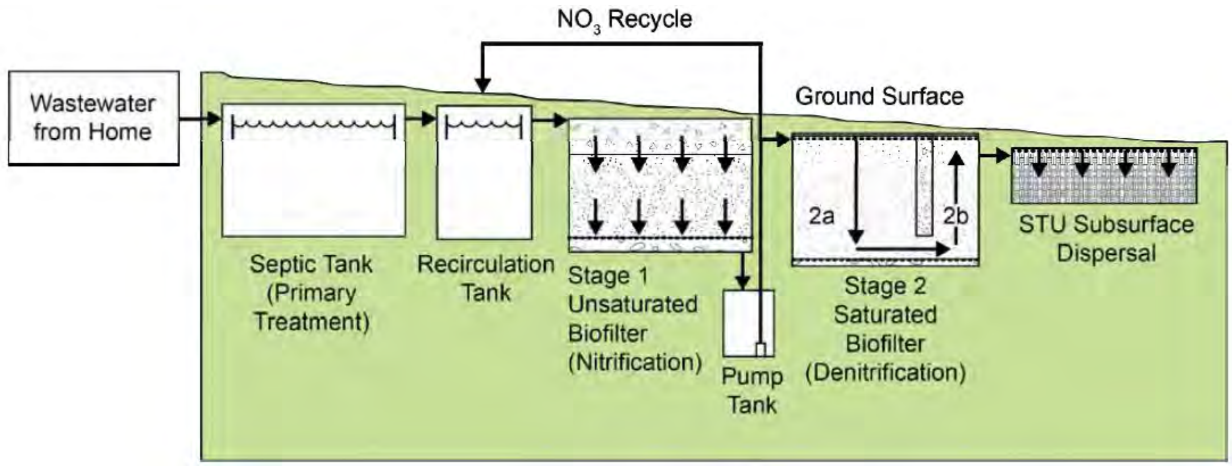

Figure AP2-25 Treatment by Recirculating Unsaturated Biofilter and Saturated Biofilter and Disposal by Soil Treatment Unit (Hazen and Sawyer, 2015)

Advantages

- Total nitrogen removal is expected to be 85 to 95% prior to discharge to the soil absorption system.
- Local materials may be used for biofilter media.

Limitations

- Pump operation and electricity will be needed if a recirculation system is included.

Routine inspections (twice a year is required by Florida code) include pump operation and electrical connections, hydraulic inspection, flushing and cleaning of distribution lines, biofilter media life, and the recirculation system. The septic tank should also be maintained to ensure proper functioning of the subsequent treatment and disposal steps.

7.1.5. Treatment by Unsaturated and Saturated Biofilter in Liner and Optional Second Saturated Biofilter and Disposal by Soil Treatment Unit

This is an in-ground variation of the previously described in-tank based system. Here, septic tank effluent is treated in a Stage 1 unsaturated biofilter stacked on a Stage 2 saturated biofilter. The effluent can continue to another Stage 2 saturated biofilter for further denitrification, or to a soil absorption system. Figure AP2-26 shows the additional Stage 2 filter and a drip irrigation soil treatment unit (Hazen and Sawyer, 2015).

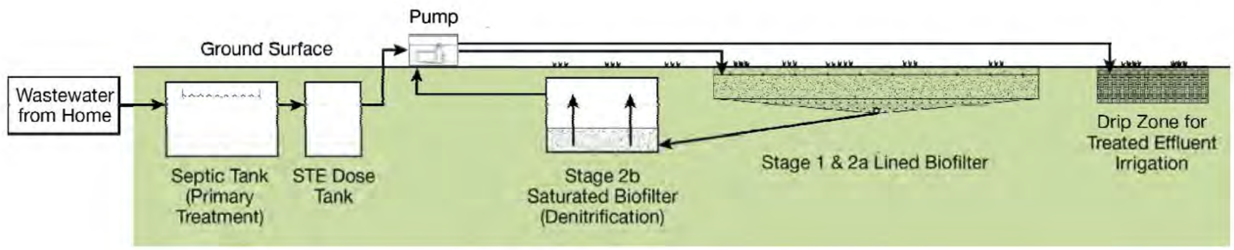

Figure AP2-26 Treatment by Unsaturated and Saturated Biofilter in Liner and Second Saturated Biofilter and Disposal by Drip Irrigation (Hazen and Sawyer, 2015)

Advantages

- Total nitrogen removal is expected to be 85 to 95% prior to discharge to the soil sbsorption system.
- Local materials may be used for biofilter media.

Limitations

- Pump operation and electricity will be needed if a recirculation system is included.

Routine inspections (twice a year is required by Florida code) include pump operation and electrical connections, hydraulic inspection, flushing and cleaning of distribution lines, biofilter media life, and the recirculation system. The septic tank should also be maintained to ensure proper functioning of the subsequent treatment and disposal steps.

7.1.6. Disposal by Layered Soil Treatment (“Layer Cake”) Systems

The layer cake system treats septic tank effluent in a modified absorption bed or trench (Figure AP2-27). The modified leach field is a “layer cake” filtration system of 18 inches of sand and 18 inches of a sand and sawdust (or woodchips) mixture. The sand supplies oxygen for nitrification to occur, and the sand and sawdust mixture create an anaerobic environment for denitrification (Hilsman, 2016).

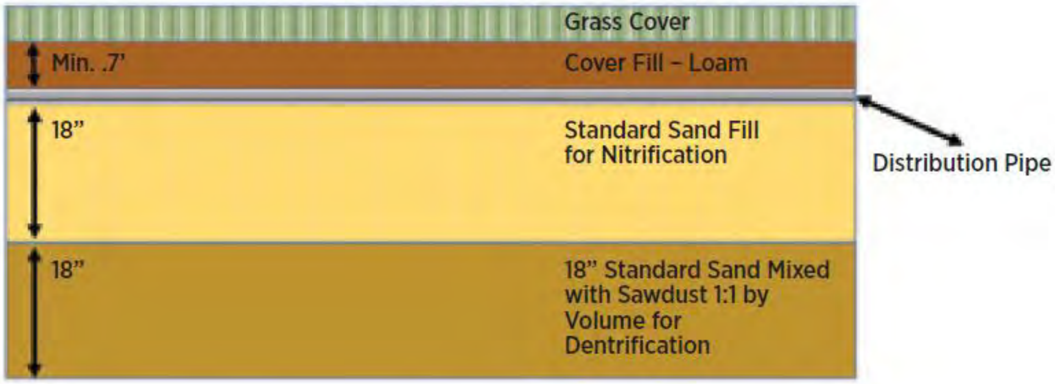

Figure AP2-27 Disposal by "Layer Cake" System (Buzzards Bay Coalition, West Falmouth Village Association, Barnstable County Department of Health and the Environment, 2017)

Advantages

- Total nitrogen removal is expected to be at least 50% and up to 90%.
- Local materials may be used for filter media.
- Low operating and maintenance requirements.

Limitations

- Pump operation and electricity may be required for conveying wastewater to the modified leach field if gravity cannot be utilized.
- The replacement interval of the sawdust/woodchips is unknown, but estimated at 50-70 years.

The septic tank and pump should be routinely inspected for proper functioning.

7.1.7. Disposal by Lined Nitrification/Denitrification Biofilter

Septic tank effluent is transferred through a low pressure distribution system comprised of a low energy pump and parallel, low pressure dosing pipes with drilled orifices (similar to an absorption bed). As the wastewater percolates down, it infiltrates the lined nitrification/ denitrification biofilter underlying the pipes. Nitrification and denitrification occur in the sand and sand/lignocellulose layers, respectively.

One configuration of the biofilter is a 6- to 8-inch soil cover, followed by a 12- to 18-inch nitrifying sand layer, and then a 12- to 18-inch sand and sawdust layer, as shown in Figure AP2-28. The system is lined to maintain saturation conditions and to allow effluent discharge to a dispersal system. An alternative configuration is presented in Figure AP2-29, where the denitrification step is designed in an upflow mode. This removes the need for an underdrain for effluent collection, and the effluent is simply discharge through overflow of the system (The New York State Center for Clean Water Technology, Stony Brook University, 2016).

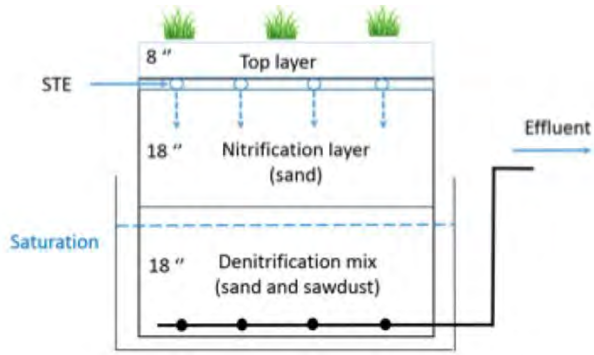

Figure AP2-28 Disposal by Lined Nitrification/Denitrification Biofilter (The New York State Center for Clean Water Technology, Stony Brook University, 2016)

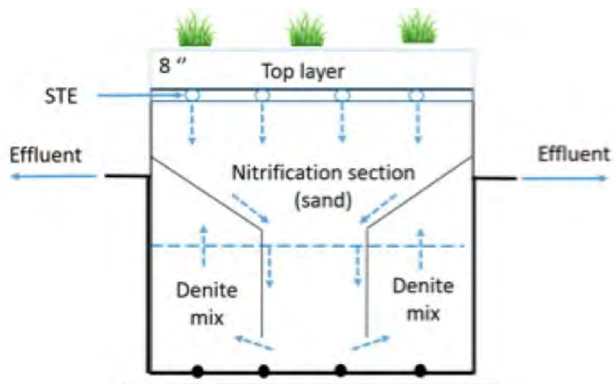

Figure AP2-29 Disposal by Lined Nitrification/Denitrification Biofilter with Denitrification Upflow Step (The New York State Center for Clean Water Technology, Stony Brook University, 2016)

Advantages

- Total nitrogen removal is expected to be up to 90%.
- Lined bottom provides more controllable system for sampling and monitoring.
- Processes are primarily driven by gravity and capillary forces.
- Saturated nature of sand and sawdust layer should minimize oxidation and degradation of the wood source over time.
- Local materials can be used for the biofilter media.

Limitations

- Pump operation and electricity needed for conveying septic tank effluent to the system.
- The replacement interval of the sawdust/woodchips is unknown, but estimated at 50-70 years.

The septic tank and pump should be routinely inspected for proper functioning.

7.1.8. Disposal by Sequence Nitrification/Denitrification Biofilter

This setup was designed to address the uncertainty of the wood material lifespan in biofilters. Literature reviews and calculations have indicated that the wood sources should persist for many decades; however, passive nitrogen reduction biofilters have not been in existence for more than a decade. Therefore, the lifespan of these wood sources remains an open question.

Septic tank effluent is transferred through a low pressure distribution system comprised of a low energy pump and parallel, low pressure dosing pipes with drilled orifices (similar to an absorption bed). As the wastewater percolates down, it infiltrates the sequence nitrification/ denitrification biofilter underlying the pipes. In this biofilter, the sand layer is coupled with an upflow woodchip biofilter in a tank that can be refilled as needed. As Figure AP2-30 shows, there is a 12- to 18-inch layer of nitrifying sand, which funnels the nitrified effluent into a collection pipe. Either by gravity or a low pressure pump, the effluent continues into the bottom of a tank filled with saturated woodchips. The effluent is allowed to flow up through the woodchip biofilter and then to a disposal system (such as absorption bed or seepage pit). The woodchip biofilter tank has a lid at the ground surface for easy accessibility to sample or replace woodchips (The New York State Center for Clean Water Technology, Stony Brook University, 2016).

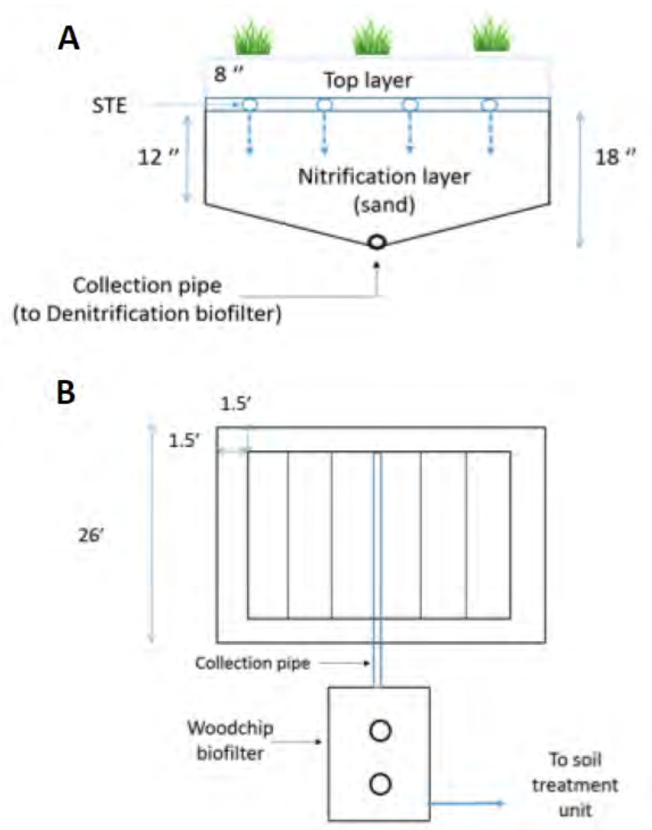

Figure AP2-30 Disposal by Sequence Nitrification/Denitrification Biofilter A) Front View of Nitrification Layer Configuration B) Plan View (The New York State Center for Clean Water Technology, Stony Brook University, 2016)

Advantages

- Total nitrogen removal is expected to be up to 90%.
- Processes are primarily driven by gravity and capillary forces.
- Saturated nature of sand and sawdust layer should minimize oxidation and degradation of the wood source over time.
- Local materials can be used for the biofilter media.
- Woodchip biofilter tank allows for convenient replacement of woodchips.

Limitations

- Pump operation and electricity needed for sending wastewater to the woodchip biofilter tank.

The septic tank and pump, if included, should be routinely inspected for proper functioning.

8. Alternative Toilets

Recently, alternative toilets with zero discharge of water have been developed for use in remote locations lacking water and/or electricity. It is important to note that in the State of Hawaii, household graywater (discharges that are *not* from toilets and kitchen sinks) systems are currently required to have an overflow pathway to a wastewater treatment and disposal system, as shown in Figure AP2-31 (Hawaii State Department of Health, 2009). Therefore, a household with an alternative toilet and a graywater reuse system for other sources of water must still have a wastewater treatment and disposal system.

Alternative toilet options include composting, incinerating, chemical, and oil flush toilets. The most commonly seen are compost toilets and incinerating toilets, which are discussed below. There has also been a recent exponential growth in alternative toilets research and a promising candidate is presented in this report.

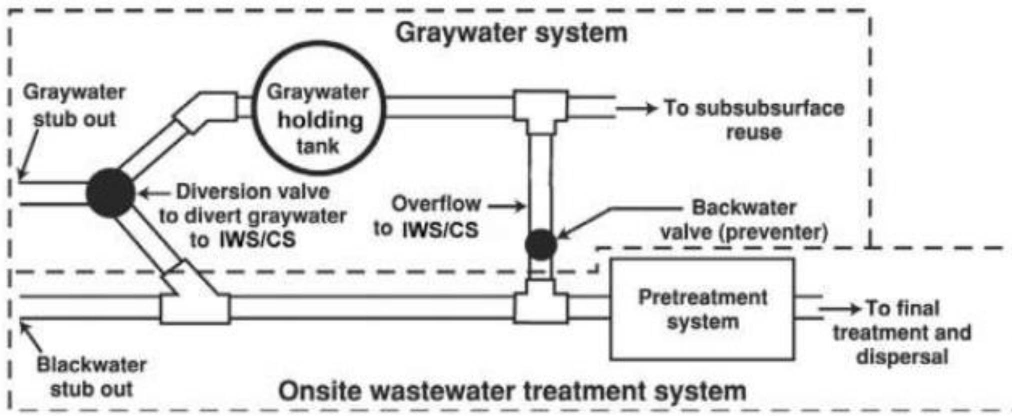

Figure AP2-31 Onsite Wastewater Treatment and Disposal Requirement for Graywater System (Hawaii State Department of Health, 2009)

8.1. Composting Toilet

A typical composting toilet (Figure AP2-32), is comprised of a composting reactor tank or bin connected to one or more waterless toilets in the house. For very small families, there are self-contained units with the compositing bin immediately under the toilet seat. Daily residential use may overload these smaller systems, so extra capacity may be necessary. Alternatively, a centralized tank reactor could be located in a basement or underground structure adjacent to the house. This may contain a rotating drum or could be built on a slope with fresh wastes at the top as the bottom of the pile ages. The reactor tank or bin contains and controls the decomposition of excrement, toilet paper, and carbon-based bulking agents such as wood chips, straw, hay, or grain hulls. Bulking agent materials break down quickly to prevent buildup of aerobic bacteria and fungi. Composting reactor tanks or bins may be single-chambered, continuous process, or multi-chamber batch units (National Small Flows Clearinghouse, 2000). The owner must remove and dispose of aged compost, turn the composting waste, and replenish bulking agents and odor control fluid (if desired)

No other liquid besides urine is present in the bin, allowing for aerobic decomposition of waste. Temperature should be properly maintained between 78 and 113° Fahrenheit for optimal decomposition rates. An exhaust system driven by a fan vents odors, carbon dioxide, and moisture from the reactor bin to the outdoors (the fan could be electricity-driven or a swamp cooler type). The decomposing material needs to be turned periodically to break up the mass and to keep the pile porous and aerated. The final material is about 10 to 30 percent of its original volume and must be properly disposed in accordance with health and environmental regulations (National Small Flows Clearinghouse, 2000).

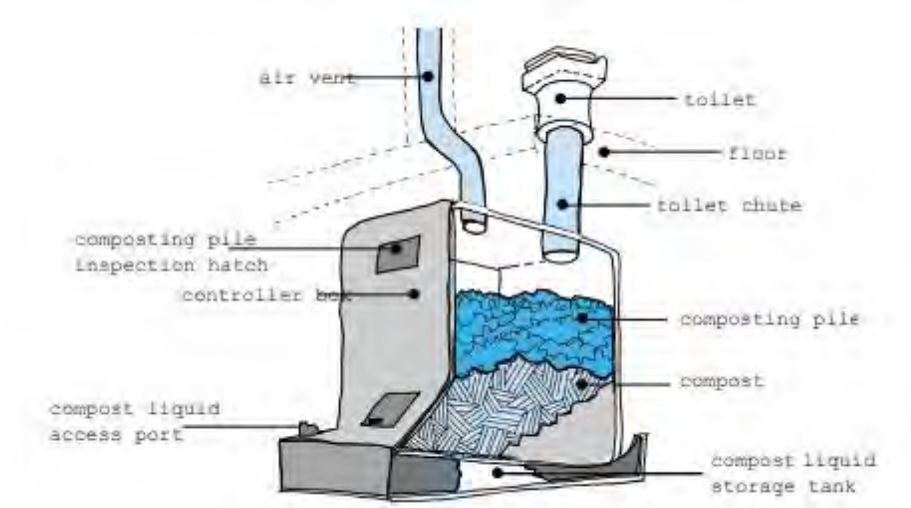

Figure AP2-32 Composting Toilet (National Small Flows Clearinghouse, 2000)

Advantages

- As a zero-discharge system, nitrogen will not be released into the groundwater.
- Since water is not needed for flushing, household water consumption is reduced.
- System consumes very little or no power.
- Residents may be able to install a reduced-size wastewater treatment and disposal system, minimizing costs and disruption to the landscape.

Limitations

- A high level of maintenance is required by the owner, such as periodic turning of the compost, daily addition of bulking agents, handling and disposal of compost, and preventing too much liquid in the composter.
- A power source is generally needed.
- Composting toilets must currently be used in conjunction with a graywater reuse system and wastewater treatment and disposal system in Hawaii.
- Composting excrement may be visible in some systems.
- There can b objectionable odors emitted from these systems.

Owners must be committed to properly maintaining the composting toilet system. Otherwise, removing the end-product and cleaning may be difficult and also cause health hazards and odor problems (National Small Flows Clearinghouse, 2000).

8.2. Incinerating Toilet

These types of toilets use electricity, oil, natural gas, or propane to burn waste to a sterile ash. A typical setup is depicted in Figure AP2-33. A paper-lined upper bowl holds newly deposited waste. The paper liner is replaced after each use. Flushing using a foot pedal causes an insulated chamber cover to lift and swing to the side while the bowl halves separate. The paper liner and its contents deposit into the incinerating chamber. When the foot pedal is released, the chamber cover reseals and the bowl halves close (National Small Flows Clearinghouse, 2000).

A “start” button on the toilet begins the burning process, which occurs after each individual deposit. An electric heating unit cycles on and off for about an hour while a blower motor draws air from the incinerating chamber over a heat-activated catalyst to remove odors. A fan then distributes the air through a vent pipe to the outdoors. The fan is also used to cool the incinerating unit. The entire cycle takes from about 1.5 to 1.75 hours per “flush” or use (National Small Flows Clearinghouse, 2000).

If the incinerating toilet runs on gas, then a toilet bowl is not present, and the waste drops directly into a holding chamber. Prior to the burning process, an anti-foam agent is added to reduce the risk of liquid wastes boiling over. The toilet seat is lifted, and a cover plug is inserted to act as a fire wall (National Small Flows Clearinghouse, 2000).

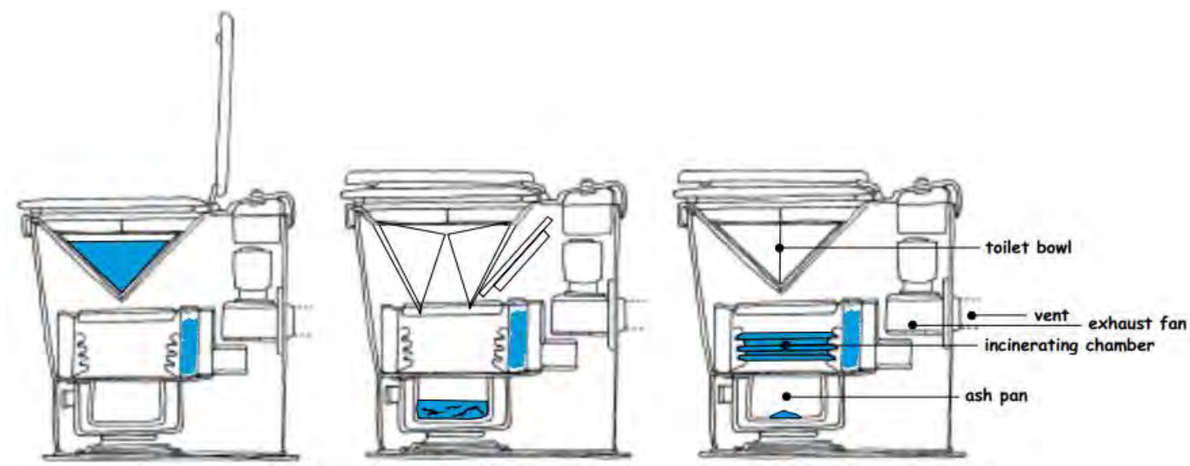

Figure AP2-33 Incinerating Toilet Shown with Seat Cover Up, Seat Cover Down and Incinerating Chamber Opened, and Seat Cover Down and Incinerating Chamber Closed (Left to Right) (National Small Flows Clearinghouse, 2000)

Advantages

- As a zero-discharge system, nitrogen will not be released into the groundwater.
- Since water is not needed for flushing, household water consumption is reduced.

- Residents may be able to install a reduced-size wastewater treatment and disposal system, minimizing costs and disruption to the landscape.

Limitations

- Care must be taken to minimize electrical hazards.
- A power source is needed.
- The toilet cannot be used during the incinerating cycle.
- Incinerating toilets must currently be used in conjunction with a graywater reuse system and wastewater treatment and disposal system in Hawaii.

Maintenance includes regular cleaning and monitoring of the blower, mechanical parts, ash collection pan, upper bowl, and odor-removing catalyst (National Small Flows Clearinghouse, 2000).

8.3. Nano Membrane Toilet

In 2011, the Gates Foundation launched the Reinvent the Toilet Challenge, where scientists, universities, and companies created new toilets that did not require a sewer system to treat human waste. The various inventions were presented at an exposition in November 2018, and one of the promising candidates is the Nano Membrane Toilet (Yu, 2018).

This toilet reportedly will operate without water or a power source. Although it is not clear how it will be self powered. When the toilet lid is closed, a rotating mechanism processes the deposited waste. A "nanostructure membrane" filters out pathogens from the liquid waste. The processed liquid can then be stored as reusable water in an underlying tank. It could be reused at the household level in washing or irrigation applications. Solids are allowed to separate through sedimentation and then burned via a combustor and converted into electricity. More specific steps are detailed in Figure AP2-34. The prototype is in progress and field testing will begin in 2019 (Yu, 2018) (Perry, 2018). If testing is successful, approval will need to be granted by the U.S. Environmental Protection Agency and HDOH prior to use in Maui residential homes.

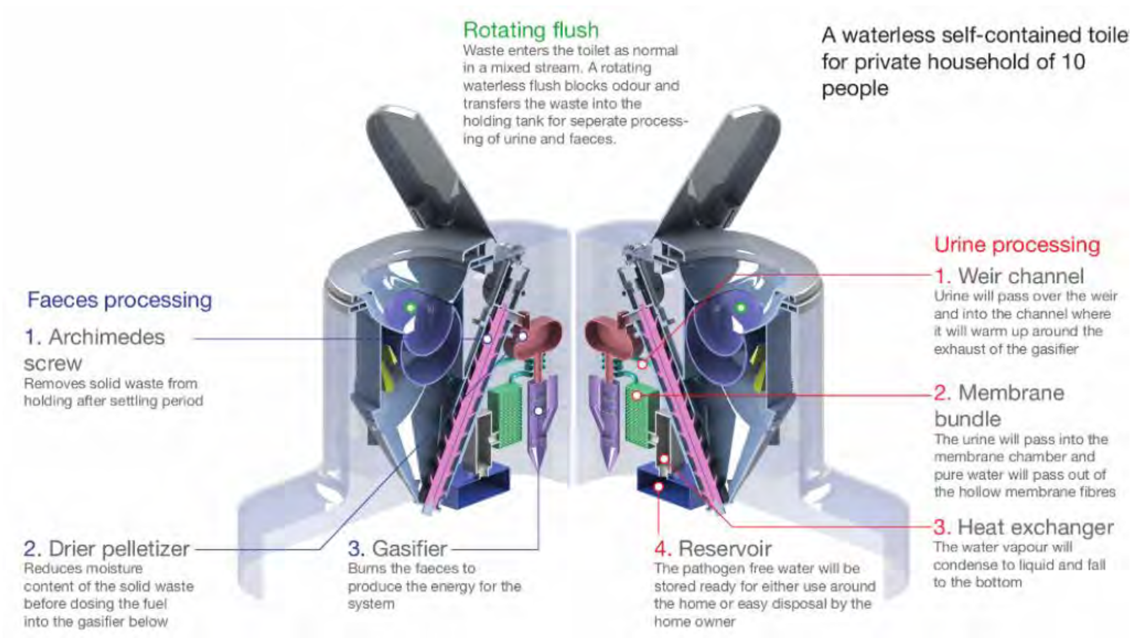

Figure AP2-34 Nano Membrane Toilet (Bill & Melinda Gates Foundation, Cranfield University, 2012)

Advantages

- As a zero-discharge system, nitrogen will not be released into the groundwater.
- Since water is not needed for flushing, household water consumption is reduced.
- Residents may be able to install a reduced-size wastewater treatment and disposal system, minimizing costs and disruption to the landscape.

Limitations

- The system is pending completion of a prototype, field testing, and federal and state approval.
- Composting toilets must still be used in conjunction with a graywater reuse system and wastewater treatment and disposal system.

9. <u>Sewering</u>

A sanitary sewer system connected to a wastewater treatment plant is an alternative to individual onsite wastewater treatment and disposal systems. Sanitary sewer systems are broadly categorized as decentralized or centralized, and these are described further below.

9.1. Decentralized Sewering

Groups of homes can be connected via a cluster system like the one in Figure AP2-35. A common area is designated as a satellite treatment facility or just a common disposal system. Typically, a cluster may have each residence on a septic tank, combine the effluent from those septic tanks in an equalization tank, and discharge to a common soil absorption system. Additional treatment may be included by a large, common aerobic treatment system or denitrification system. A cluster could also have a single, large septic tank to collect each household's wastewater (Water Resources Research Center and Engineering Solutions, Inc., 2008).

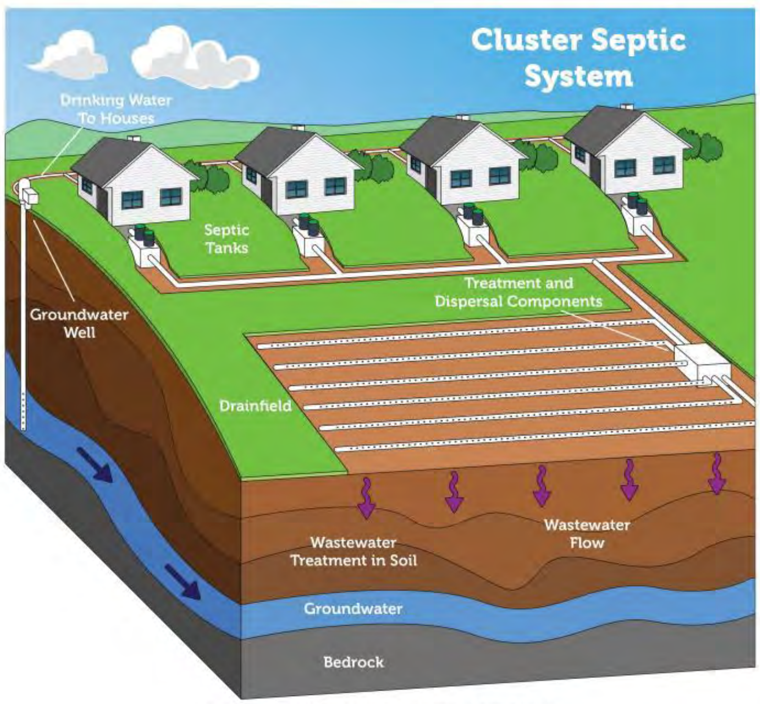

Figure AP2-35 Cluster System (United States Environmental Protection Agency, 2018)

Advantages

- Contaminants are transferred from each residence to a single treatment and disposal unit that can be more economical and better controlled and monitored.
- If the treatment and/or disposal components include denitrification, total nitrogen removal should be at least 50%.
- Literature review has indicated that for total flows between 5,000 and 15,000 gallons per day, cluster systems are more economical than individual onsite systems.

Limitations

- Contaminants are placed in a single confined space, rather than over a larger area that individual systems would use.
- Caution must be taken to prevent groundwater from ponding under the cluster system.
- Continuous monitoring must be performed using groundwater wells upstream and downstream from the final disposal site.
- Regulations also require alternating absorption beds and reserving land space for backup in case an absorption bed fails.
- Regulations would require employment of a state-licensed operator to monitor and maintain such systems.

9.2. Centralized Sewering

Decentralized sewering can be extended to centralized sewers. For this option, a larger number of homes are connected by a more extensive sanitary sewer network. The combined wastewater effluent is managed at a centralized wastewater treatment plant as depicted in Figure AP2-36.

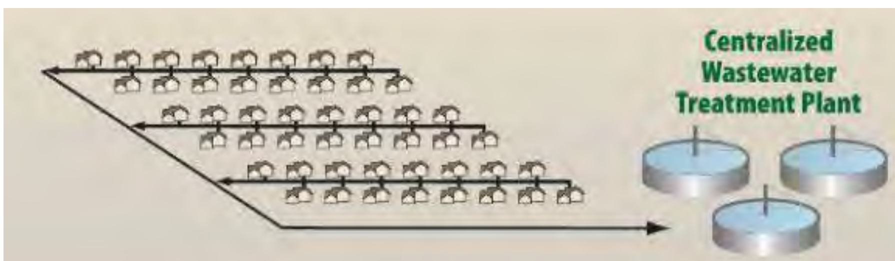

Figure AP2-36 Centralized System (D'Amato, 2016)

Advantages

- Contaminants are transferred from each residence to a single treatment and disposal unit that can be more economical and better controlled and monitored.
- Depending on the specific treatment components at the wastewater treatment plant, total nitrogen removal could reach 100%.

Limitations

- Large collection systems are expensive to construct and maintain and may also involve pump stations with associated power costs.
- Wastewater treatment plants require high levels of cost, power, labor, and management.

10. Point of Use Treatment

Instead of treating wastewater prior to dispersal into the ground, it is possible to continue the status quo and further contaminate the underlying ground water. If that groundwater is needed as a potable supply, point-of-use treatment can be implemented at the wellhead prior to distribution as drinking water. This treatment would have to satisfy HDOH's Safe Drinking Water Act to ensure quality drinking water. The specific treatment processes required would include at least a process to remove nitrate such as ion exchange, a process to remove trace organics such as activated carbon and a disinfection process such as chlorination. Regular sampling/analysis/reporting as well as obtaining renewable permits would be required. State-certified oparators wouldl be needed. The costs of treatment would include construction and operation and maintenance including chemicals, labor and electricity. This option would not meet Act 125, which requires all cesspools to be replaced.

Advantages

- Expense of upgrading cesspools is avoided.
- Drinking water quality remains protected.

Limitations

- Does not meet Act 125 regulation. Cesspools will still need to be replaced or upgraded.
- Does not prevent nitrate contamination in groundwater.

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Appendix III: Stakeholder Workshop Group Notes (transcribed and un-edited)

March 12, 2019

Upcountry Cesspool Stakeholder meeting WG

Look into factor of chlorination (chloramines?) leading to nitrates in groundwater

Phone group:

- Sina Pruder
- Sean O'Keefe
- Joanna Seto
- Lorrin Pang

Bookends

What is a good option for the cost alternative (lowest cost)

Stay away from the "someone else paying" scenarios for now

Sean: we don't have $ info

- The options document sent out was helpful to understand the different technologies available, but there was no cost info; they can't evaluate what would be the cheapest if they are lacking cost info
- Important information is lacking in order to be able to address the cost objective
- Cost estimates are challenging, from engineering standpoint, without details of each given case
- Range and average would be helpful; what's likely for Maui? Costs will be different from Oahu

Don't want to just buy the cheapest; could get a cheap tank, but cheap materials will fail, run risk of collapse with pumping

Septic and leach field might be the cheapest; the question is whether this is the solution?

- Great to keep in mind for future exercise on comparing across objectives

Is this fair? Pineapple pollution example. Pineapple fields have pesticides and chemicals in the soil that will last a very long time; not fair to future landowners, Nearby landowners, downhill landowners

- We talk about how upcountry drinking water is not from the aquifer; it comes from elsewhere (east Maui); 1 solution regarding fairness = bring in water for the downhill people. Bring in water for the people that have already-polluted water from the plantations.
- Fairness: polluting groundwater doesn't affect polluter, it affects people downhill.

Certainly, we don't want to add more N to the soil; that impacts future; takes 25 years to get to the aquifer.

- Want to protect; avoid expense, avoid further polluting

Source reduction options? Separating N in wastewater; source separation toilets; urine is where majority of the nitrogen in wastewater comes from.

- Where does it go?

Current Tax credit incentive has limitations:

- $10,000 max doesn't cover the full cost of a system
- Max # of available credits; statewide limit covers barely a fraction of cesspools in upcountry alone.
- Option that could make $ easier to bear: no / low interest loan programs
- How does cost compare to sewer fees? Over lifetime, Monthly cost could be similar to sewage fees; what would 20 years of sewage fees look like?

Clean Water Act loan programs; could be an underutilized source of financial assistance

Need a support system to implement upgrades

Composting toilets are cheaper; 10% cost of septic system

- Could be attractive to funders, who may be more inclined to subsidize cheaper options if they're just as efficient
- Issues to consider: graywater regulations, homeowner has to "get down and dirty with their waste"

Thinking outside the box – graywater N from soaps

- Soap regulations?
- Keeping your waste on your land, instead of it going elsewhere

  "At least your stuff is on your land"

Everybody wins

Presby system reduces N; meets NSF 40, maybe even 245? (50% N redxn)

- don't want high maintenance (mechanical parts, pumping every few years)
- Wants something with low maintenance
- System that reduces volume of wastewater (smaller system, keep costs low, divert other water)
  - Could drastically reduce volume to be treated
- Considerations:
  - Change in estimates / regulations: Estimates are still based on 200 gal / bedroom
- Roger: still have to have a leach field for Presby system

Focusing on high density areas

- Composting toilet considerations: pathogens in high-density areas (Haiti example; people weren't composting fully)

Funding

Need to consider the *true value* of a system; could be delayed; slow return on investment

- Beneficiary of true value could be 40 years down the line; should be willing to pay for investment
- Willingness to pay: other costs (cutting into ag production, etc)

Timelines! Must consider the timeline of benefits and costs

Somebody has to give $ up front; County has to be willing to go in and pay for it (in discussion of decentralized systems)

Connecting to decentralized system would require establishing easement

Need to find vacant area to put system in; need 100% buy-in

Construction to connect to system covered by… ? (? State clean water act?)

Notes – Kula workshop

3/12/19 Group: Kirsten

Minimize cost

- ONE:
- Get chloramines out of drinking water if a problem
  - Issues identified: may be really expensive to fix? May not be cost effective compared to other options
- Need to really understand what the N source are → need a study
- RISK: depends on the outcome of the studies whether this minimizes risk
- EQUITY: if major issue, will spread cost across larger population inexpensively
- TWO:
- Fix the worst offending cesspools
- Improve the standards and maintenance of existing
  - This would require getting rid of the 2050 ban
- RISK: somewhat
- EQUITY: fixers pay, so others are happy unless you spread the cost across the entire community somehow
- THREE:
- Change the law banning cesspools (extend past 2050), only ban for new homes/buildings
- RISK: Poor, maintains status quo
- EQUITY: great now, but pushes onto future generations.
- FOUR:
- Innovative technology; solar-powered; fits into the cesspool hole so it fixes the hole AND doesn't dig up the yard.
- RISK: good as central treatment if tech works
- EQUITY: everybody pays themselves
- FIVE:
- community facilities district (tax for public infrastructure) – use park or community center area for treatment
- RISK: Good
- EQUITY: shared with everyone across the tax district; tax shows up on real property bill
- Issue: requires law/regulation – is this really "public infrastructure"?
-

Minimize risk to aquifer

- ONE: Build wastewater treatment plant (centralized in upcountry Maui)
  - Issues with level of treatment? What would happen with discharge? Reuse?
  - EQUITY: everyone in county would pay through taxes
  - COST: very expensive

- TWO: Ban cattle farming
  - Issues: note VERY controversial, said mainly as a hypothetical bookend. Rejected as an option for inclusion. NOT included.
- THREE:
- Fix chloramine, if needed
- Gauge for nitrogen at the household level to find worst offenders; find lava tubes

Maximize equity and fairness

- Share the cost across all users of the aquifer not just the polluters
- Have feds pay for it (EPA?)
- Increase the credit available

WINS

- Get chloramines out of the drinking water, if they are an issue. Study the impact and figure out cost-effectiveness
- Innovative technology – within cesspool? – at household level

FUNDING

- Pukalani WWTP model at Kula: serves the high density communities (Kula, Haiku, Olina, Haliimaile). Costs would be for construction of pipelines and o and m. construction could be financed via a civil improvement district. Maybe we can get the water pipes at the same time! This would be a huge incentive! Developers should pay for the pipelines. Maybe put the pipelines in the gulches, but watch out for flooding. Put the WWTP down where there is enough solar energy to run it. Then for the households NOT connected, the state/county should pay x%.

Final thoughts:

- Find common solutions – hui up households to achieve some economies of scale
- We may need regulatory change to allow households to collectively treat waste together (cross property lines)

Kula (3-12-19) Meeting Notes: MB

Overall minimum cost

Minimum cost alternative

What is the lowest cost option?

Somebody else pays?

Private investment?

State -> Maui

Fed -> State

Lorrin:

Would like to see the cost to society overall first -> then depending on that partition who pays…

Joanna:

Meg: regulatory = cheap?

New composting toilets… ?

Sean: Document listed all the technologies was very helpful – send same with cost.

Kind of left with replacing a cesspool with the cheapest unit feasible for each TMK? [that won't fail and end up needing replacing straight away]

Cost SOOO important to narrow the scope

Roger → how much is a

AVERAGE!!! Upper/ Lower/ What's likely in Maui.

Plastic tanks for $1500 but they'll fail – value and life and risk of failure are important too

Sina (wastewater branch)

In Upcountry Maui, there is a lot of soil from the ground to where the aquifer is at?

Sina is looking at the alternatives and thinking that septic + leach = most economic ?

Would that be a solution though?

There are 7000 cesspools => would centralized management be cheaper?

Can we RANK -> make a shopping list? It's not as simple as we think?

Could we weight based on what we thinking is contributing to risk?

ALTERNATIVE: FOCUS ON DENSITY!!!!

Whether it is being used is IRRELEVANT

Can't just pollute the groundwater because it might be needed – It's not PONO

In lower areas, water is already polluted because of pesticide.

IS IT FAIR?

Put aside the amines?

Let's say the cesspools are polluting downhill

Upcountry water is brought in from East Maui -> not crapping in own water? -> but influencing downhill.

Bringing water? / Don't drill? / Treat the water (activated carbon) -> it works for pesticides, but doesn't help with Nitrogen, so you would need a different type of treatment plant… it's easy to treat pineapple pesticides….

Joanna:

DON'T want to ADD

DO want to PROTECT, DO want to AVOID expense

Possible reduction in volume of groundwater – fair for future?

OUT of the BOX: -> SINA?

Looking at the sources?

?? is probably a big contributor? Source reduction? Separating what's causing the high N in the wastewater. Wastewater treatment plant?

SOURCE SEPARATION: Urine Separating Toilets!!! (70% of N is in Urine)

- **Question re: what we do with it?**

FUNDING!!!!!

The only current program for helping to fund is the tax credit program

Because priority one, everyone in Upcountry qualifies!!

Tax credit for the WHOLE amount? (10,000 is under the cost)

There is also a cap on the total amount:

- **Only 2500 cesspools that could be closed -> this is way not enough**
- **Low or no interest loan program!! (like the solar panels in oz)**

- **If you could pay back the loan on a 25000 septic tank installation over 25 years, its similar to a monthly sewer bill with a base charge + gallon charge**
- **Average 600g / day…**

➔ **Can you have people be responsible, but make it easier to pay!!!!!**

Environmental loan programs?

Clean water state revolving fund loans program.

Is available for providing low interest loans to homeowners… but not able to do broad scale for loads of homeowners

What about a water loans program? Needs a supporting financial support system.

Drinking water -> 15% set aside for local projects, has been used in the past in places where wells are -> Joanna is open to ideas, but needs to know priorities.

Costs other than $$? Other considerations… ??

Cost reduction: SERIOUS LOOK AT COMPOSTING TOILETS/ WATERLESS SOURCES!!!

➔ **Grey water management?!! Outside the box!!! So good!!**
➔ **Could be the best!**
➔ **Would need to change the grey water rules!**
➔ **Composting toilets need work?**
  - **Maintenance cost?**
  - **Auditing and monitoring needs and requirements**
  - **Health risks, and infectious diseases, especially in high density areas**
  - **Lorrin has read a bunch of info about Haiti**
  - **Berkley has a microchip**
  - **RISK: Pathogens were recorded especially if people didn't let it**

➔ **Main N in grey water are shampoos and stuff**

- **What about a shampoo regulation?**
- **Your stuff goes on your land – instead of elsewhere.**
- **Send laundry to the plants**

Sina:

Likes systems that are PASSIVE – Presby system?

Equivalent to NSF40

Low cost for O&M??

Divert laundry away from individual wastewater -> only put water from kitchen (black water) and toilet. Size system smaller would reduce costs by a lot!!! Reducing the flow by 50% could reduce the cost.

Department is open to evaluating the regulations for system sizes?

Programs care about cost-effectiveness

The true value for all of society? Are we getting ahead -> more clean water is good

When do you get the clean water -> takes 30 years -> slow return

-> TRUE VALUE

TIMELINES FOR COSTS AND BENEFITS ARE IMPORTANT

AND/OR Willingness to pay, providing it's the cheapest

Pretty

Doesn't smell bad.

Costs other than $$? Other considerations… ??

TREES -> FOOD

SMELL

SPACE

PRODUCTION

MB: suggested to the group that land footprint could be documented as a cost in the strategy evaluation.

LOW COST LOANS ARE GOOD?

Photo-voltaics?

DECENTRALISED? – can – but needs land easement and everyone has to be onboard. Would work if county did it because they can require everyone to tie in. Hard if a private company did.

In big island, the county put in a sewer line, and the properties in the zone of contribution received funds to make that connection from the drinking water.

SEWER? -> cost only, permanent commitment. Maintaining it is really expensive. Lifetime of sewer fees.

LOGISTICALLY CHALLENGING?

At the end:

Dick Mayer suggested that some common solutions might reduce costs – e.g. a 4 home treatment system, that can go across boundaries.

It was noted that to residents, some objectives are more important than others – how will we decide/ integrate the information. We will be able to say for this goal, Alt X is better than Alt Y, for this goal XXX is true. KO explained that since that is a normative value, it's not for us to decide.

____

Sharing:

I noted that KO group wanted to know the impact of Nitrates from chloramines and whether switching to something more expensive would drop the N in the system.

"It's not PONO to pollute"

KO group also suggested something like community centralized systems in high density areas, with a focus on innovative low tech, low power solutions. They liked the idea of solar panel = balance.

AF group wanted to know about regulatory reform. Wanted a focus on contributors. Also I had a note about risk mapping re: N from leachfield for each OSDS/TMK based on depath, age, lava tube…

____

Notes – Kula workshop

3/12/19

Group: Phone In (Whitney)

Bookends

What is a good option for the cost alternative (lowest cost)?

Doing nothing cheapest, but can't just pollute the groundwater because it might be needed – It's not PONO. In lower areas, water is already polluted because of pesticide, but even so, want to protect; avoid expense, avoid further polluting, not add.

Possible reduction in volume of groundwater – what is needed/fair for future?

Don't want to just buy the cheapest; could get a cheap tank, but cheap materials will fail, run risk of collapse with pumping

Septic and leach field might be the cheapest; but likely not a solution to the contamination.

There are 7000 cesspools => would centralized management be cheaper? Especially in high density areas?

Bringing water? / Don't drill? / Treat the water (activated carbon) -> it works for pesticides, but doesn't help with Nitrogen, so you would need a different type of treatment plant… it's easy to treat pineapple pesticides with a filter, but not the Nitrogen.

Alternative to see if it makes any difference:

Replace cesspool with the cheapest unit feasible for each TMK that won't fail and end up needing replacing straight away.

Alternative: Focus on High Density areas

Either sewer or decentralized systems in high density areas, definitely for new developments, and something simple, like the Presby system in other sites.

Barriers:

Connecting to decentralized system would require establishing easement

Need to find vacant area to put system in; need 100% buy-in.

Would work if county or co-ordinated it because they can require everyone to tie in. Hard if a private company did it. Iif the community all asked for it, then maybe some public land easement could be used for the site.

Somebody has to give $ up front; County has to be willing to go in and pay for it.

Sewer connection costs $: On big island, the county put in a sewer line, and the properties in the zone of contribution received funds to make the connection.

SEWER? -> permanent commitment. Maintaining it is expensive. Lifetime of sewer fees.

Alternative - Everybody wins: Low Maintenance

Something like e.g. the Presby system – Low Maintenance, reduces N; meets NSF 40, maybe even 245? (50% N redxn)

- Low maintenance. Mechanical parts, pumping every few years increase costs and reduce compliance.
- System that reduces volume of wastewater (smaller system, keep costs low, divert other water)
- Could drastically reduce volume to be treated. Reducing flow by 50% could reduce the cost.
- Considerations:
    - Change in estimates / regulations: Estimates are still based on 200 gal / bedroom
    - Leach field still required for Presby system

High Density Alternative was again suggested, could include highly effective system upgrades as a tweak

<u>Alternative - Out of the Box: What if we separated what's causing the high N in the wastewater?</u>

SERIOUS LOOK AT COMPOSTING TOILETS/ WATERLESS SOURCES

- ➔ Barrier: Grey water management
    - Would need to change the grey water rules
    - Regulation wise, you would still need an overflow leach field for the grey water for when the water isn't used
- ➔ Barrier:
    - Composting toilets need work?
    - Maintenance cost?
    - Auditing and monitoring needs and requirements
    - RISK: Health risks, and infectious diseases, especially in high density areas, especially if management required.
- ➔ Barrier:
    - Social – some people don't like the smell etc.
- ➔ Main N in grey water are shampoos and stuff
    - What about a shampoo regulation?
    - Your stuff goes on your land – instead of elsewhere.
    - Send laundry to plants?
- ➔ SOURCE SEPARATION: Urine Separating Toilets is another option (70% of N is in Urine)

<u>FUNDING</u>

Current Tax credit incentive has limitations:

- $10,000 max doesn't cover the full cost of a system → Credit for whole amount?
- Max # of available credits; statewide limit covers barely a fraction of cesspools in upcountry alone. Only 2500 cesspools that could be closed (7000 in UC Maui)
- Option that could make $ easier to bear: no / low interest loan programs
    - How does cost compare to sewer fees? Over lifetime, Monthly cost could be similar to sewage fees; what would 20 years of sewage fees look like? **If you could pay back the loan on a 25000 septic tank installation over 25 years, its similar to a monthly sewer bill with a base charge + gallon charge**

Clean Water Act loan programs; could be an underutilized source of financial assistance, but it doesn't have the capacity for broadscale loans to homewowners – not a finance institution, and bringing one in (e.g. a bank has high costs).

Drinking water fund has 15% of the total amount can be used for local projects, and has been used in the past in places where wells are, but priority locations need to be identified before this could be available in UC Maui.

Need to consider the *true value* of a system; could be delayed; slow return on investment

- Beneficiary of true value could be 40 years down the line; should be willing to pay for investment
- Willingness to pay: other costs (cutting into ag production, etc)

Timelines! Must consider the timeline of benefits and costs

Additional Notes:

Timelines for costs and benefits important, and/or willingness to pay, providing cost-effective. **For instance,** ~ 30 year delay on clean water, = slow return

Costs other than $$ to consider:

TREES -> FOOD

SMELL

SPACE

PRODUCTION

➔ Maybe land footprint could be documented as a cost ?

Appendix IV: Groundwater model

Groundwater and Transport Modeling

The purpose of the numerical groundwater flow and transport modeling was to test various cesspool conversion alternatives. The groundwater flow model that was used is the USGS groundwater modeling code MODFLOW 2005, an international standard for simulating groundwater flow. The model is represented by a grid of cells in three dimensions, and groundwater flow is calculated as water movement based on groundwater flow paths between adjacent cells. A modular three-dimensional multi-species transport model, MT3DMS, was used to simulate movement of nitrogen due to groundwater flow. MT3DMS uses the flow solution from MODFLOW to simulate the movement of dissolved contaminants in groundwater (Zheng and Wang 1999 and 2012). This modeling code is capable of simulating dissolved contaminant movement by advection (the movement with groundwater flow), diffusion (the movement of contamination due to a concentration gradient), and dispersion (the spreading of contamination due to multiple flow paths of differing characteristics in the aquifer). MT3DMS also simulates the reduction in dissolved contaminant mass due to processes such as decay or transformation and sorption (attachment) to the aquifer matrix (Zheng and Wang 1999 and 2012).

The model from the "Upcountry Maui Groundwater Nitrate Investigation Report, Maui, Hawaii" was used as the basis for this project, with updates based on new data and community feedback described below. Overall, data in this model were drawn from Commission on Water Resources Management (CWRM) well and pumping records, previous Source Water Assessment Program (SWAP) and onsite sewage disposal system (OSDS) models of east Maui (Whittier et al., 2004; and Whittier and El-Kadi, 2014), the USGS groundwater flow model of central and west Maui (Gingerich, 2008) and various GIS coverages from the State GIS website (http://planning.hawaii.gov/gis/download-gis-data/). Selected assumptions and components of the model are included in subsequent sections.

Updates to 2018 Groundwater Model

To improve agreement between model results and field sampling results, and in response to Upcountry Maui community concerns, the following updates have been made to the 2018 groundwater model:

- Added the Haiilimaile Wastewater Treatment Plant infiltration ponds (29 mg/L) and Pukalani Wastewater Treatment Plant infiltration beds (10 mg/L) as additional nitrogen sources.
- Increased former pineapple nitrogen source from 1.5 mg/L to 2.5 mg/L to better match the measured groundwater nitrogen values.

- Decreased Pukalani Golf Course recycled water source from 7.0 mg/L to 3.0 mg/L, based on data provided by the Pukalani Golf Course and Pukalani Wastewater Treatment Plant (WWTP).
- Added nitrogen source from golf courses without recycled water application (1.5 mg/L).
- Increased naturally occurring nitrogen in soil from 0.3 mg/L to 0.5 mg/L.
- The resolution of the recharge coverage was revised so the largest recharge polygon no larger than a square 300 m on each side. In many cases, the square is sub-divided where there is a transition to difference N source types.
- Updated the groundwater recharge to reflect the latest data released by the USGS (Johnson 2016).
- Based on a literature review, the percentages of nitrogen removal rates of OSDS Classes I (any system receiving soil treatment), II (septic tank to seepage pit), and III (aerobic treatment unit to seepage pit) have also been revised: Class I has a removal rate of 47%, Class II has a removal rate of 10%, and Class III has a removal rate of 20%.

Nutrient transport modeling

The distribution of nitrate in groundwater was simulated using the transport code MT3DMS (Zheng & Wang, 1999; and Zheng, 2010). The various forms of nitrogen in wastewater are converted to nitrate in the upper layers of the soil by aerobic nitrification, resulting in nitrate as the stable end species, as shown in Figure AP4-1. Nitrate remains the stable form of nitrogen under oxidizing conditions, as it is travels vertically through the vadose zone to groundwater, and then follows groundwater paths to the receiving body of water. Therefore, the transport model focuses on simulating nitrate. The model was also run with a 50-year simulation to allow nitrate to reach steady-state.

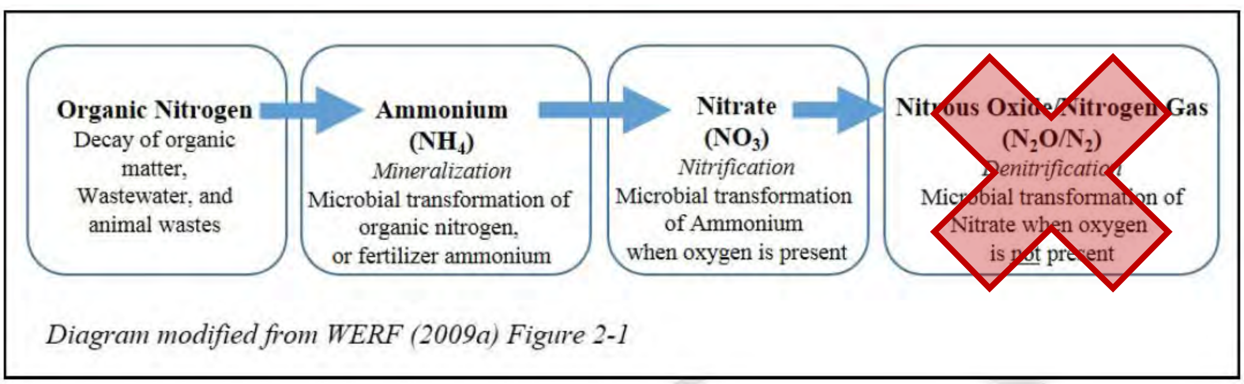


Figure AP4-1 Chemical transformation of organic nitrogen

The primary sources of nitrate modeled are listed below. AP4-1 lists the source concentrations used for the model and the basis for the values selected. Figures AP4-2, AP4-3, and AP4-4 illustrate the locations of the various sources.

- Legacy fertilizer leached from former sugar cane and pineapple cultivation

- Onsite sewage disposal leachate
- Application of recycled wastewater at Pukalani Golf Course
- Fertilizer at golf courses not using recycled wastewater
- Leachate from Haiilimaile Wastewater Treatment Plant infiltration ponds and Pukalani Wastewater Treatment Plant infiltration bed
- Natural/background levels (including ranchlands).

Table AP4-1: Nitrate Sources and Basis for Modeled Concentrations (mg/L)

Nitrogen Source	Nitrogen Concentration (mg/L)	Basis
OSDS		Effluent rate assumed 70 gal/day/person, 1.5 persons per bedroom (USEPA 2002).
Cesspool (Class IV)	87	Based on household effluent concentrations (WERF 2007).
Septic to Seepage Pit (Class II)	58	Assumes 33% nitrogen removal rate in septic tank (WERF 2009).
Septic to Soil Treatment (Class I)	34	Assumes 41% nitrogen removal rate in soil (Tasato and Dugan 1980)
Historical Pineapple	2.5	Calibrated to simulate concentrations in wells located in or near former pineapple fields.
Historical Sugar Cane	5.0	Calibrated to concentrations in groundwater beneath former sugar cane fields as indicated by concentrations in Consolidated Maintenance Base Yard Wells.
Pukalani Golf Course Recycle Water	3.0	Accounts for golf course fertilizer and additional nitrogen in recycled water. Includes application and leaching data from golf course.
Golf Course (recycled water not applied)	1.5	Accounts for golf course fertilizer and assumptions for application and leaching rates.
Haliimaile Wastewater Treatment Plant infiltration ponds	29	Based on infiltration rate and cesspool level of treatment.
Pukalani Wastewater Treatment Plant infiltration bed	10	Based on nitrate test results of effluent from Pukalani Wastewater Treatment Plant.
Natural/Background (including	0.5	Approximate average value for wells

ranchlands)		for groundwater with no anthropogenic influence.

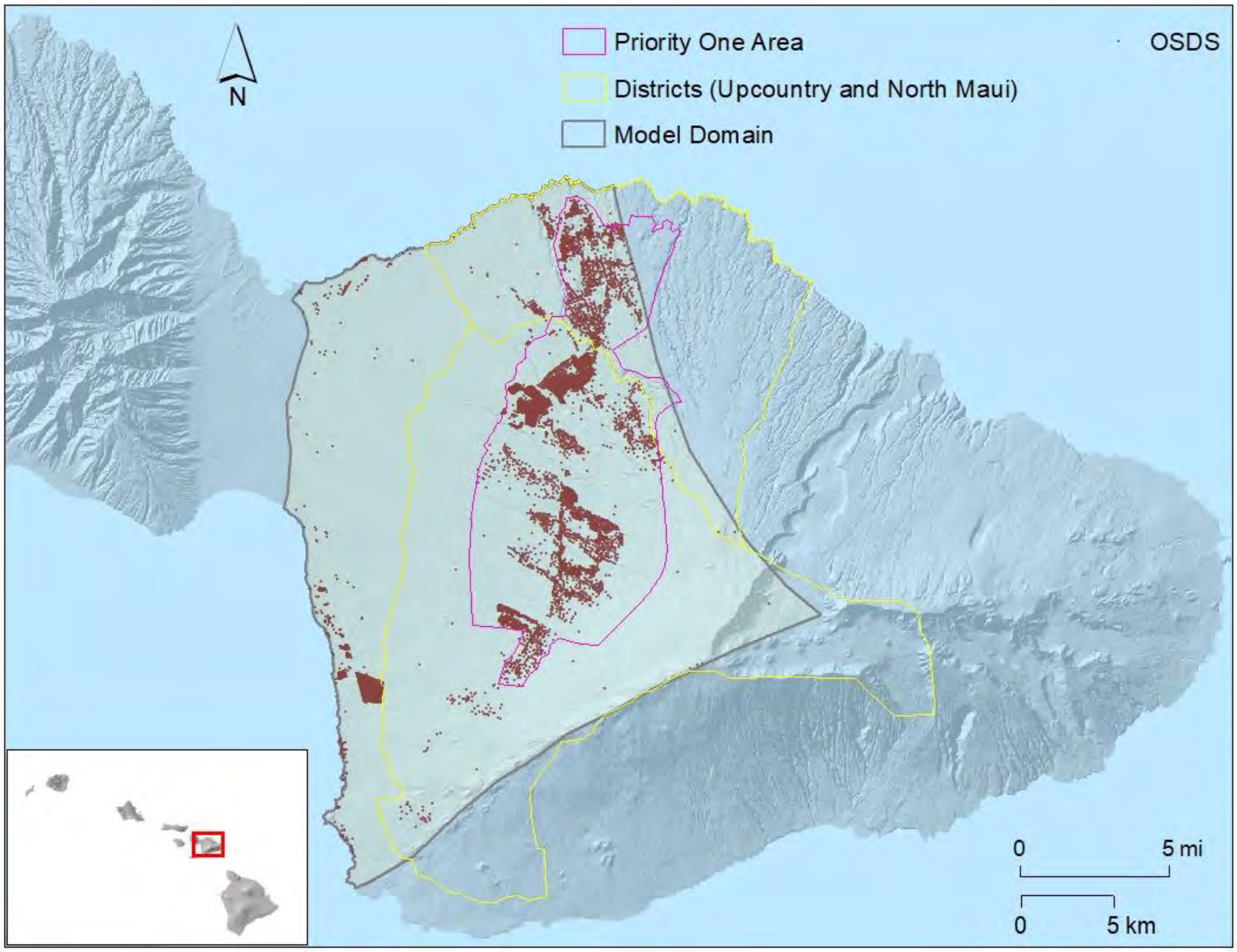


Figure AP4-2. Groundwater model domain and locations of OSDSs

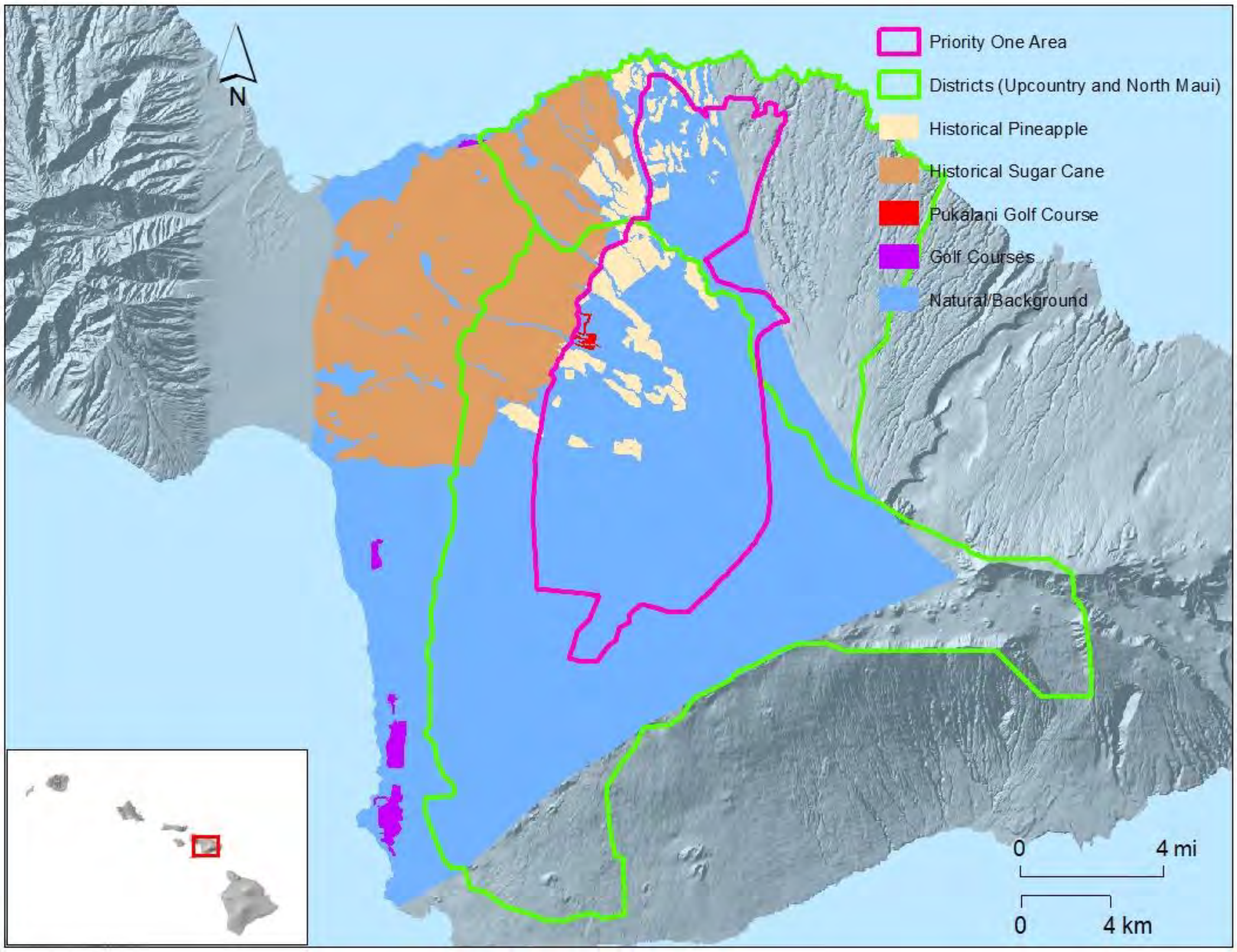


Figure AP4-3. Groundwater model domain and locations of historical pineapple, historical sugar cane, Pukalani Golf Course, golf courses (without application of recycled water), and natural nitrate sources

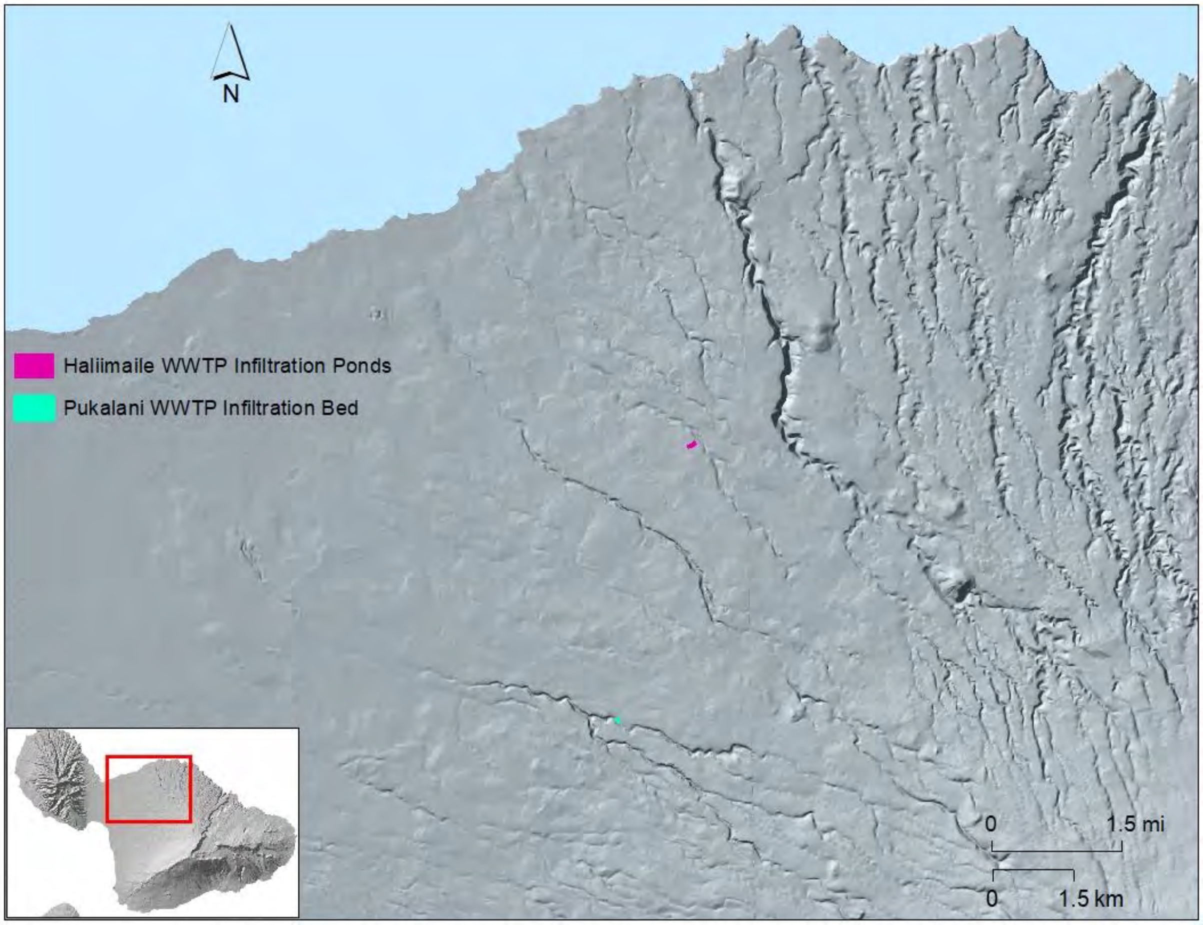


Figure AP4-4. Groundwater model domain and locations of Haliimaile and Pukalani wastewater treatment infiltration ponds and bed

Appendix V - Areas with greater than 5 and 10 Milligrams per Liter (mg/L) Nitrate Concentrations for each Alternative

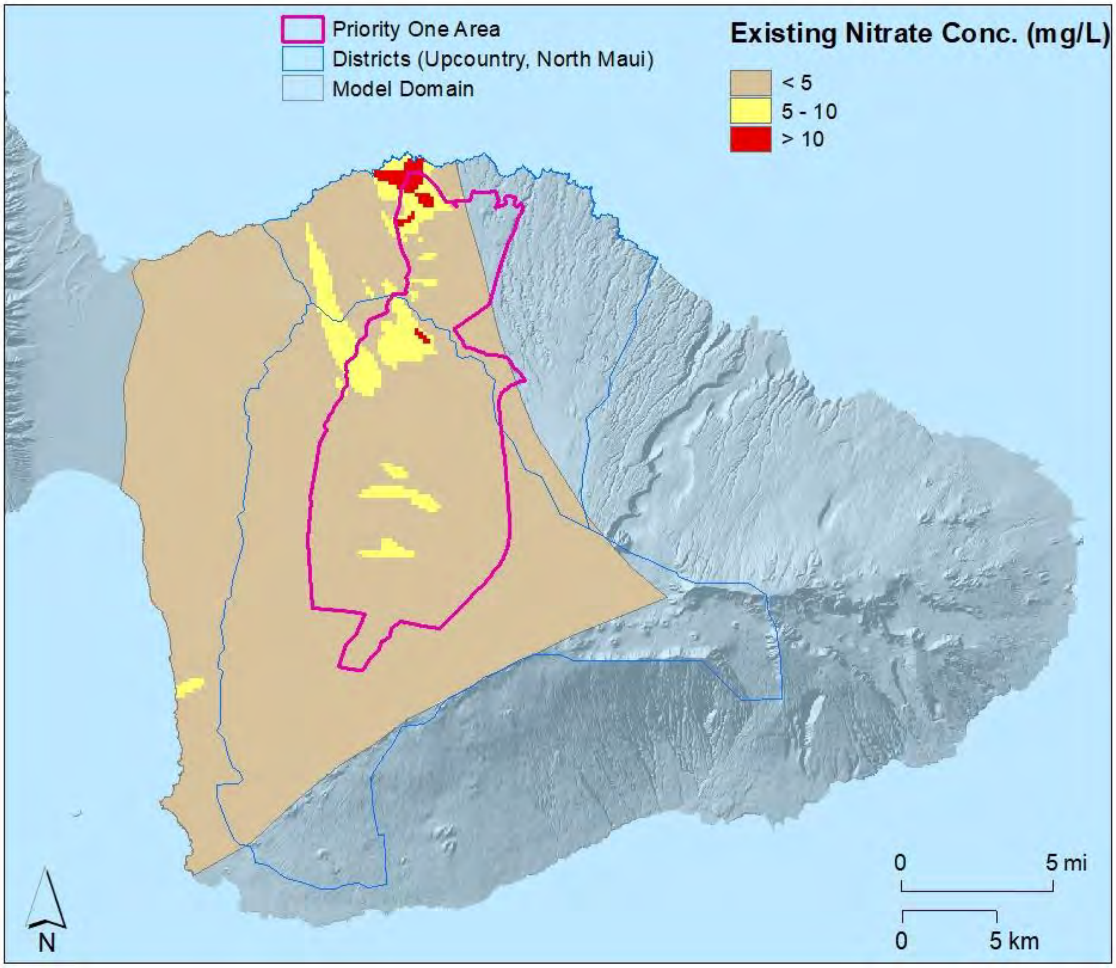


Figure AP5-1. Existing Nitrate Concentrations of Base Model

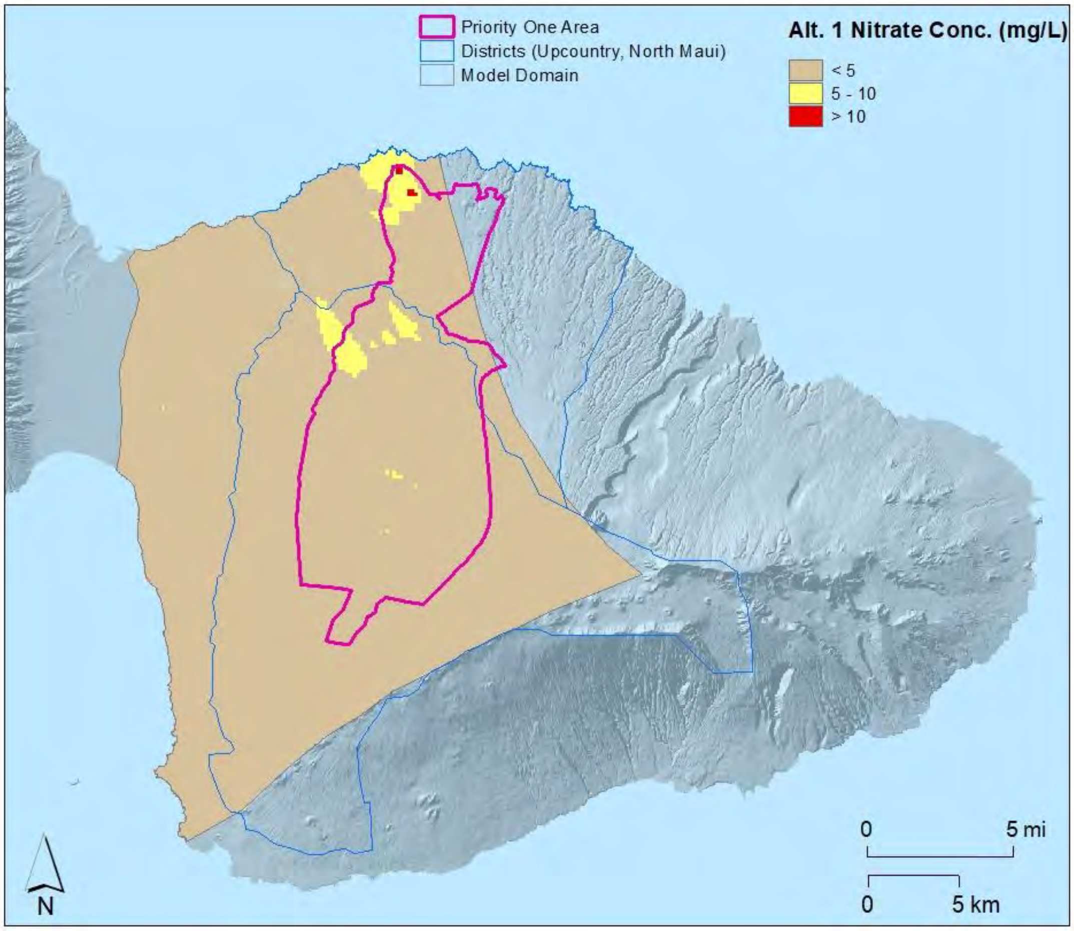


Figure AP5-2. Nitrate Concentrations of Alternative 1: Cesspools Upgrade to Septic Tank to Absorption System and Alternative 4: Cesspools Upgrade to Septic Tank to Recirculating Sand Filter to Seepage Pit. These results are equal because tax map keys (TMKs) where absorption systems are not feasible, seepage pits are allowed. TMKs where absorption systems are feasible, seepage pits are not allowed.

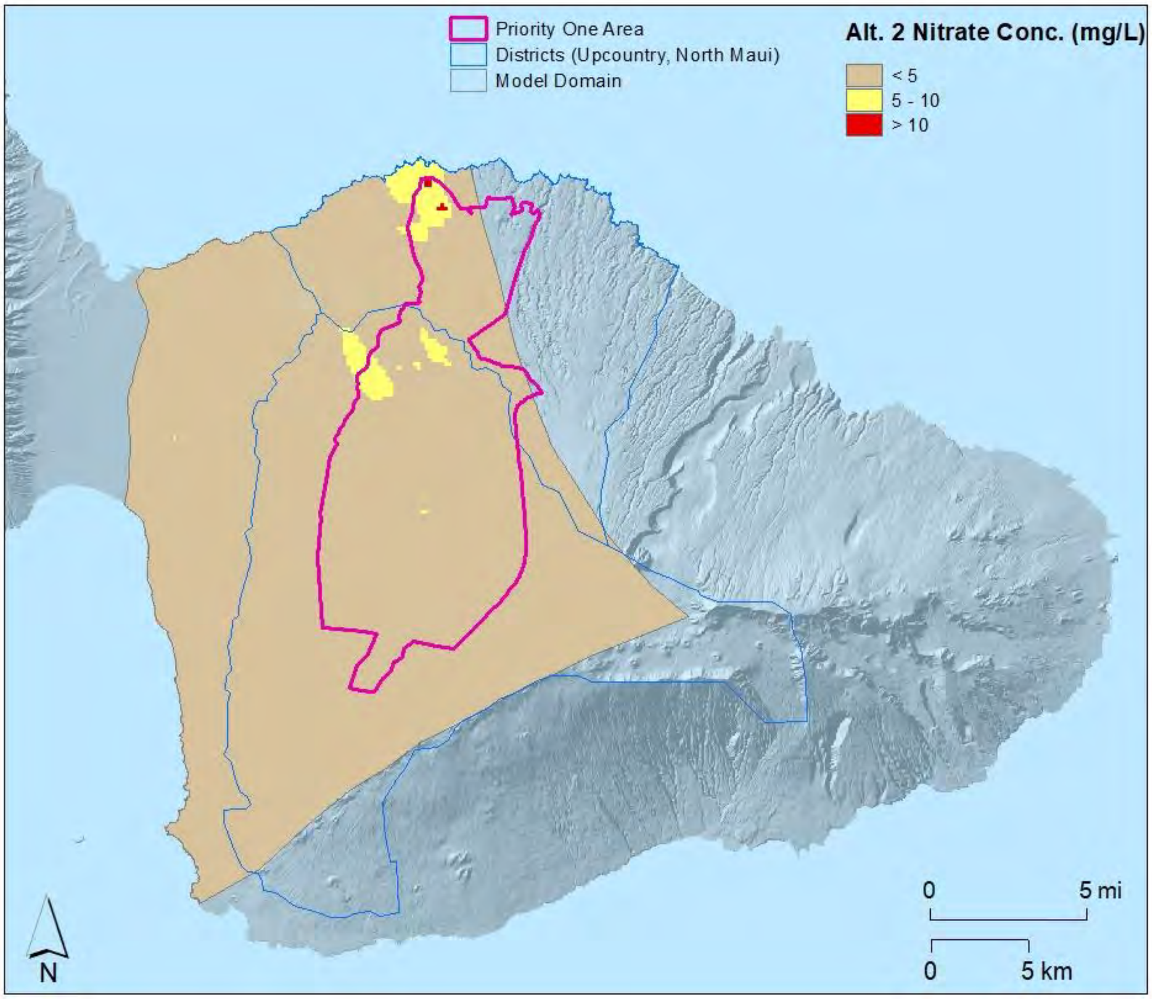


Figure AP5-3. Nitrate Concentrations of Alternative 2: Cesspools Upgrade to Septic Tank to Constructed Wetland

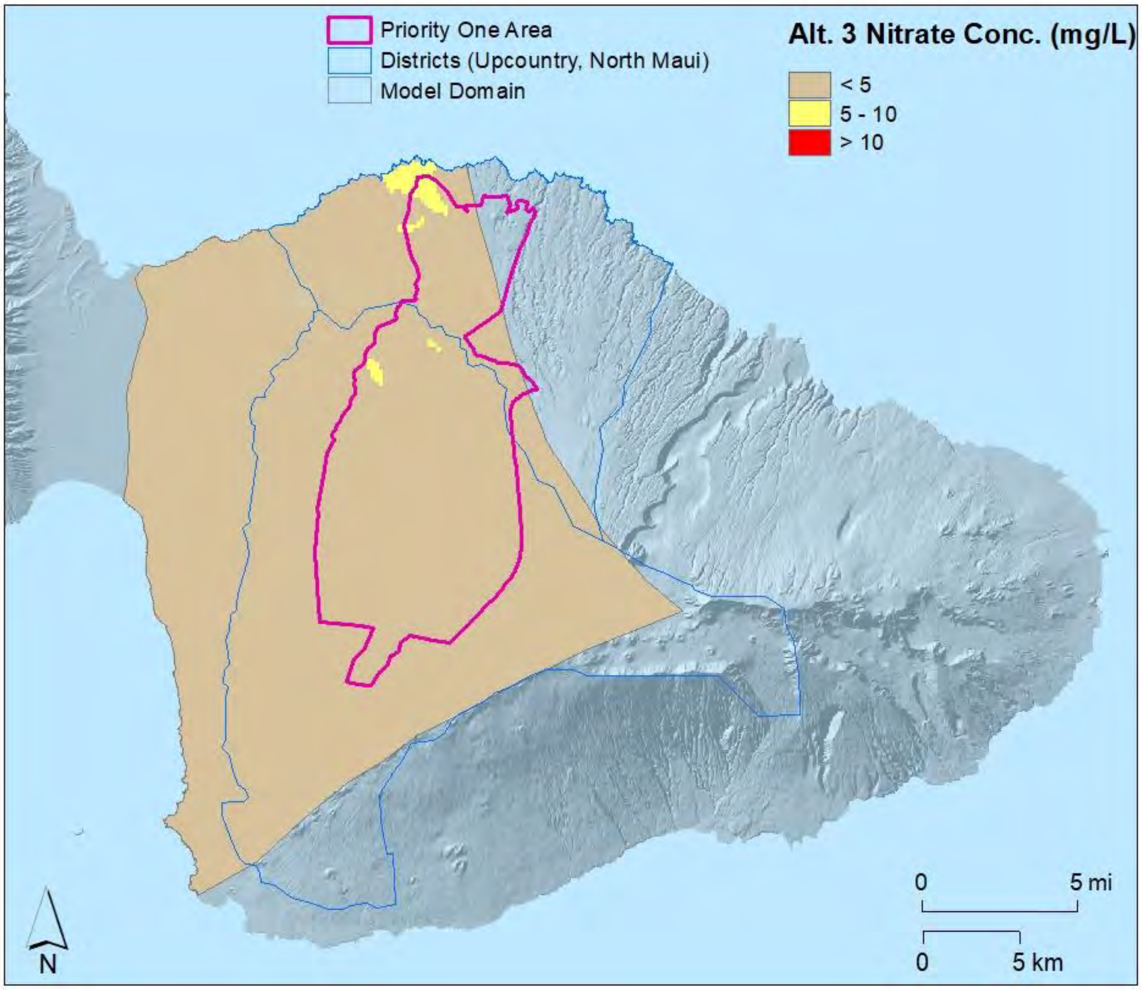


Figure AP5-4. Nitrate Concentrations of Alternative 3: Cesspools Upgrade to Septic Tank to Recirculating Sand Filter to Drip Irrigation

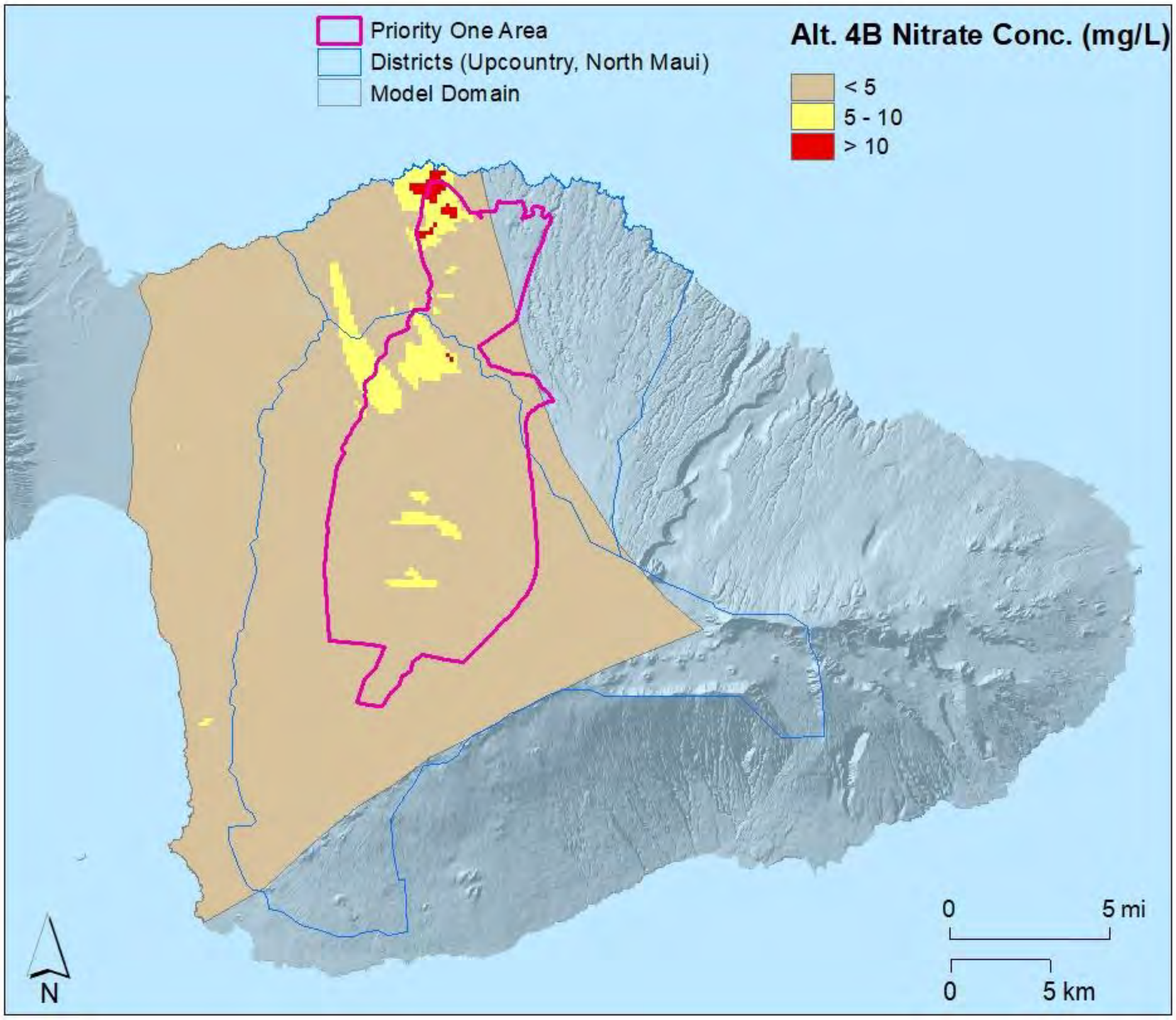


Figure AP5-5a. Nitrate Concentrations of Alternative 4B: Cesspools Upgrade to Septic Tank to Seepage Pit with calibrated loading (1.5 persons/BR and 70 gal/person)

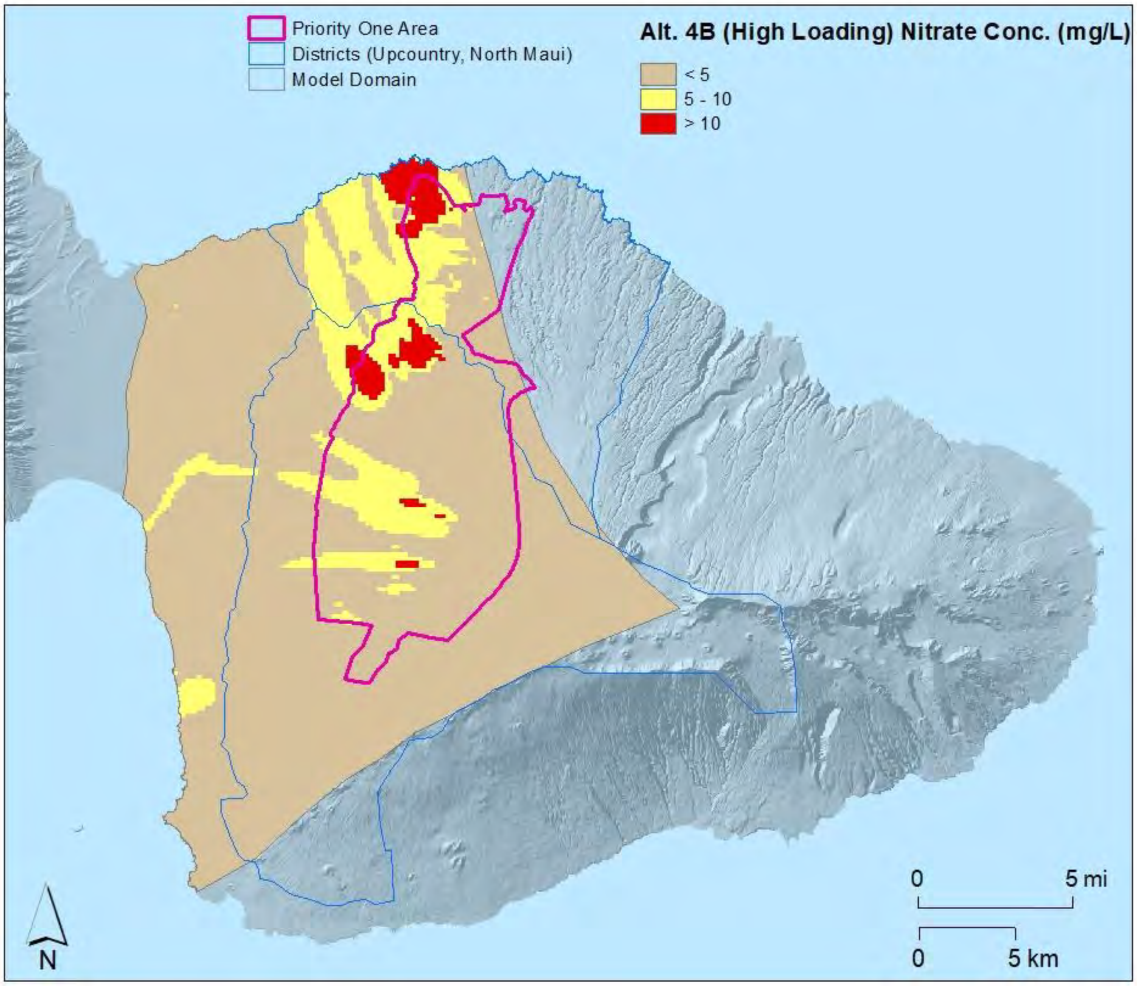


Figure AP5-5b. Nitrate Concentrations of Alternative 4B_HI: Cesspools Upgrade to Septic Tank to Seepage Pit with higher loading (2 persons/BR and 100 gal/person)

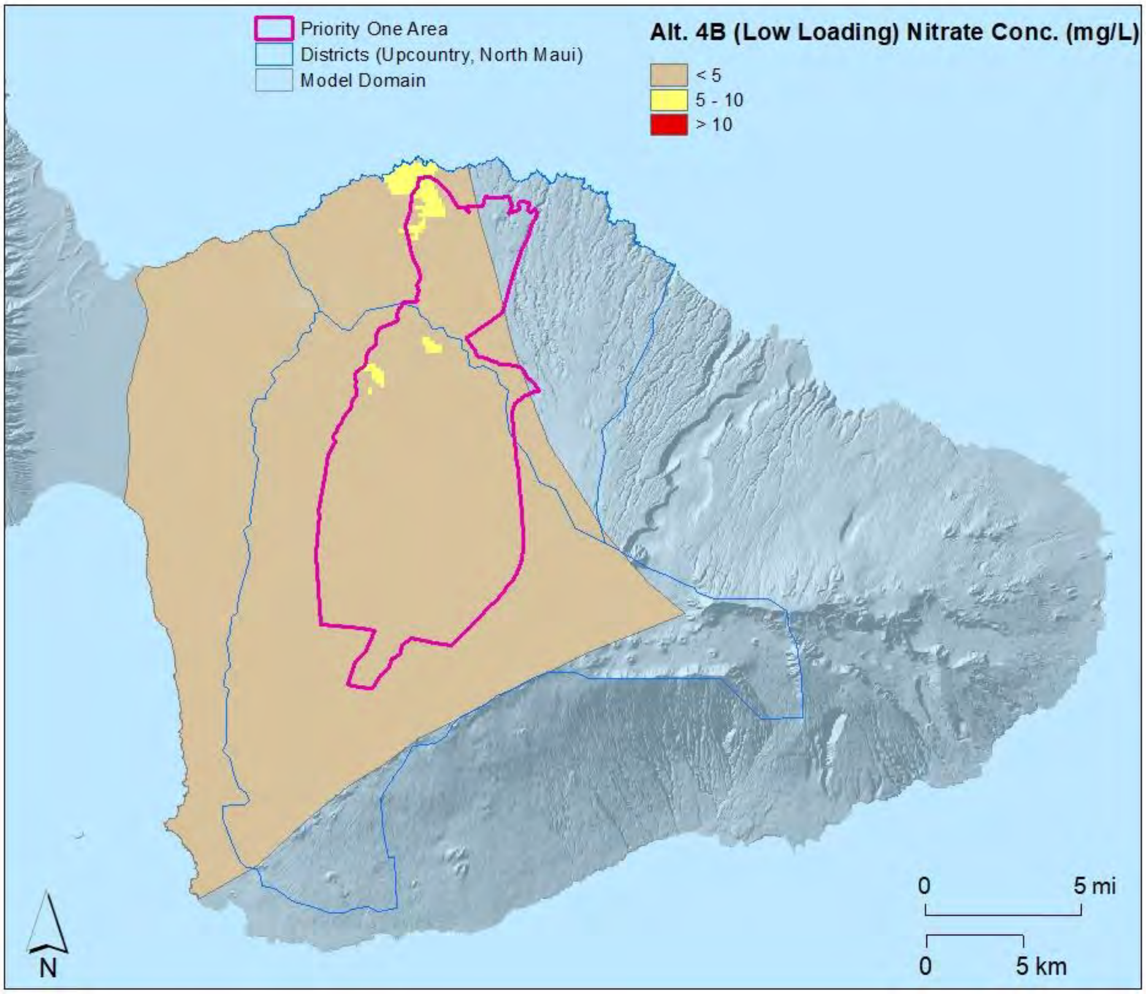


Figure AP5-5c. Nitrate Concentrations of Alternative 4B_LO: Cesspools Upgrade to Septic Tank to Seepage Pit with lower loading (1 persons/BR and 70 gal/person)

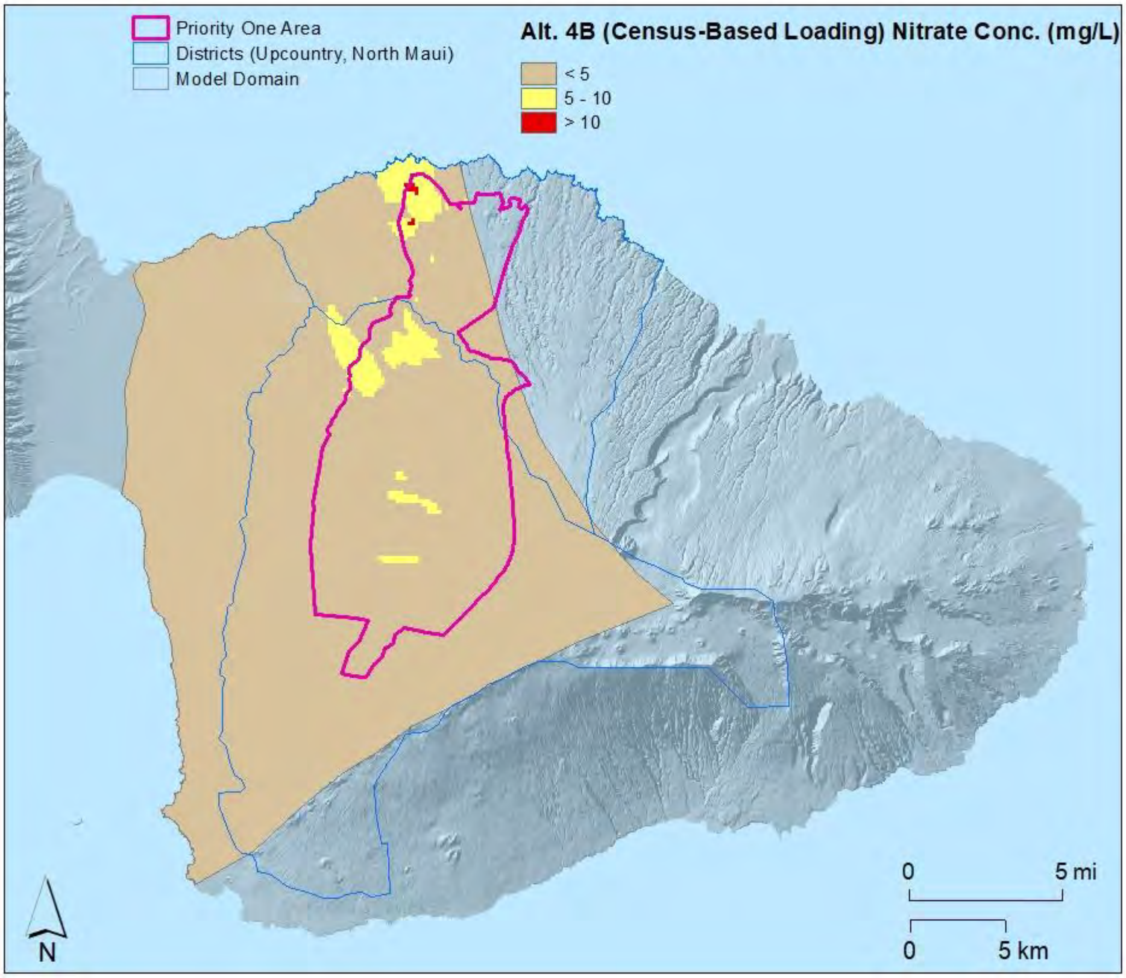


Figure AP5-5d. Nitrate Concentrations of Alternative 4B_Census: Cesspools Upgrade to Septic Tank to Seepage Pit with 2010 Census-based loading (1 persons/BR and 70 gal/person)

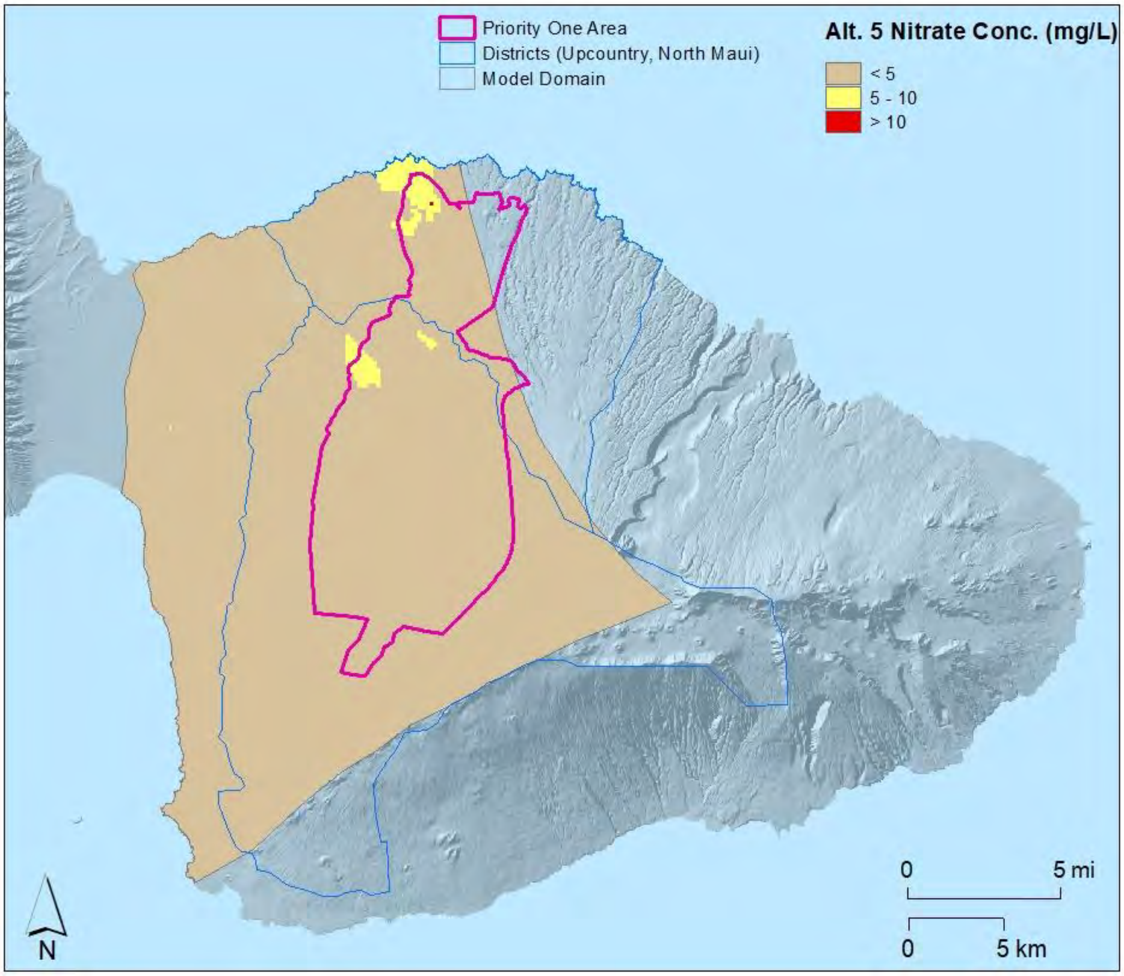


Figure AP5-6. Nitrate Concentrations of Alternative 5: Cesspools Upgrade to Septic Tank to Eliminite to Absorption System

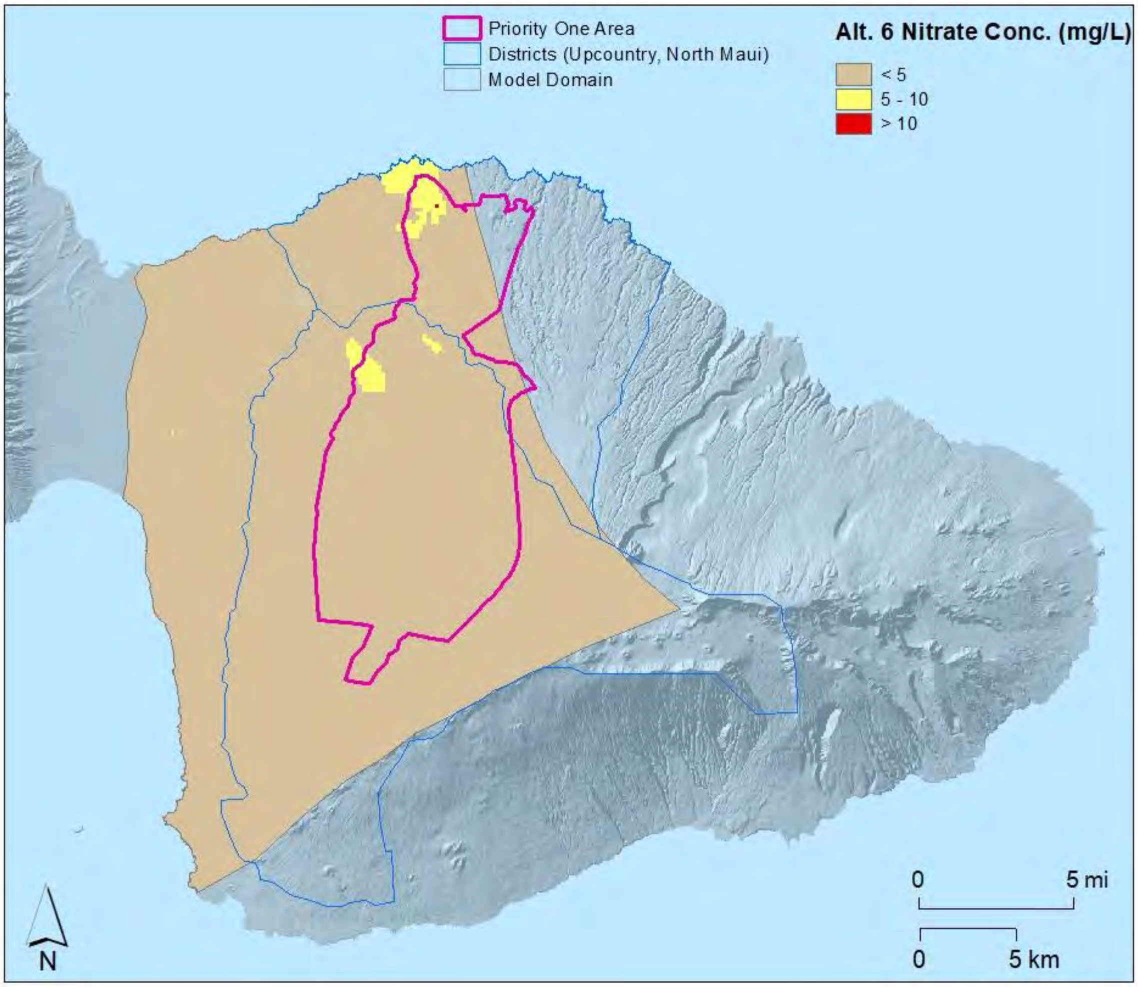


Figure AP5-7. Nitrate Concentrations of Alternative 6: Cesspools Upgrade to Septic Tank to Presby

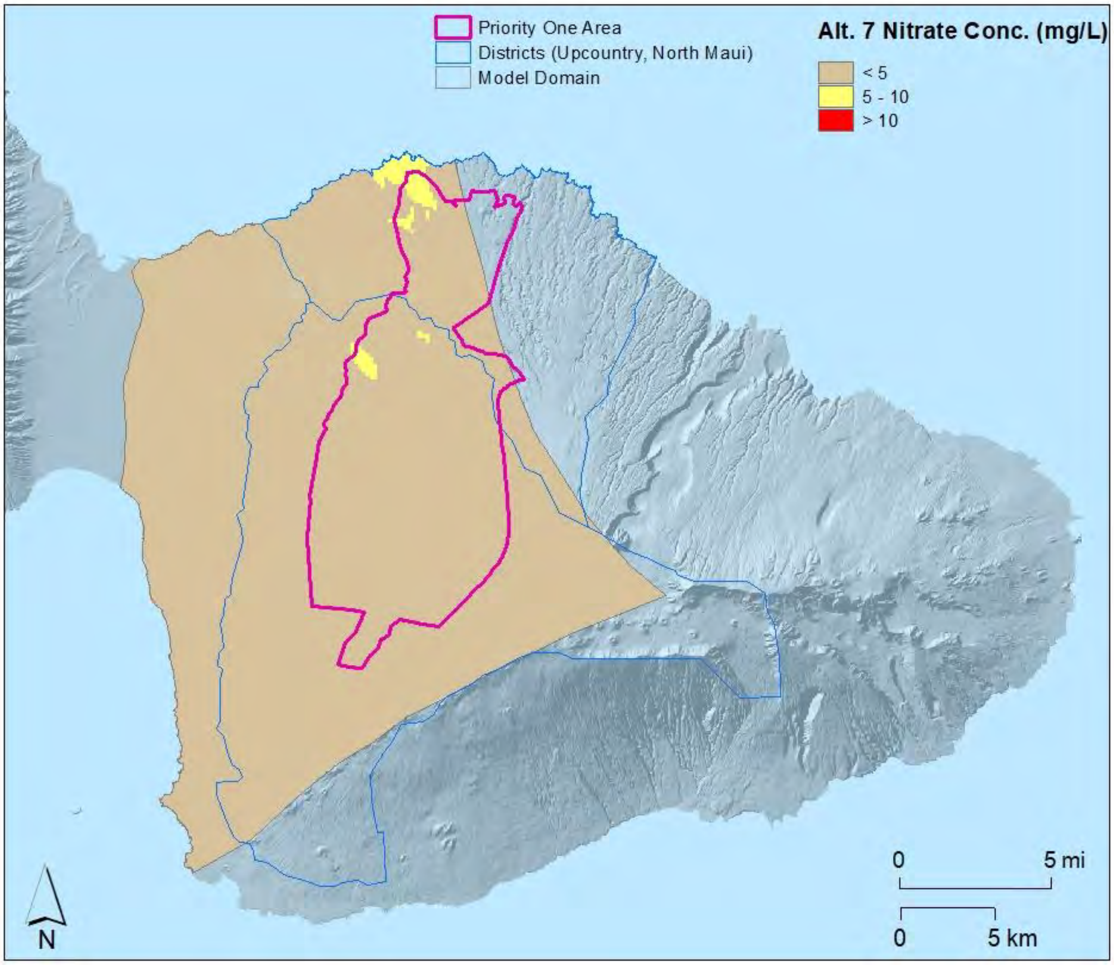


Figure AP5-8. Nitrate Concentrations of Alternative 7: Cesspools Upgrade to Septic Tank to NITREX to Absorption System

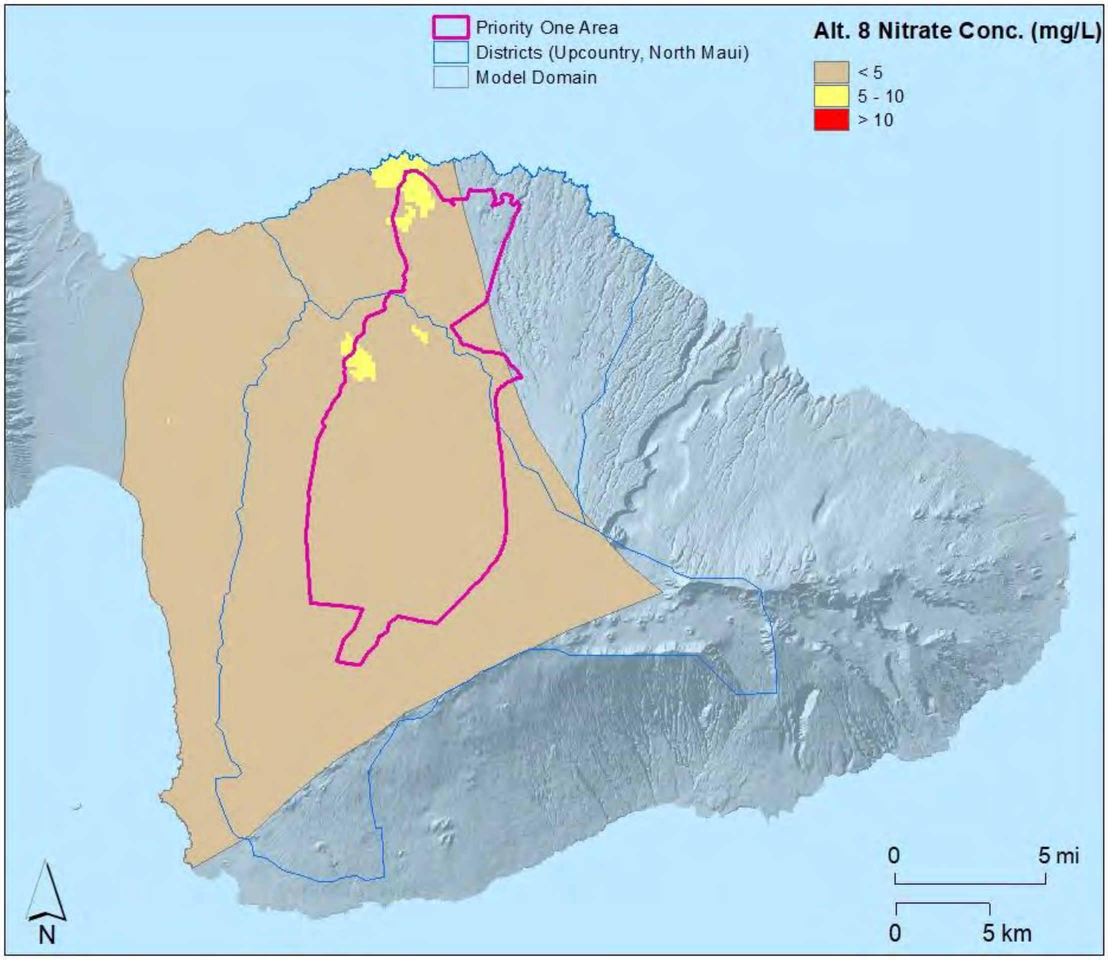


Figure AP5-9. Nitrate Concentrations of Alternative 8: Cesspools Upgrade to Septic Tank to Recirculating Gravel Filter System to Absorption System

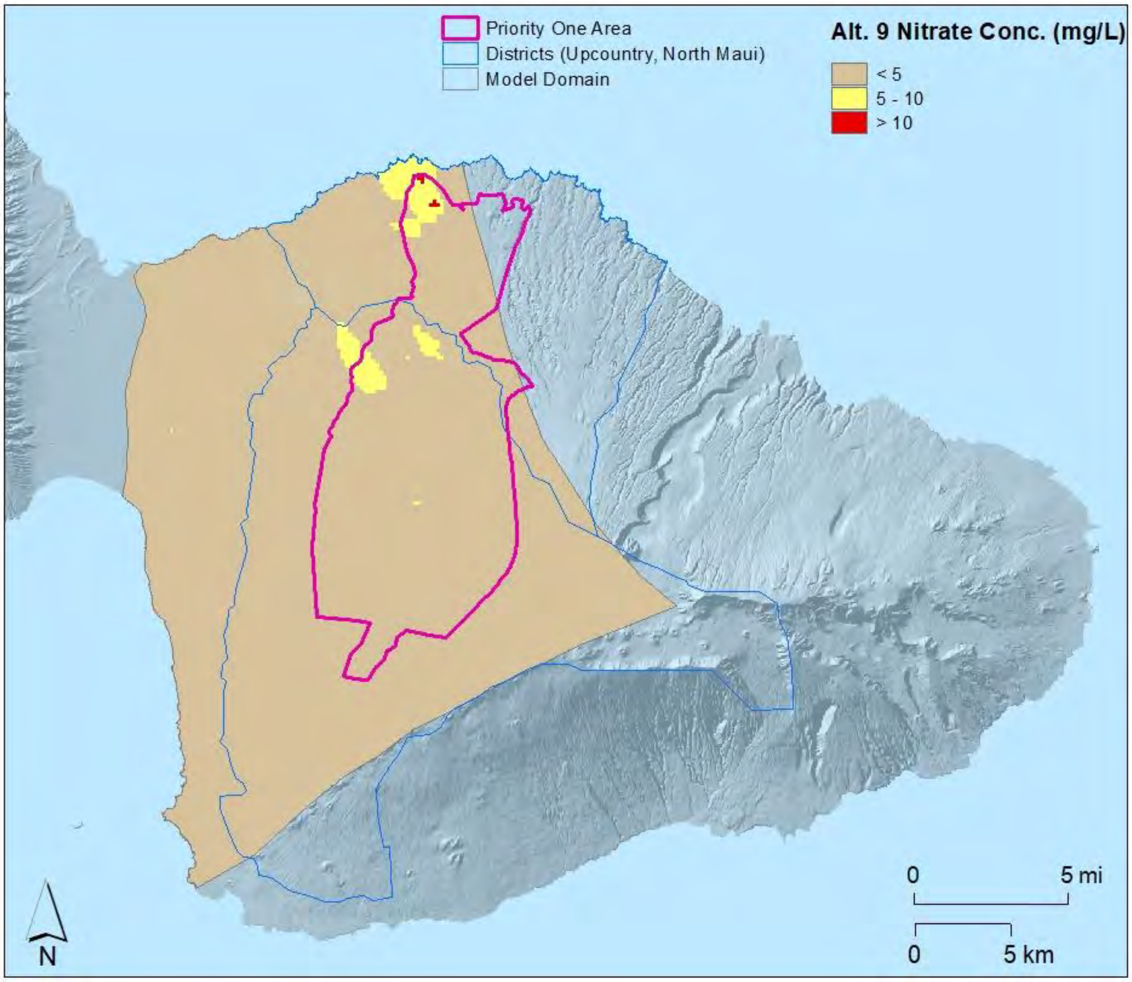


Figure AP5-10. Nitrate Concentrations of Alternative 9: Cesspools Upgrade to Septic Tank to "Layer Cake"

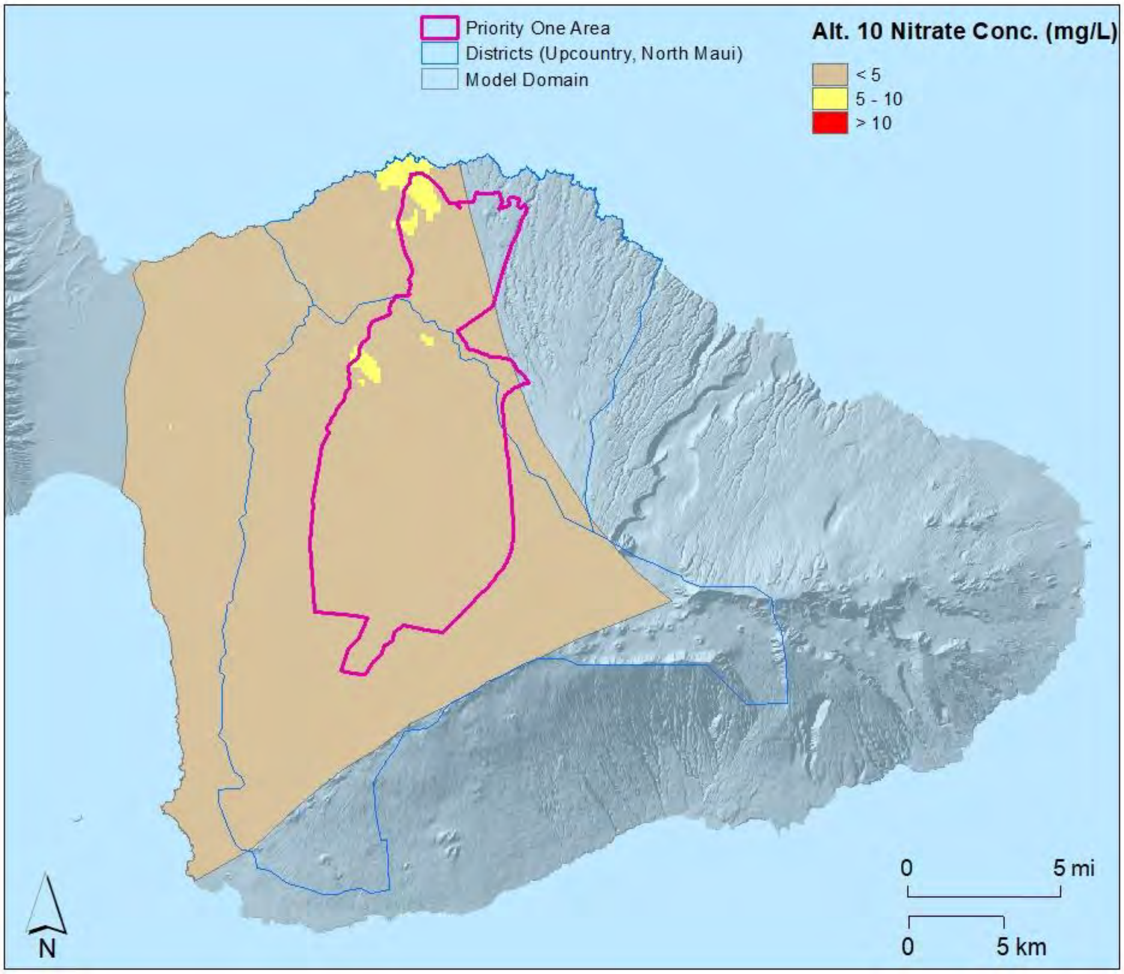


Figure AP5-11. Nitrate Concentrations of Alternative 10: Cesspools Upgrade to Septic Tank to Lined/Sequence Nitrification/Denitrification Biofilter

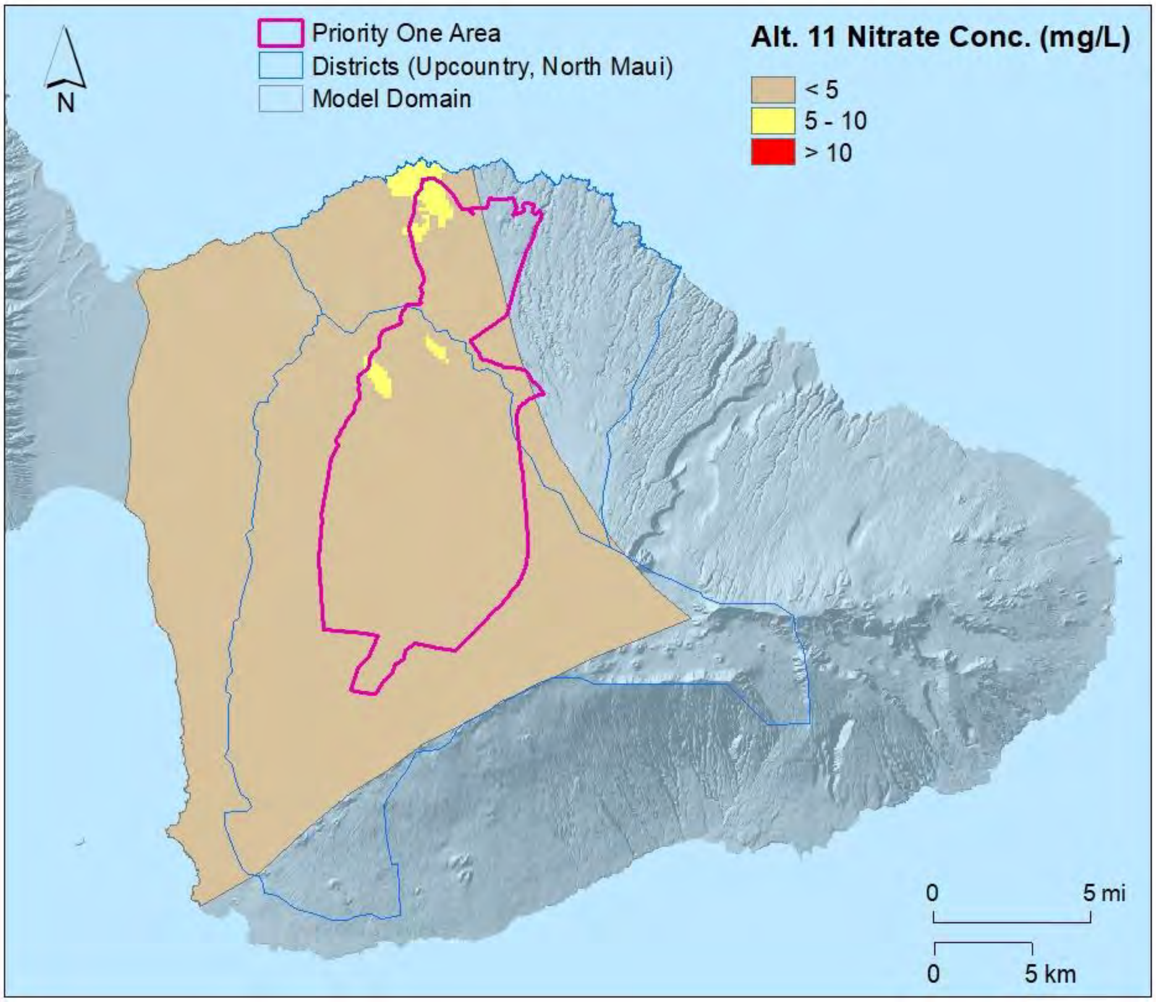


Figure AP5-12. Nitrate Concentrations of Alternative 11: Cesspools Upgrade to Aerobic Treatment Unit-Nitrification to Absorption System

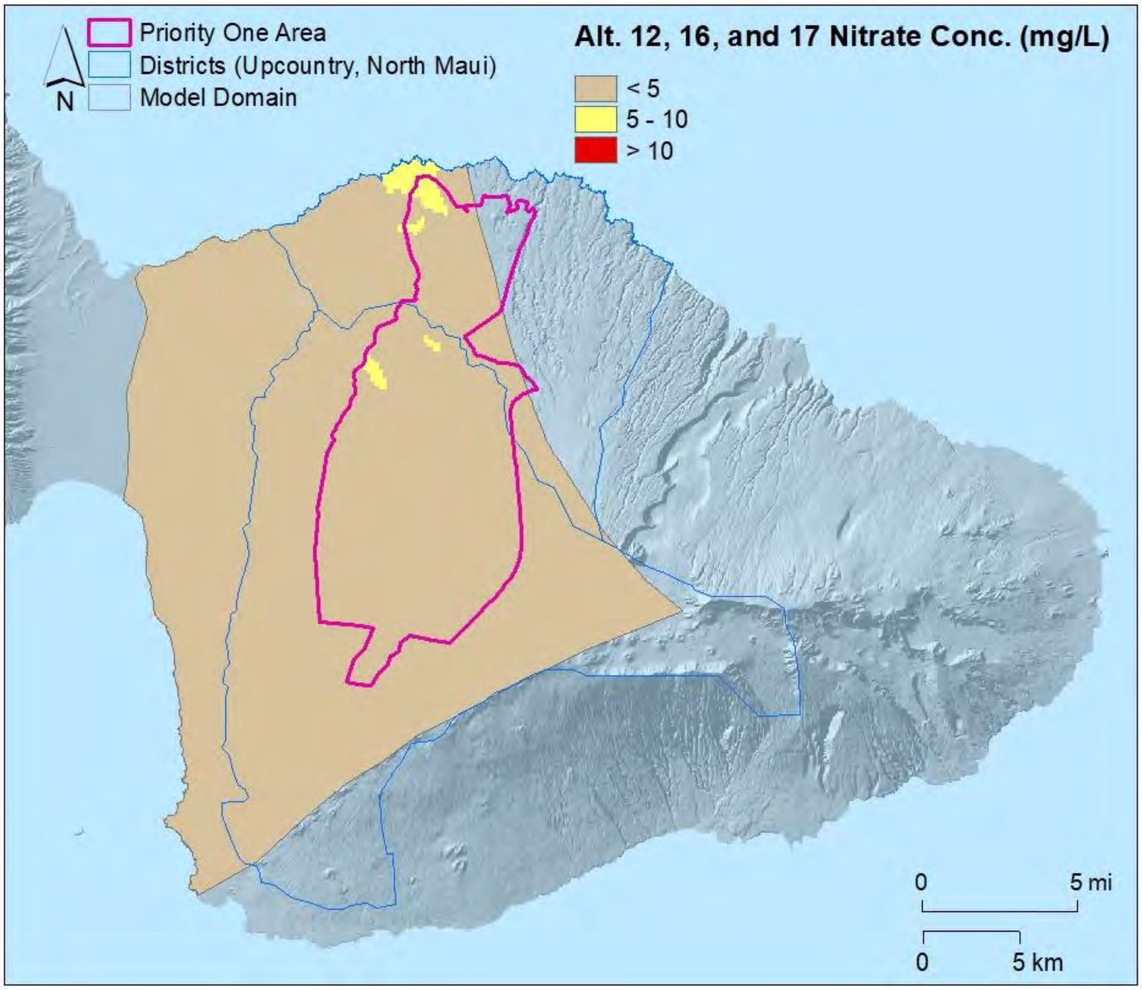


Figure AP5-13. Nitrate Concentrations of Alternative 12: Cesspools Upgrade to Aerobic Treatment Unit-Nitrification/Denitrification to Absorption System, Alternative 16: Cesspools Upgrade to Aerobic Treatment Unit-Nitrification/Denitrification to Disinfection to Seepage Pit, and Alternative 17: Cesspools Upgrade to Septic Tank to Passive Florida Units (medium, in ground). Alternatives 12 and 17 are equal because the nitrate reductions and feasibility constraints for Aerobic Treatment Unit-Nitrification/Denitrification and passive Florida units (medium, in ground) are the same. Alternatives 12 and 16 are the same because TMKs where absorption systems are not feasible, seepage pits are allowed; and TMKs where absorption systems are feasible, seepage pits are not allowed.

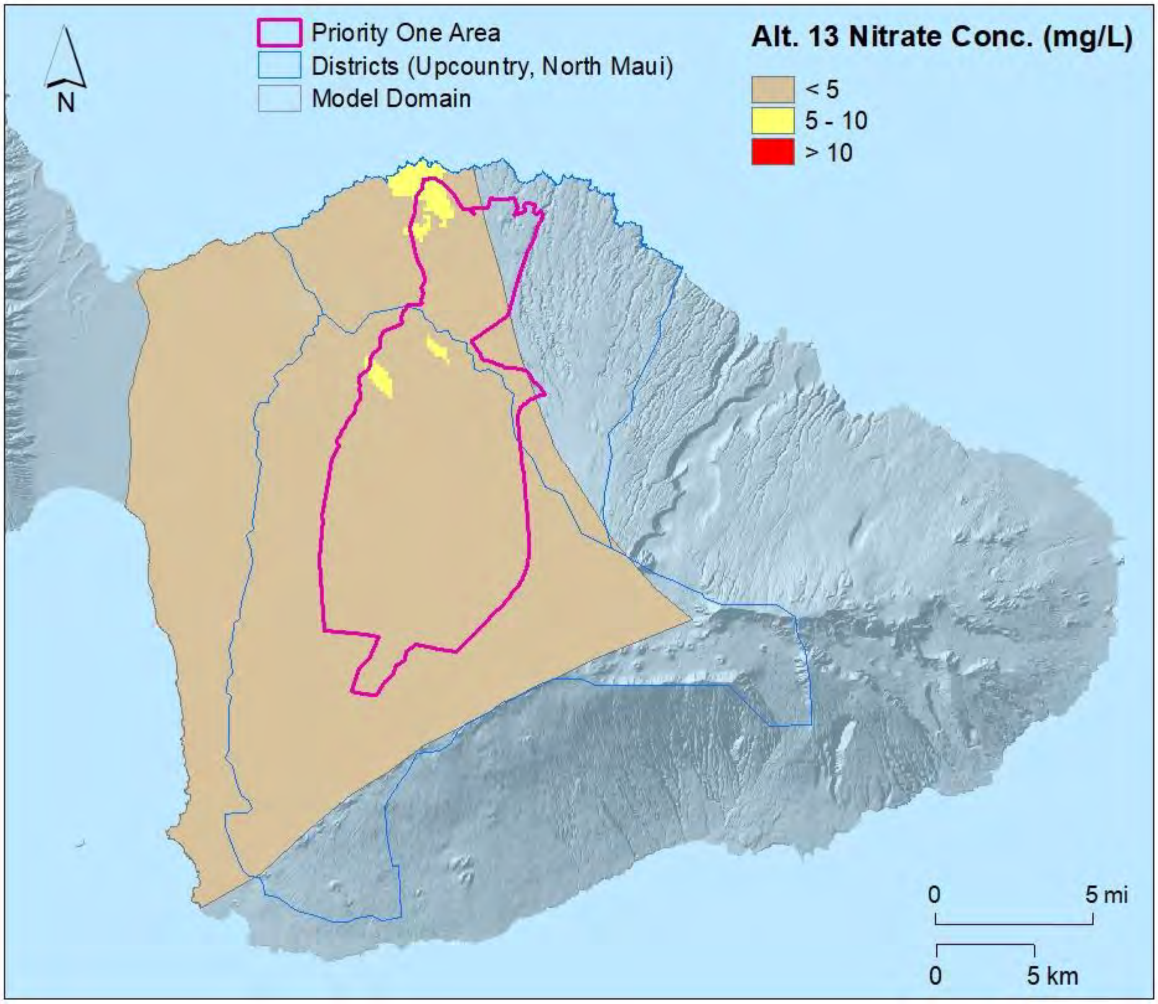


Figure AP5-14. Nitrate Concentrations of Alternative 13: Cesspools Upgrade to Aerobic Treatment Unit-Nitrification to Constructed Wetland

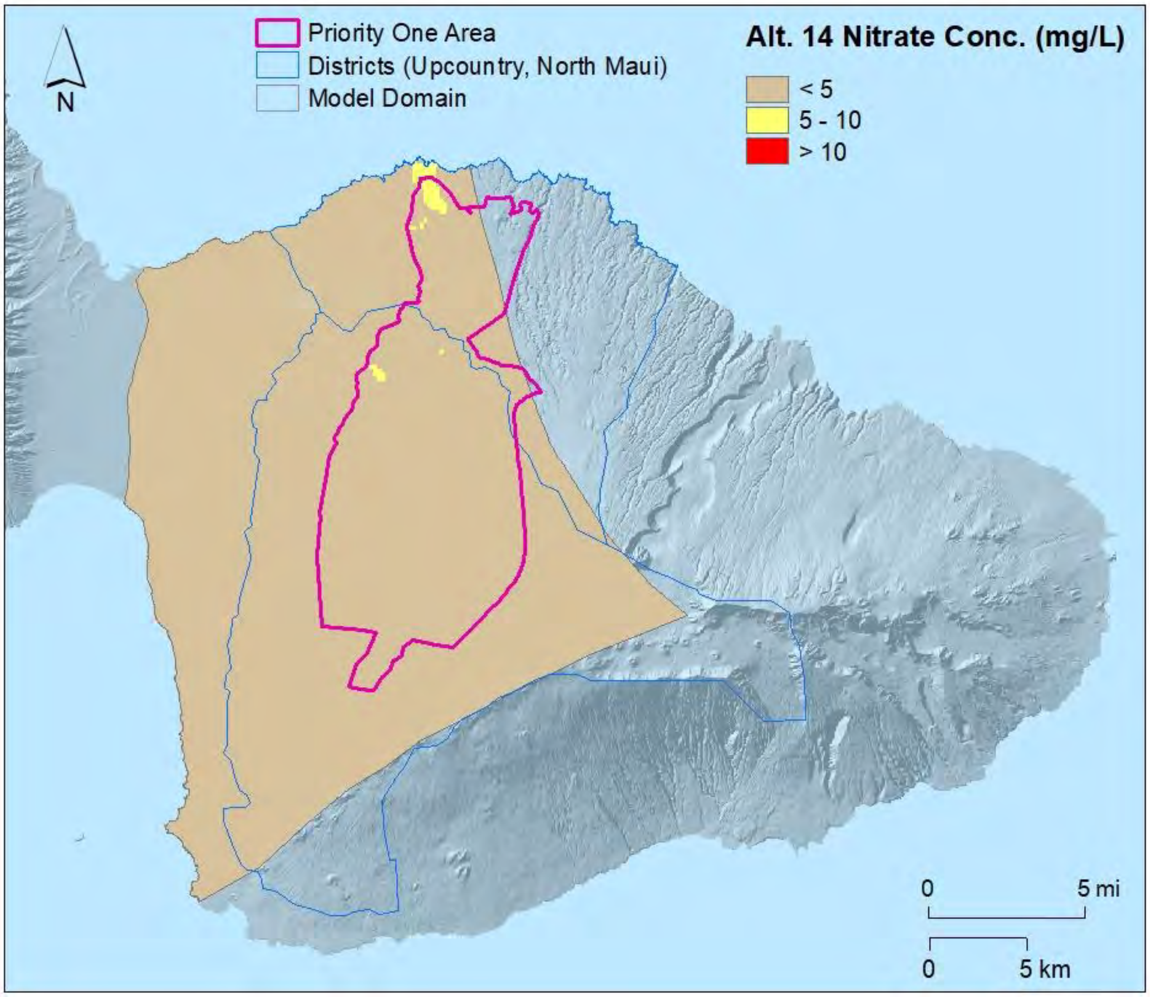


Figure AP5-15. Nitrate Concentrations of Alternative 14: Cesspools Upgrade to Aerobic Treatment Unit-Nitrification to Evapotranspiration

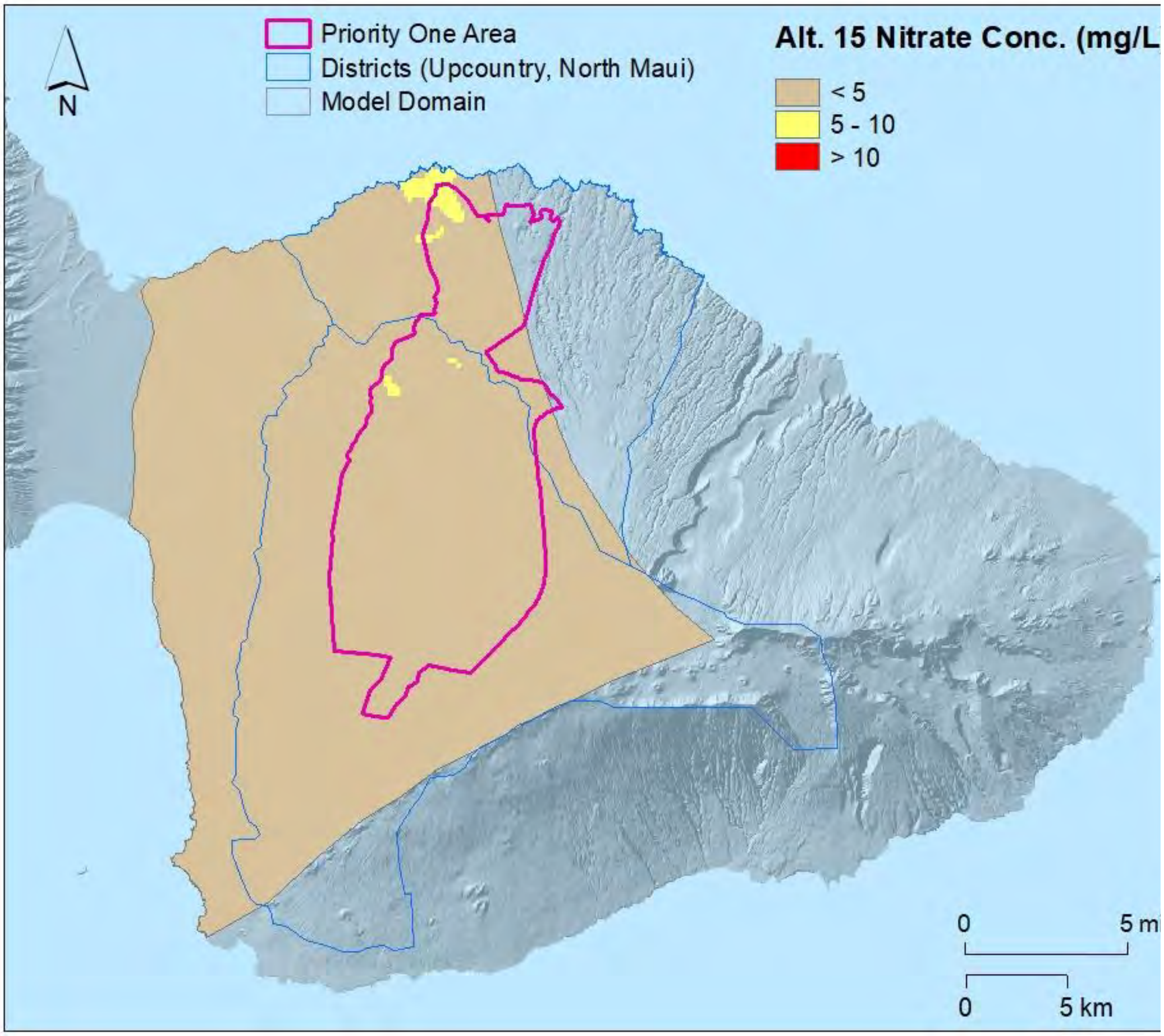


Figure AP5-16. Nitrate Concentrations of Alternative 15: Cesspools Upgrade to Aerobic Treatment Unit-Nitrification to Disinfection to Drip Irrigation

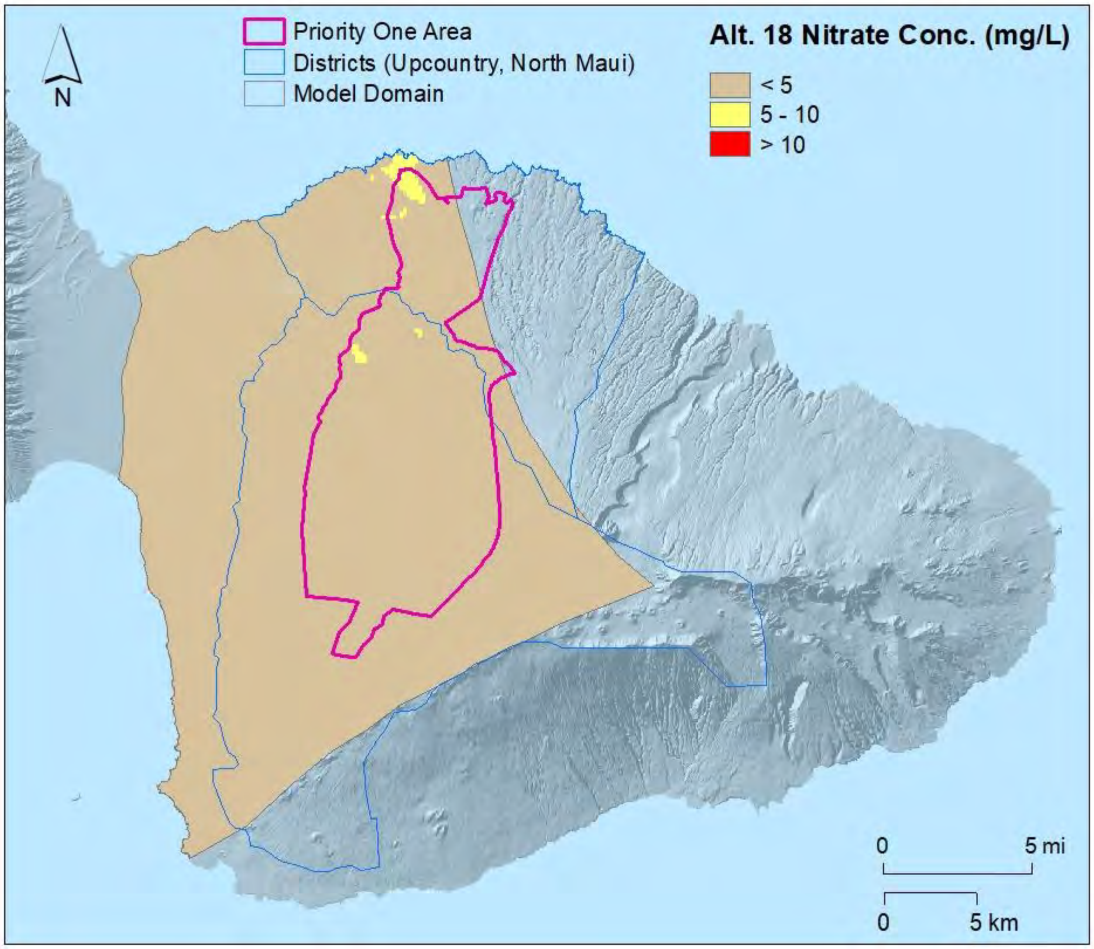


Figure AP5-176. Nitrate Concentrations of Alternative 18: Cesspools Upgrade to Septic Tank to Passive Florida Units (high) to Absorption System

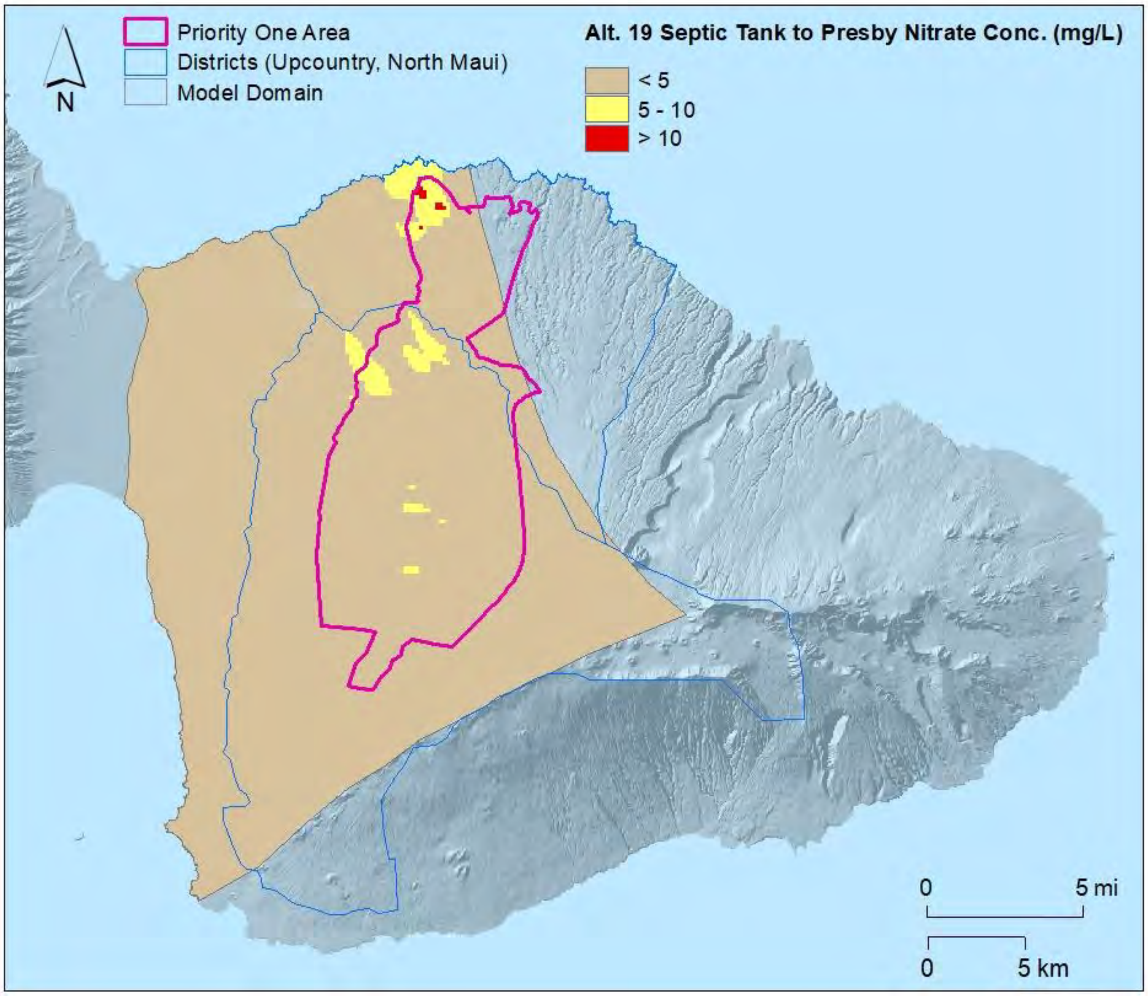


Figure AP5-18. Nitrate Concentrations of Alternative 19A: 22% Top Contributors Upgrade to Septic Tank to Presby (highest mass reduction in alternatives 1-18)

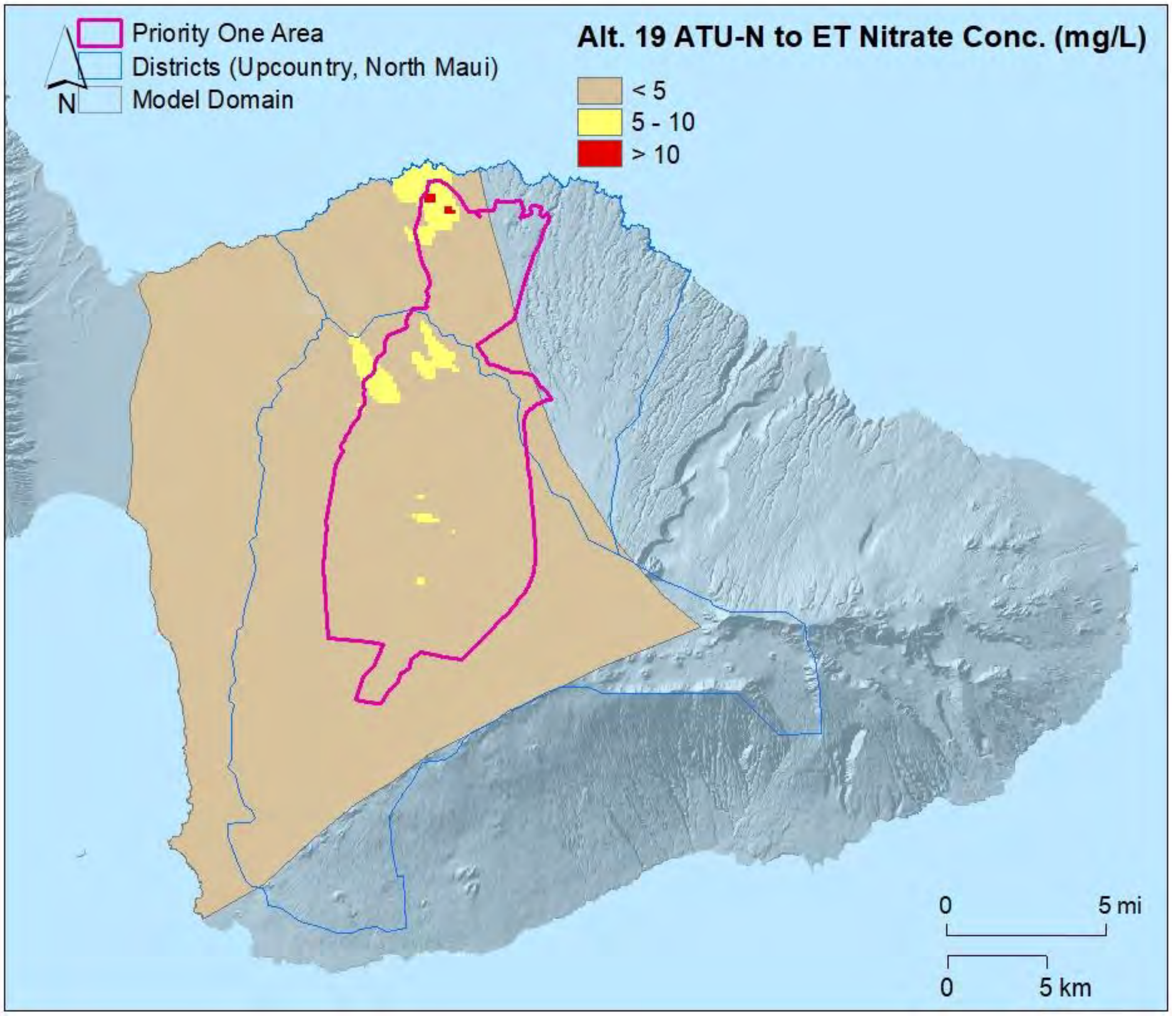


Figure AP5-19. Nitrate Concentrations of Alternative 19B: 22% Top Contributors Upgrade to Aerobic Treatment Unit-Nitrification to Evapotranspiration: (smallest area >5 mg/L in alternatives 1-18)

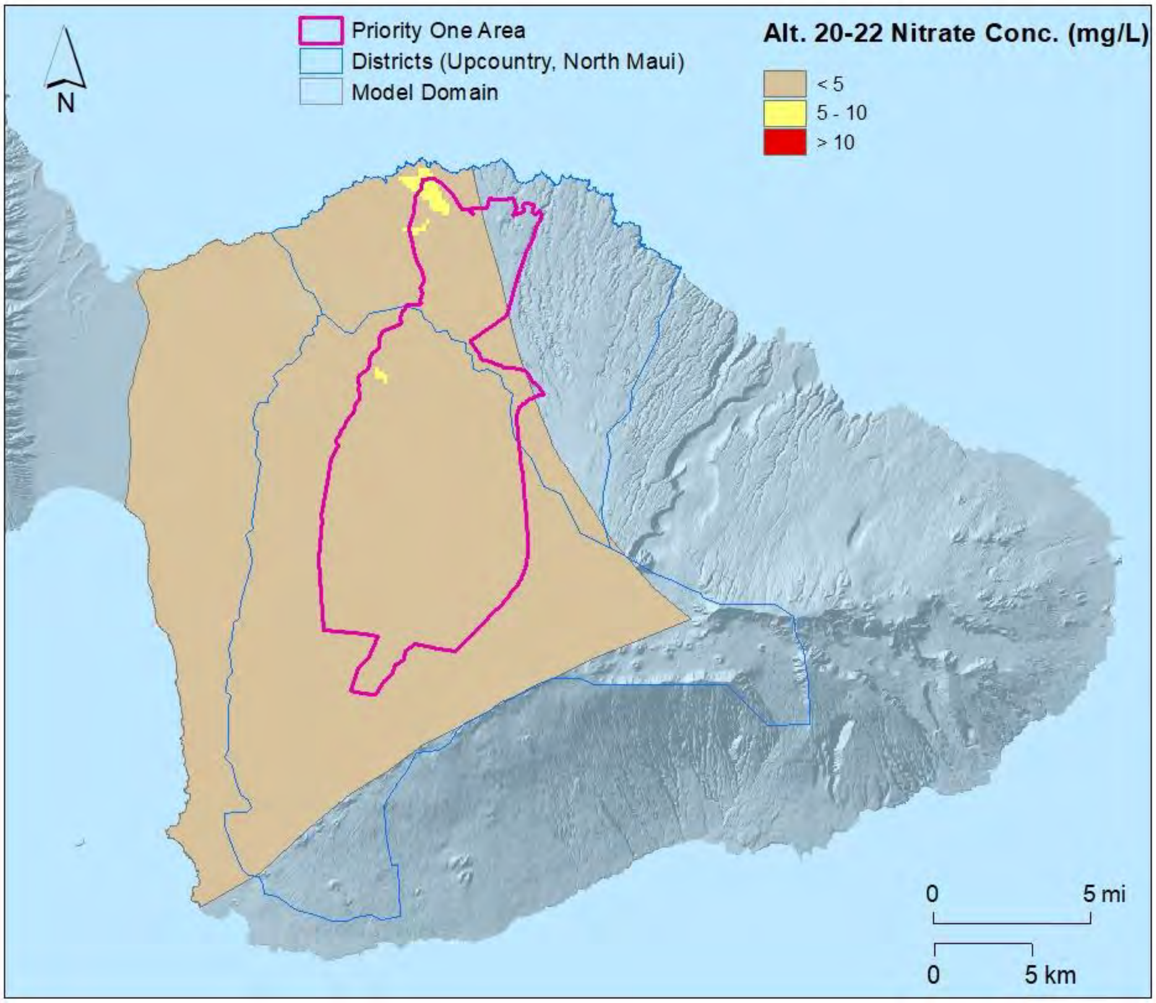


Figure AP5-20. Nitrate Concentrations of Alternatives 20-22: Sewer Makawao and Cesspool Upgrades to Septic Tank to Presby (cheapest option) Elsewhere, as possible

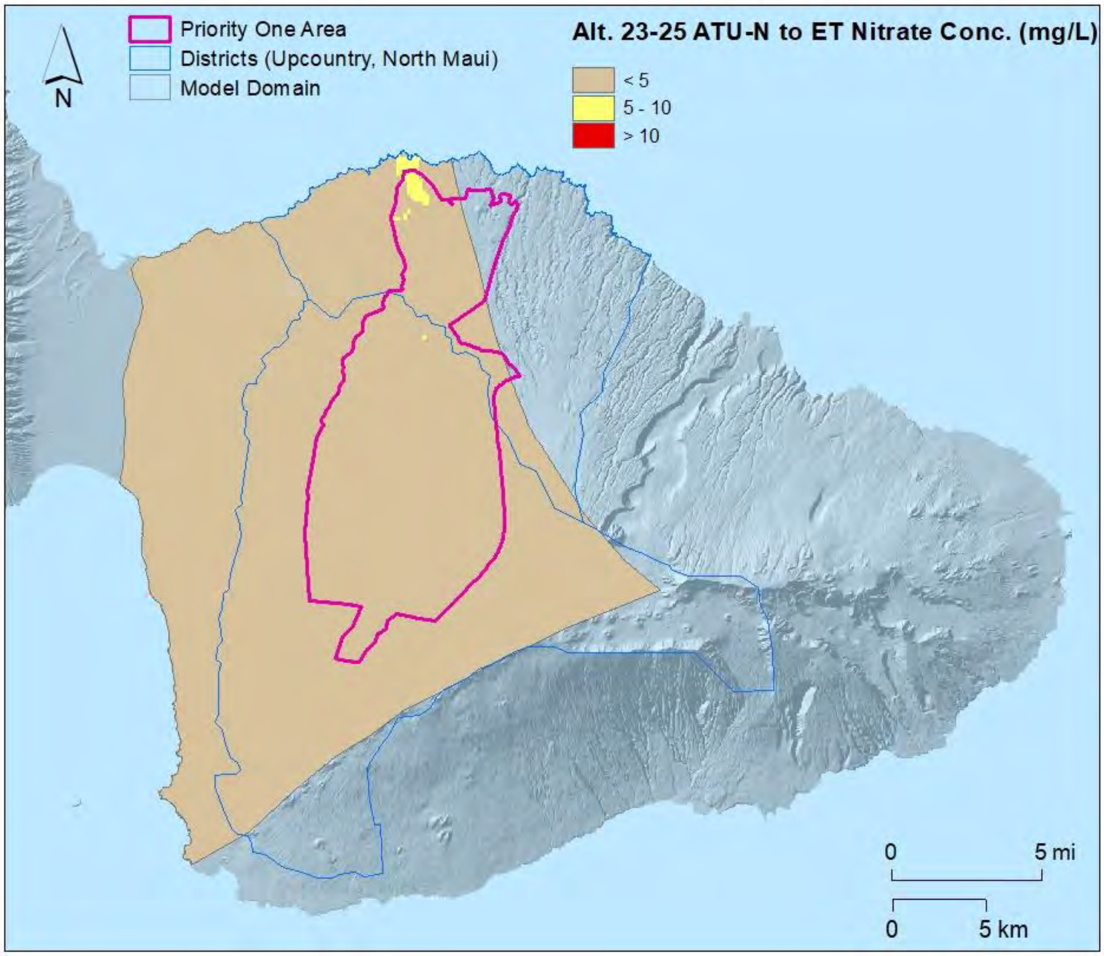


Figure AP5-21. Nitrate Concentrations of Alternatives 23A-25A: Sewer Pukalani and Cesspool Upgrades to Aerobic Treatment Unit-Nitrification to Evapotranspiration (smallest area >5 mg/L in alternatives 1-18) Elsewhere, as possible

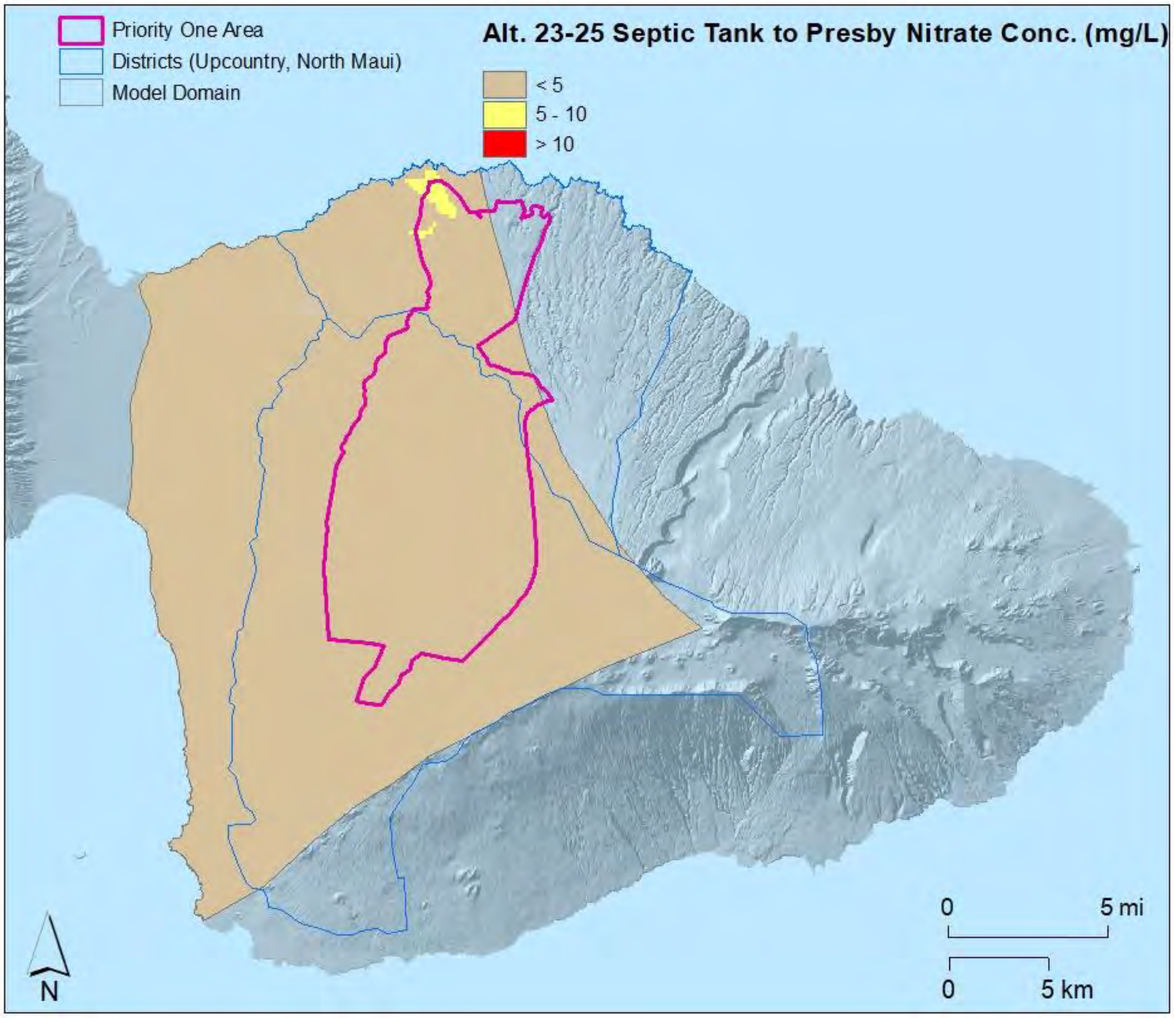


Figure AP5-22. Nitrate Concentrations of Alternatives 23B-25B: Sewer Pukalani and Cesspool Upgrades to Septic Tank to Presby (highest mass reduction in alternatives 1-18), as possible

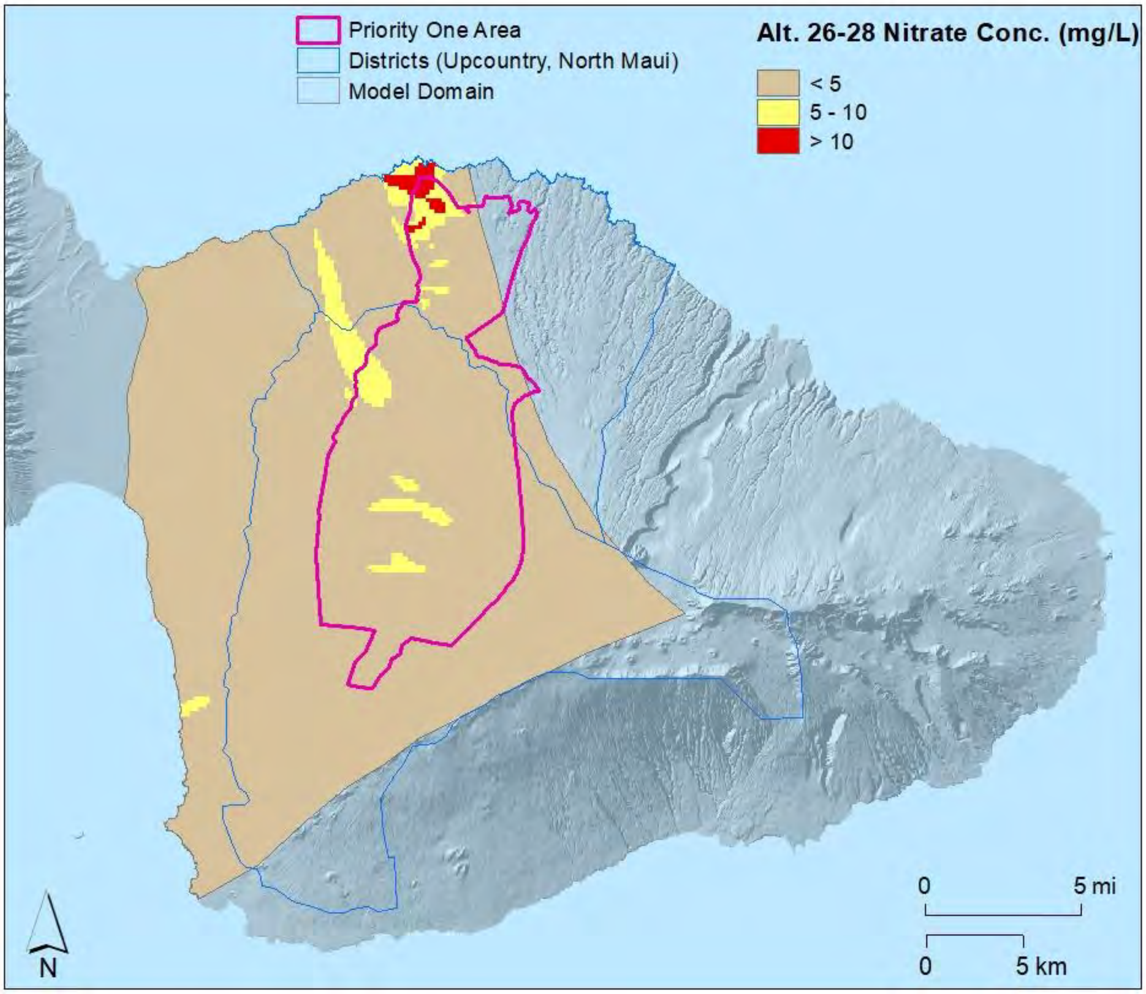


Figure AP5-23. Nitrate Concentrations of Alternatives 26-28: Sewer Makawao and No Cesspool Upgrades Elsewhere

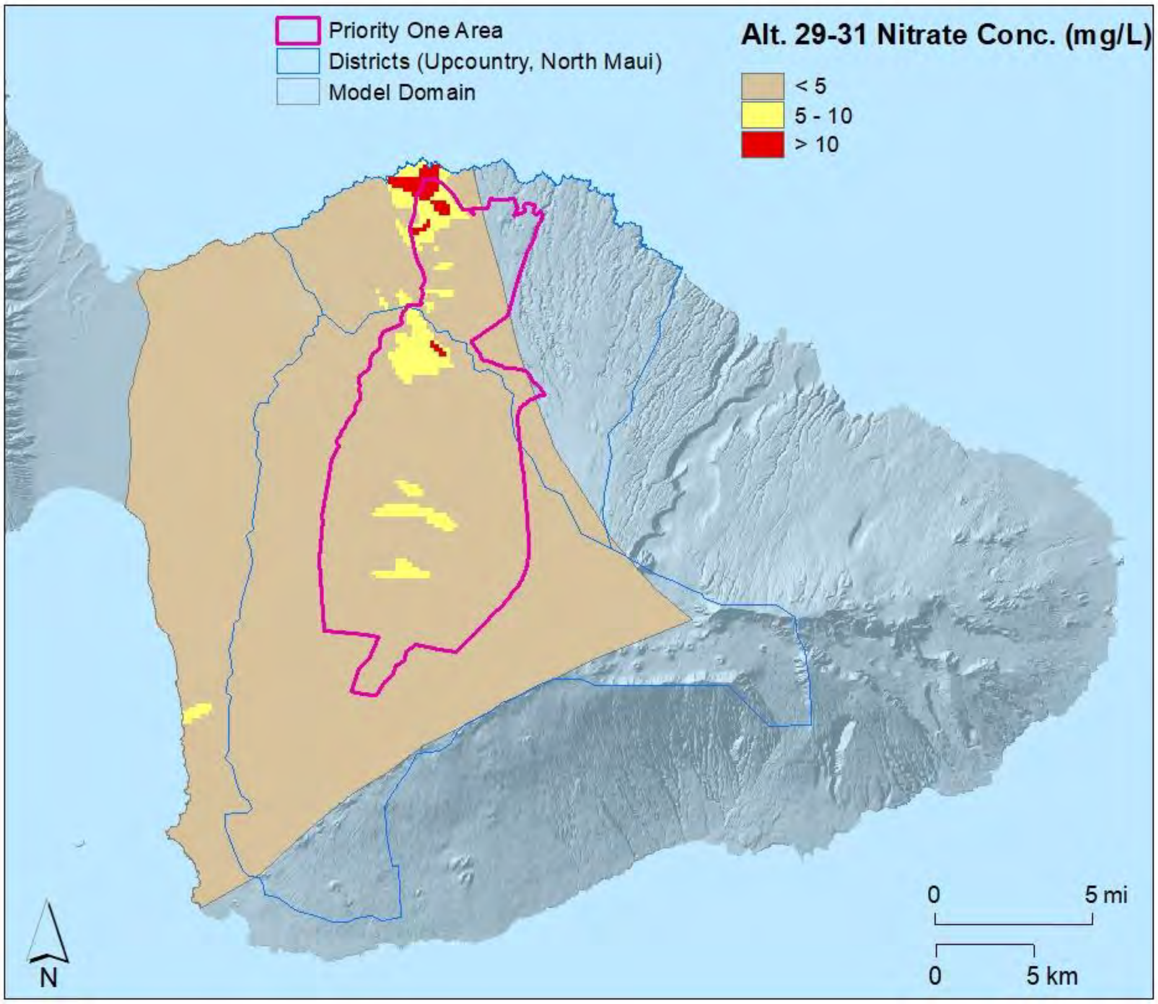


Figure AP5-24. Nitrate Concentrations of Alternatives 29-31: Sewer Pukalani and No Cesspool Upgrades Elsewhere

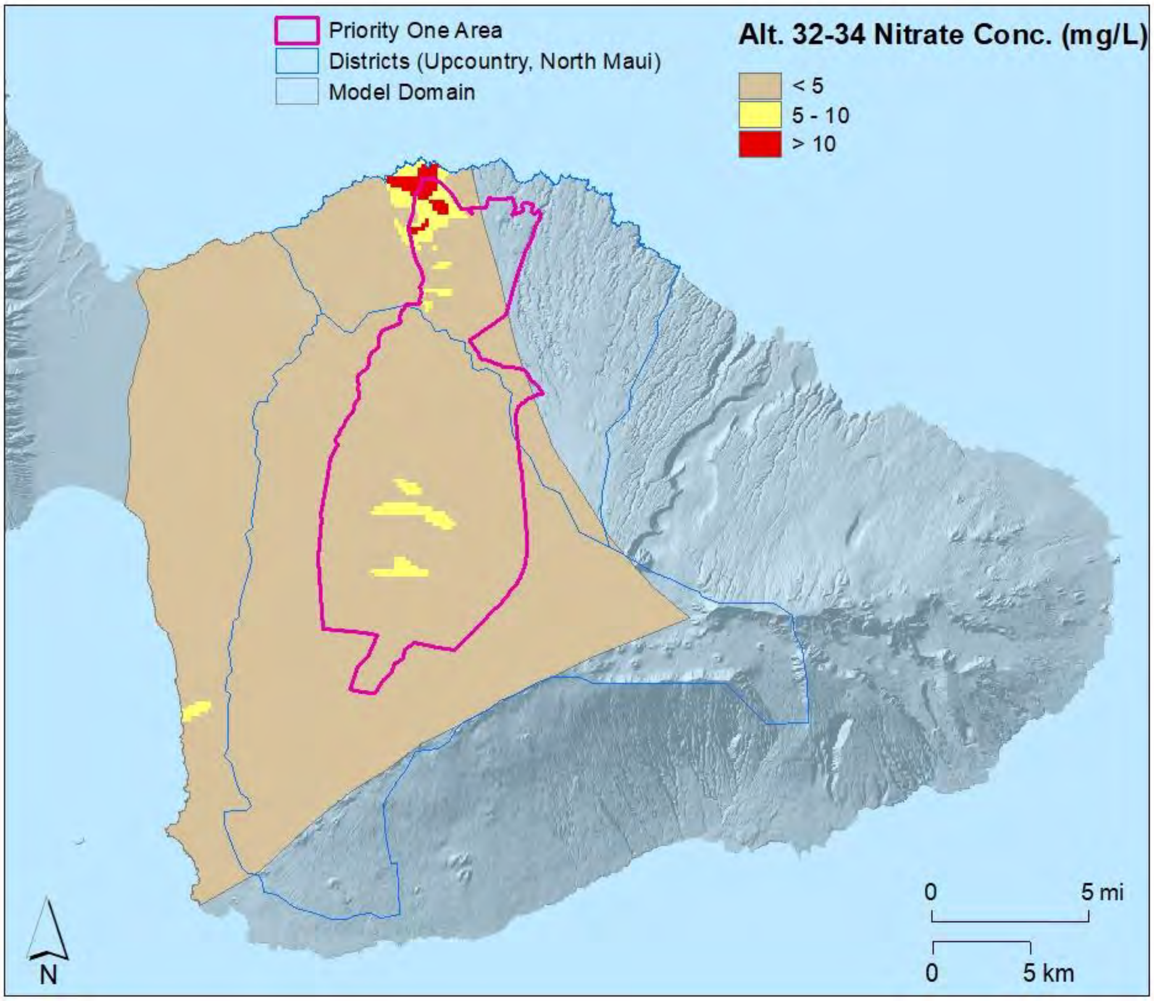
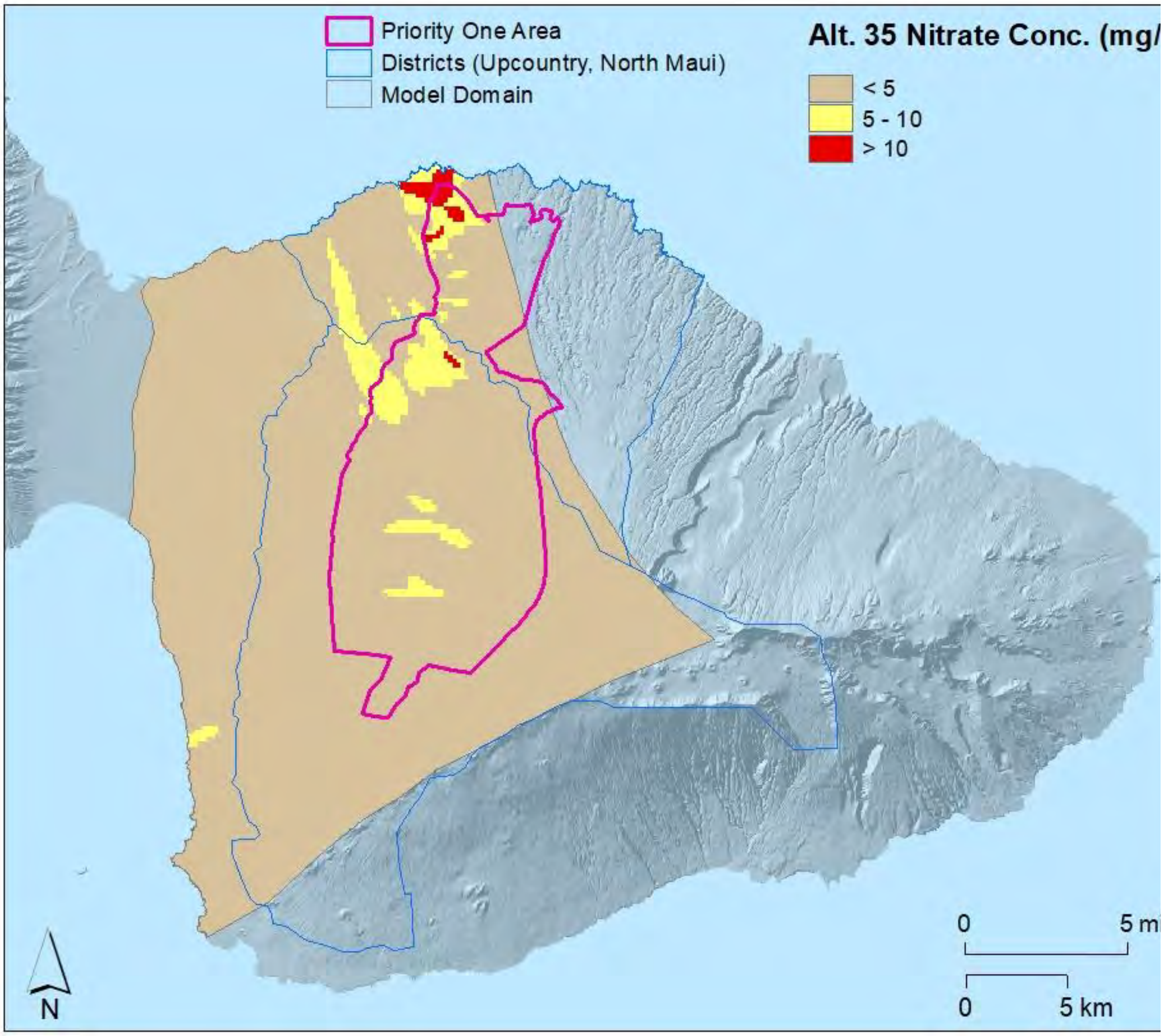


Figure AP5-25. Nitrate Concentrations of Alternatives 32-34: Sewer Makawao and Pukalani and No Cesspool Upgrades Elsewhere



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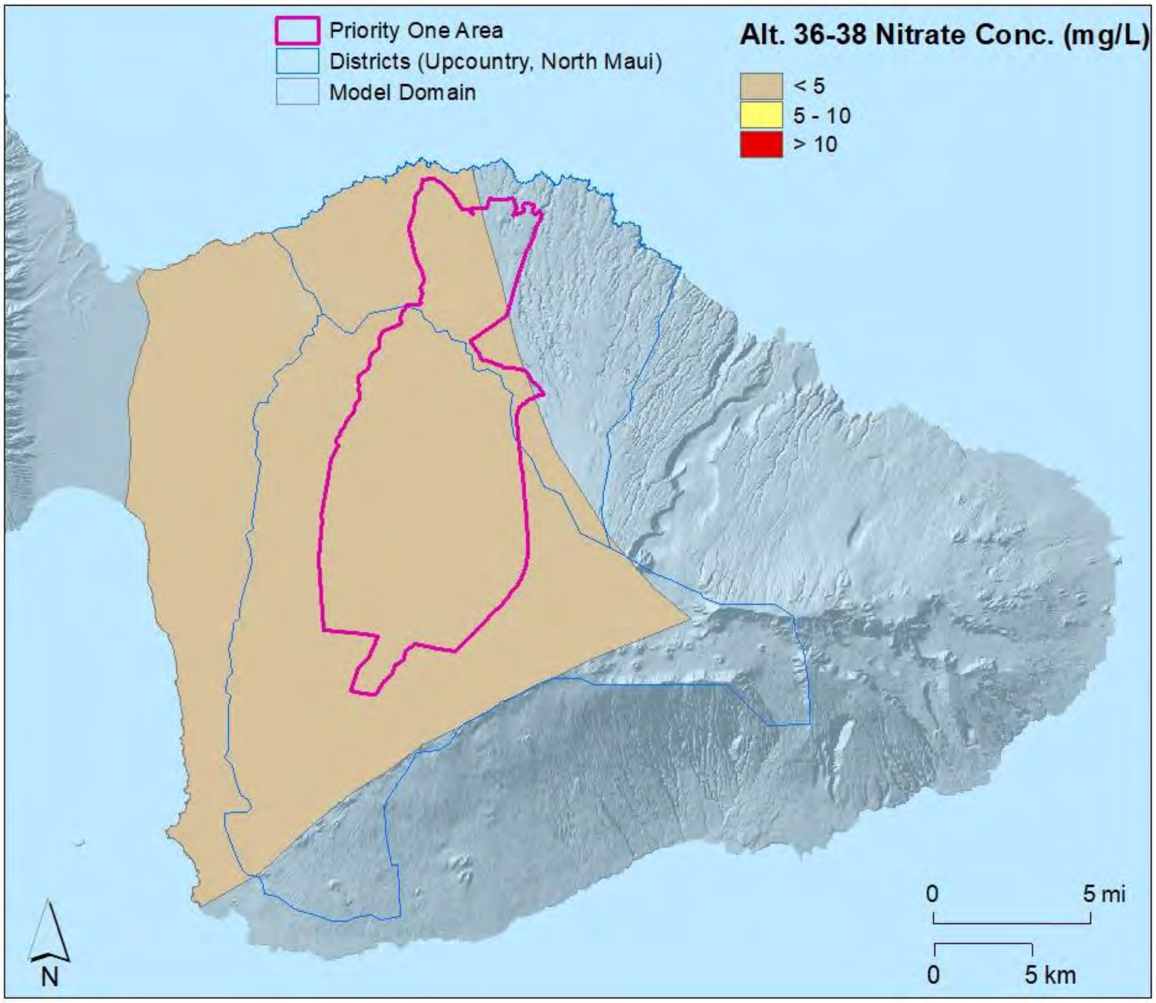

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Appendix G. 2022 Hawai‘i Cesspool Hazard Assessment & Prioritization Tool – 2022 Updated Report & Technical Appendices

2022 Hawai‘i Cesspool Hazard Assessment & Prioritization Tool

2022 Updated Report & Technical Appendices

October 2022
SPECIAL REPORT WRRC-SR-2022-02 (Revised)
UNIHI-SEAGRANT-TT-21-03 (Revised)

Prepared For:
State of Hawai‘i Department of Health Wastewater Branch
State of Hawai‘i Cesspool Conversion Working Group

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Executive Summary

Background

In 2017, the Hawaiʻi State Legislature passed Act 125 mandating that all of Hawaiʻi's estimated 80,000+ cesspools be replaced by 2050. Cesspools are a substandard sewage disposal method and are widely recognized to harm human health and the environment. An essential step in meeting this critical goal is defining a replacement prioritization method for different geographic areas and social categories. This project and its deliverables will help the State use its limited resources which are spread over a large and diverse landmass, to determine the most vulnerable areas of contamination more efficiently. The data and information presented in this report will assist the Cesspool Conversion Working Group (CCWG) and the Hawaiʻi State Department of Health (DOH) reevaluate and replace older statewide cesspool prioritization methods developed between 2009 and 2017. Though this report and the former prioritization efforts share some overlap in their approaches to evaluate the hazards cesspools pose, including using some of the same inputs and assumptions involved in individual calculations, there are significant differences concerning the methodology and results. This project will provide the CCWG and its Data and Prioritization Subgroup with updated information and data to make informed planning and preparation decisions through the geographic information system (GIS) tool titled: the Hawaiʻi Cesspool Prioritization Tool (HCPT) and this report and technical appendices.

Objectives

The HCPT and the associated report and recommendations will assist the CCWG in creating a long-term cesspool upgrade plan for delivery to the Hawaiʻi State Legislature in 2022. The HCPT's top three objectives are to:

1. Identify a comprehensive list of risk factors and develop a new cesspool prioritization and hazard assessment for the four main Hawaiian Islands;
2. Examine and categorize previously uncategorized (Priority Level 4) cesspools;
3. Reevaluate the 2017 DOH Cesspool Prioritization Report and provide recommendations based on new findings where appropriate.

Methodology

A simplified geospatial hazard-based model (data with a geographical or map-based component) was developed to integrate multiple types of risk factors to visualize, assign, and rank each factor at the individual cesspool level and collectively. The data used for the tool includes physical drivers and impacts on social and ecological assets. Physical drivers were defined as elements that control the movement of pollution, reduce capacity, or otherwise affect the overall level of impact a cesspool has on the land and also the water quality nearby. Social and ecological drivers represent quantifiable human and environmental values within the areas affected by the discharge of cesspool effluent. The tool applies high-confidence groundwater models (currently used by DOH) to determine effluent (human waste) flow paths and to link each cesspool unit to the estimated location along the coastline most affected by its discharge. Due to the model framework and request from the DOH, the current HCPT does not evaluate other sources of groundwater pollution, including agriculture or injected wastewater, or integrate observed coastal or groundwater quality observations as did the previous report. A total of fifteen risk factors were included in the model:

1. Distance to municipal or domestic drinking water wells;
2. Well capture zones;
3. Distance to streams and wetlands;
4. Distance to the coastline;
5. Sea level rise zones;
6. Precipitation;
7. Depth to groundwater;
8. Groundwater flow paths;
9. Soil characteristics;
10. Cesspool density;
11. Coral cover;
12. Fish biomass/recovery potential;
13. Beach user-days;
14. Proximity to a lifeguarded beach; and
15. Coastal ocean circulation proxy

Although the method chosen assigns a cumulative hazard score to each cesspool in the inventory, combination effects from nearby cesspools and the practicalities of management approaches make it more beneficial to group scores by pre-defined geographic areas from the United States Census. The HCPT categorizes priority areas based on existing census-designated boundaries, including census tracts, block-groups, and blocks where the number of cesspools exceeds a minimum threshold. The HCPT was designed to be as objective as possible with prioritization based solely on the relationships between datasets, thereby reducing human bias as much as possible. All data used in the HCPT is at the statewide scale, normalized, and based on regulatory rules or modeling outputs.

Results

The HCPT prioritization method (Figure ES1) places each geographic area into three Prioritization Categories that include:

1. **Priority Level 1:** Greatest contamination hazard (map color of red).
2. **Priority Level 2:** Significant contamination hazard (map color of orange).
3. **Priority Level 3:** Pronounced contamination hazard (map color of yellow).

The total number of cesspools in the state categorized as Priority Level 1 was 13,821, with 12,367 and 55,237 as Priority Level 2 and Priority Level 3, respectively. Approximately 35%, 7%, 21%, and 37% of cesspools in the Priority Level 1 group are located on O'ahu, Maui, Kaua'i, and Hawai'i Island, respectively. All results are updated as of 2022, See Appendix C for details.

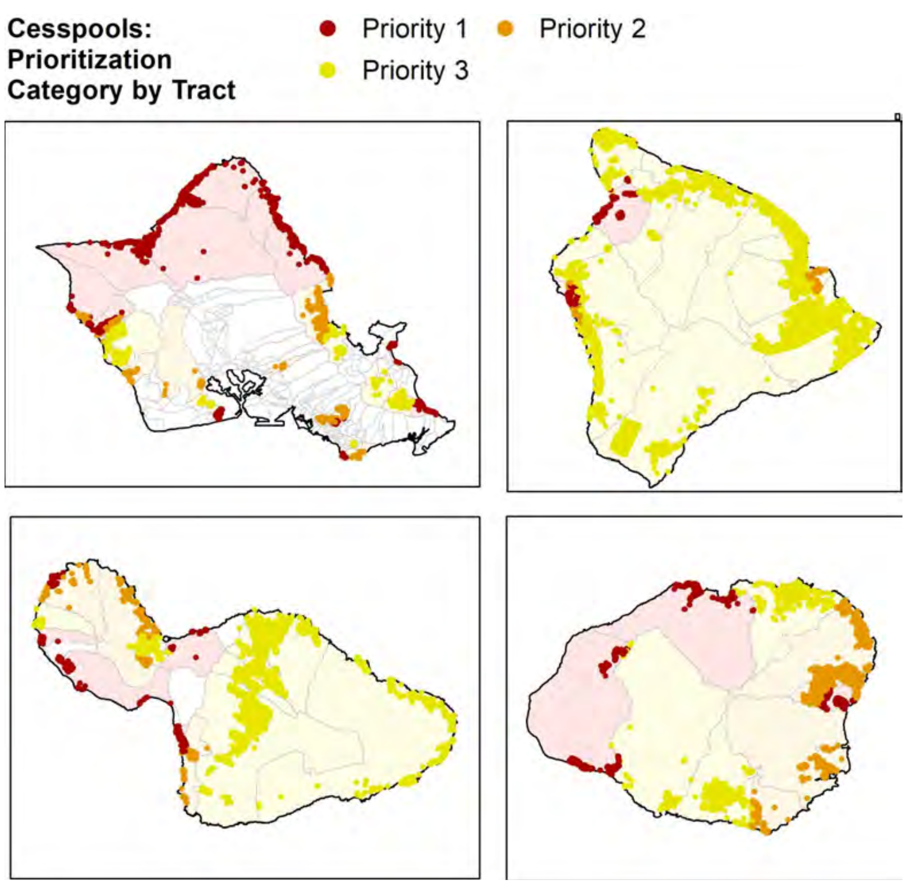

Figure ES1. *Statewide map highlighting the simplistic design of the three-tiered categories, census tracts, and their respective colors to signify a priority score.* (Updated 2022)

Key Takeaways:

1. A shift in priority ranking is to be expected due to the amount of available data and the use of census tract areas to frame the overall scores. The few areas with previous scientific data supporting the presence of wastewater pollution should be treated accordingly and factored in separately when developing conversion schemes.

2. Results and information from the 2017 prioritization effort are not part of the HCPT and are included in this report for reference and comparative purposes only, including using the 2017 priority category titles, i.e., Priority Level 1, 2, and 3.

3. Observation-based tracer (water quality) datasets were intentionally excluded from the HCPT algorithm used to calculate prioritization scores.

4. The authors recommend that all statewide cesspool inventory continue to be refined and, if possible, ground-truthed to ensure the most accurate results of the tool and for future statewide OSDS management and cesspool conversion.

5. All cesspools are substandard sewage disposal systems and pose some threat to their surroundings. Therefore, each cesspool in the inventory was assigned a priority ranking, and this analysis considers none to be exempt from conversion.

6. The tool is merely a starting point for assessing the areas with the most significant hazards and is meant to support the development of a thorough and thoughtful cesspool conversion plan. The tool cannot make decisions regarding cesspool conversion prioritization timelines.

Abstract

Cesspools are a substandard sewage disposal method and widely recognized to harm human health and the environment. The state of Hawaiʻi has an estimated 82,000 cesspools. To address pollution concerns, the Hawaiʻi State Legislature mandated replacement of all cesspools by 2050. A major step in achieving this goal is to categorize cesspools based on potential or realized harm to humans and the environment. This report details a comprehensive tool designed for this purpose. After researching similar efforts, methods and datasets were chosen that met the needs of state government, cultural values, and environmental sensitivities. The Hawaiʻi Cesspool Prioritization Tool (HCPT) was developed by integrating fifteen risk-factors that either control or relate to how cesspool impacts are distributed across communities and the environment. These factors were processed with a geospatial model to calculate a single prioritization score for every cesspool in Hawaiʻi. Because sewage pollution impacts are cumulative, individual scores were consolidated by census boundary areas. Results from the HCPT prioritization were validated through comparison with a statewide assessment of nearshore wastewater impacts funded by Hawaiʻi Act 132. Future data, organized within census area frameworks, can be layered onto the results to address equity and outreach challenges.

The HCPT was designed to be as objective as possible with prioritization based solely on the relationships between datasets, thereby reducing human bias as much as possible. All data used in the HCPT is at the statewide scale, normalized, and based on regulatory rules or modeling outputs. The total number of cesspools in the state categorized as Priority Level 1 was 13,821, with 12,367 and 55,237 as Priority Level 2 and Priority Level 3, respectively. Approximately 35%, 7%, 21%, and 37% of cesspools in the Priority Level 1 group are located on Oʻahu, Maui, Kauaʻi, and Hawaiʻi Island respectively. (*Updated* 2022)

Background and Motivation

In 2017, the Hawaiʻi State Legislature passed Act 125 mandating that all cesspools be replaced by 2050. A report produced by the Hawaiʻi Department of Health Environmental Management Division in 2017 titled: Report To The Twenty-Ninth Legislature State of Hawaiʻi 2018 Regular Session: Relating To Cesspools and Prioritization for Replacement (DOH Cesspool Prioritization Report) detailed a prioritization method to identify high-priority cesspools across the state (Hawaiʻi State Department of Health: Environmental Management Division, 2017). However, new data and recent directives by the

Cesspool Conversion Working Group (CCWG) and Hawaiʻi State Department of Health (DOH) have provided the necessary information and catalyst to reevaluate the original prioritization methods and framework. Prioritization of cesspool areas helps the State use its limited resources spread over a large diverse archipelago more efficiently, reducing any uncertainties to determine vulnerable areas of contamination. This project aims to provide the CCWG and its Data and Prioritization Subgroup with updated information and data through the creation of a geographic information system (GIS) tool titled: the Hawaiʻi Cesspool Prioritization Tool (HCPT).

Objectives

The HCPT will assist the CCWG in creating a long-term cesspool upgrade plan for delivery to the Hawaiʻi State Legislature in 2022. This project's main objectives are to:

1. Identify a comprehensive list of factors that will assist in the creation of a new cesspool prioritization and hazard assessment for the four main Hawaiian Islands;
2. Examine and categorize previously uncategorized (Priority Level 4) cesspools;
3. Reevaluate the 2017 DOH Cesspool Prioritization Report. Provide recommendations based on new findings where appropriate;
4. Identify possible exemption criteria for cesspools in areas not in need of time-sensitive cesspool upgrades;
5. Develop a web-based tool to prioritize and view specific cesspools based on identified attributes and data.

Comparison to 2017 Prioritization

The DOH requested that the results of previous efforts to categorize cesspools not be included in the new priority ranking methodology. Nonetheless, 2017 priority areas are overlaid onto the HCPT maps for comparison purposes and transparency.

The two prioritization efforts share some overlap in their methods to evaluate the hazards cesspools pose, including using some of the same inputs and assumptions involved in individual calculations. However, there are also significant differences concerning the methodology and results. For example, the previous prioritization effort evaluated the risk ranking of onsite sewage disposal systems (OSDS) at the resolution of broad geographic regions, e.g. Upcountry Maui. The HCPT treats all cesspools as nonpoint pollution sources, lumping them into finer scale frameworks of United States Census Bureau tracts, blocks and block-groups. Additionally, the HCPT algorithm does not require inputs in the form of documented impacts from cesspools, as previous assessments have. Doing so would limit where the tool can be applied, and would inherently result in bias towards places that have previously been selected for scientific studies or routine monitoring. The method in the HCPT decreases subjectivity in defining prioritization areas and simplifies public interactions with the tool, while still maintaining in-depth analysis of individual cesspools for DOH personnel. Additionally, the HCPT did not evaluate existing infrastructure elements such as nearby sewer mains, injection wells, or future sewer plans. However, these are essential elements that should be included in an overall conversion scheme.

There is some usefulness in understanding the process used for previous efforts to prioritize cesspools as a mechanism to evaluate the new results. **The information provided below is not part of the HCPT and included for reference and comparative purposes only.** The 2017 DOH Cesspool Prioritization Report identified fourteen critical locations that should receive priority when implementing a replacement plan. The previous report's prioritization method relied upon the following five factors:

1. The density of cesspools in an area;
2. Soil characteristics;
3. Proximity to drinking water sources, streams, and shorelines;
4. Groundwater inputs (agriculture and injected wastewater); and
5. Physical characteristics of coastal waters that may compound the impacts of wastewater.

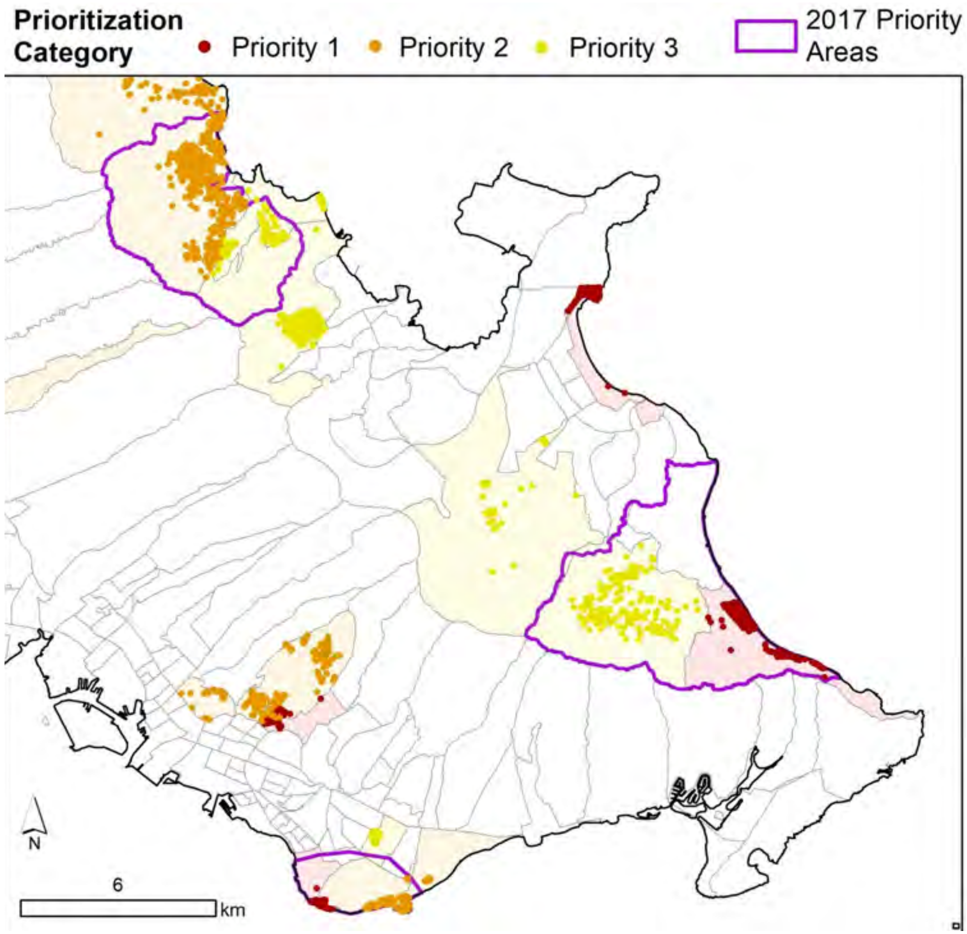

Figure 1. *Example map of Oʻahu highlighting the locations of previous 2017 priority areas paired with the newly developed priority scheme, synthesized by census tracts. (Updated 2022)*

In order to demonstrate how the newly designated priority areas overlap with the 2017 priority areas from DOH, the authors also performed a comparative analysis, detailed in Appendix A. There readers can view how the HCPT results fit into previous efforts. Further discussion of why and how the schemes differ follows in subsequent sections. **Finally, with direction from DOH and the CCWG, the HCPT continued use of the 2017 priority category titles, i.e. Priority Level 1, 2 and 3. However, the definitions that accompany the old 2017 priority categories are not continued and do not apply to the HCPT.**

Conceptual Model

Before continuing, it is important to clarify the language used in this report. The terms risk and hazard are often used interchangeably. However, for this exercise, the term hazard will be used to denote potential for harm. The Canadian Centre for Occupational Health and

Safety (2021) defines a hazard as "any source of potential damage, harm or adverse health effects on something or someone." Risk is defined as "the chance or probability that a person will be harmed or experience an adverse health effect if exposed to a hazard, see Equation 1 (Canadian Centre for Occupational Health and Safety, 2021). Identifying specific risks, such as the number of people who will contract an illness from cesspool pollution is beyond the capability of this assessment. We can, however, estimate the risk of a hazard that may cause harm to people or the environment and offer a priority ranking to achieve this goal. In our prioritization, this was done through evaluation of the cesspool distance to a hazard or potential for exposure to wastewater contaminants through mechanisms such as swimming or drinking water. A complete evaluation and integration of exposure science is beyond the scope of this project.

$$\text{Risk} = \text{hazard} \times \text{exposure}$$

Equation 1. *Risk equals hazard times exposure.*

Tool Structure

The current report and HCPT expand on the previous efforts to provide a quantitative, up-to-date hazard assessment of geographic areas that may be adversely impacted by cesspool pollution. The HCPT uses the most up-to-date data available and its methods are reproducible and transparent. Relevant information, including source code, is publicly accessible through published notes books located on GitHub (click here to view). It was developed in consultation with local experts, engineers, and government associates to prioritize cesspools in the allotted time frame of the contract and CCWG needs. Though the prioritization process is inherently contextual, every effort has been made to create a non-biased objective evaluation of cesspool hazards in an equitable and fact-based methodology. There will be shifts in ranking between the old prioritization method and the new method. **The shift in ranking is to be expected due to the amount of available data and the use of census tract areas to frame the overall scores. For the few areas that have previous scientific data supporting the presence of wastewater pollution, they should be treated accordingly and factored in separately when developing conversion schemes.** The current HCPT does not evaluate other sources of groundwater pollution (agriculture or injected wastewater) or integrate observed coastal or groundwater quality observations as did the previous report. It was determined that other sources of groundwater pollution can significantly complicate the behavior of wastewater tracers, and the geographic extent of water quality data availability is very limited for statewide application.

Therefore, observation-based tracer datasets were intentionally excluded from the algorithm used to calculate prioritization scores. Instead, the HCPT's results are validated against the most robust statewide assessment of coastal wastewater impact available using observed and modeled nitrogen impacts from the Hawaiʻi Act 132 statewide study of sewage contamination.

The HCPT uses the following criteria (risk factors) to calculate a geographic prioritization score:

1. Distance to municipal or domestic drinking water wells;
2. Well capture zones;
3. Distance to streams and wetlands;
4. Distance to coastline;
5. Sea level rise zones;
6. Precipitation;
7. Depth to groundwater;
8. Groundwater flow paths;
9. Soil characteristics;
10. Cesspool density;
11. Coral cover;
12. Fish biomass/recovery potential;
13. Beach user-days;
14. Proximity to lifeguarded beach; and
15. Coastal ocean circulation proxy

As mentioned previously, adverse impacts from cesspools are cumulative. Therefore, it was important to identify a proper scale to evaluate the updated priority ranks. The HCPT frames cumulative cesspool pollution within United States Census Bureau tract boundaries to achieve this goal. The United States Census Bureau (n.d.) identifies census tracts as "small, relatively permanent geographic entities within counties (or the statistical equivalents of counties) delineated by a committee of local data users. Generally, census tracts have between 2,500 and 8,000 residents, and boundaries that follow visible features." Using census tract boundaries allows for more detailed resolution and increases objectivity from previous efforts. There are approximately 320 census tracts within the state of Hawaiʻi, and of these, just over 100 have a sufficient number of cesspools (greater than 25) to be ranked by the HCPT. Two additional census layers are available for analysis and include census block groups with 837 total and 236 ranked (greater than 20 cesspools) and census blocks with 22,780 total and 1,107 ranked (greater than 10 cesspools).

The new prioritization method utilized in the HCPT tool places each geographic area into three priority categories (Figure 1):

1. **Priority Level 1:** Greatest contamination hazard (map color of red).
2. **Priority Level 2:** Significant contamination hazard (map color of orange).
3. **Priority Level 3:** Pronounced contamination hazard (map color of yellow).

When homeowners use the HCPT web-based map tool they will enter a property TMK or address into a search bar. The HCPT will display the cesspool location(s) on a map with a color-coded dot of the corresponding priority. In addition, the surrounding census tract will be highlighted in the hazard category color to further help display the data. The public portion of the HCPT was designed to help homeowners obtain the most pertinent information in the fastest method possible. The DOH will have access to individual layers and ranking of cesspools in a similar online map tool for planning and management purposes.

While updating the prioritization method, the authors were asked to make recommendations to identify potential exemption criteria for groups of cesspools that are unlikely to severely impact the environment and human health. **In reality, all cesspools are substandard sewage disposal systems and pose some threat to their surroundings. Therefore, each cesspool in the inventory was assigned a priority ranking, and none are considered by this analysis to be exempt from conversion.** However, from a policy perspective, it is untenable to review every single system on an individual level. Therefore, the tool results are consolidated into prioritization areas using census boundaries at multiple different resolutions. In order to not skew the census area priority ranks by including areas with a small number of cesspools, a minimum number of cesspools within each census area was established, and those census areas with less than the minimum number were not ranked. Specifically, the cesspools in census tracts with less than 25 units were not ranked on the tract level, cesspools in census block-groups with less than 20 units were were not ranked on the block-group level, and cesspools in census blocks with less than 10 units were were not ranked on the block level. **Despite the fact that these more isolated cesspool units are likely to be less prone to contributing to cumulative effects, they nonetheless do receive a priority score, but only at the individual cesspool level.**

Tool Development

After researching related legal, academic, and gray literature via internet searches and academic databases including Google Scholar, Web of Science, and Pubmed, a simplified geospatial hazard-based model was developed to visualize, assign, and rank multiple factors to point locations on a map. This method assigns a cumulative hazard score to each cesspool in the inventory. Similar tools for OSDS prioritization described in the literature were considered when developing this methodology for Hawaiʻi, and include Hawaiʻi Department of Health (2017); Flanagan et al. (2019); Kinsley et al. (2004); and Oosting & Joy (2013). Although the HCPT provides a hazard score for every individual cesspool in the inventory, combination effects of nearby units, as well as the practicalities of management approaches mean it is more beneficial to aggregate these scores by pre-defined geographic areas, similar to Kinsley et al. (2004) and Oosting & Joy (2013). However, Hawaiʻi has a unique political structure and both highly urbanized and rural populations, making traditional ecological/political aggregate frameworks, such as watershed boundaries, incompatible. Instead, the HCPT uses existing census-designated boundaries as described in the Background and Motivation section. The prioritization scores of all cesspools within each census area are averaged, and this average score is then assigned to the census-boundary area to represent the cumulative hazards from all cesspools in that unit. **Although the variables used likely have various interrelationships, each input in the tool is distinct in its representation of hazards and treated as independent of one another for simplicity.**

By using an aggregated risk and hazard assessment methodology, the tool estimates the likelihood of adverse impacts or pressures to a given area resulting from human activities (cesspool effluent discharge). Additionally, the HCPT differs from other models by incorporating societal and environmental values such as beach visitor use, fishery health, coral cover, and the potential for cesspool remediation to improve coastal ecosystems. The tool cannot evaluate all social and environmental information relevant to cesspool pollution or decision-making associated with cesspool conversion, nor is the tool intended to replace robust planning, policy, and management processes. **The tool is merely a starting point for assessing the areas with the most significant hazards and is meant to support development of a thorough and thoughtful cesspool conversion plan. The tool cannot make decisions regarding cesspool conversion prioritization timelines.**

Developing a tool that is unique to Hawaiʻi means there are several differences from the method(s) used previously to prioritize cesspool hazards in Hawaiʻi, and methods that exist across the continental United States. These differences include:

- Incorporating high-confidence groundwater models to determine effluent flow paths and to link each cesspool unit to the location along the coastline most affected by its discharge. These models have previously been validated through the sampling of coastal wastewater indicators, and are considered to be relevant for this purpose.

- Considering impacts to social and ecological assets located downgradient from each cesspool as a part of the overall ranking. These include lifeguarded beaches, coral reef habitat, fish biomass, and a proxy for coastline usage.
- Calculating cumulative hazard scores (based on nonpoint source pollution dispersion) using non-arbitrary census-designated areas at multiple resolutions to develop a more realistic nonpoint source pollution framework.
- Excluding parameters such as lot size or system age. Hawaiʻi is an outlier when comparing continental models to evaluate OSDS priority zones because of limited real estate space and the high density of OSDS per acre. Age was excluded because cesspools have similar impacts irrespective of maintenance or system age.
- Assumes all properties are occupied year-round versus actual property use (i.e., seasonal, vacation rental)
- Excludes commercial and industrial properties.
- Incorporates sea level rise projections from the Hawaiʻi Sea Level Rise Viewer.

The HCPT moves beyond qualitative methods and assessments using water quality impact research, which is subject to sampling bias and limited for statewide analysis. The focus is instead on measurable environmental factors, regulations, and values (with statewide data) tied to water quality to create a quantitative assessment that can add future data to refine scores if needed. However, not all areas have data for measurable impacts. Therefore, some assumptions were made when data gaps existed or simplifications were required, which will be discussed further in elements of the Methodology section.

The HCPT development team aims to use an iterative user design process for its web-based map/public viewer. Our goal is to understand human dimensions and needs regarding cesspool prioritization information. Because the process is iterative, several updates of the tool may be created to serve different audiences. The audience for the public map tool is primarily homeowners, while the advanced map tool is developed for internal DOH scientists, and other state employees indirectly involved in the cesspool conversion issue and associated wastewater challenges.

Methodology/Dataset Categories

This section will describe the framework and systems used to create the HCPT as well as the challenges encountered. The results of the tool rely on the best publicly available data.

As the tool was being developed, several challenges were identified regarding data consistency and quality. These include:

- TMK number discrepancies with county tax data and DOH database.
- Accuracy of OSDS classification (cesspool, septic, aerobic treatment unit).
- Accuracy of the number of OSDS.
- Limited statewide data regarding water quality indicators/impacts.
- Limited data on sewer laterals (private/municipal).

Physical Drivers and Environmental Quality Hazards

Physical drivers, for this report, are elements that control the movement, reduce capacity, or otherwise affect the overall level of impact a cesspool has on the land and also the water quality nearby. Much of the data used in the HCPT is also used by agencies like DOH or county water supply departments for source water protection and public health. The impact an individual cesspool has on its surroundings depends on many factors. Even with readily available data, it is difficult to assess impact due to various environmental factors and complex interactions. No tool can fully predict or assess all environmental variables. Primary factors that contribute to the HCPT include physical factors such as soil suitability and surrounding geology, location, and proximity to environmentally sensitive areas like wetlands and coastlines. Additional factors include social and ecological assets affected through the coastal discharge point of effluent, and cumulative impacts of other nearby cesspools. **Importantly, the tool's concept is based on the hypothesis that the more cesspools in an area, the less effective natural soil and subsurface systems will be at degrading cesspool effluent.**

Because this project was designed to assess cesspools statewide, only data that was at the statewide scale were used. Though this may exclude other important datasets, DOH requested a statewide methodology. Where these datasets had missing values, gaps were filled using the best available proxies described below in their categories. **Generally, only datasets with a minimum of 90% geographic coverage of the state were used.** Often, the geographic coverage of many of these datasets only extended across the four main Hawaiian Islands. While it is recognized that there are cesspool impacts on the outer islands of Moloka‘i, Lanai, and Ni‘ihau, these islands were not included in a number of key datasets necessary to this analysis. The authors recommend that DOH establish a ranking system for these islands when time and funding allows. The relationship between the cesspool location and the geographic distribution of the hazard or risk-factor was either defined as a scalar value (1 to 100) or a categorical value (0 or 100) through individual scaling factors based on regulatory or evidence-based thresholds. For example, any cesspool within 50 feet of the coastline was assigned a scalar score of 100 based on the state regulatory setback distance.

Value-Based Environmental/Human Hazards

While the physical factors can control the level of impact a cesspool typically has, other factors can help quantify human and environmental value within the areas affected by the discharge of cesspool effluent. In order to develop scores for these values, the HCPT uses groundwater models developed by DOH. The models assess where cesspool effluent will discharge along the coast and where impacts will be realized. Because DOH is tasked with protecting human and environmental health, the following ecological and social factors were included in the calculation of priority scores:

1. Lifeguard tower locations/swimming beaches
2. Coral cover/recovery potential
3. Resource fish biomass/recovery potential
4. Coastline usage and visitation (user-days)

More detailed information about each input is provided in the sections below.

Cesspool Locations/Grouping

The basis of the HCPT begins with cesspool locations. Cesspool location data was obtained from the State of Hawaiʻi Geospatial Data Portal. Oʻahu cesspool location data was created in 2008 and the other island(s) cesspool data was developed in 2010. However, it was evident that updates would be needed to develop an accurate assessment of cesspool prioritization in 2021. Efforts were made to update known errors, incorporate data from 2020, add cesspools installed before the 2016 statewide ban of new cesspools, and remove cesspools that have been converted. **The authors recommend that all statewide cesspool data continue to be refined and, if possible, ground-truthed to ensure the most accurate results of the tool and for future statewide OSDS management and cesspool conversion.**

The prioritization framework and algorithms rely on having accurate information regarding the location and number of cesspools. Updates include the incorporation of recent (up to 2020) permitting data from the DOH Individual Wastewater System Database (IWD) including newly (before 2017) permitted cesspools and units that have been converted to septic tanks or other treatment systems. County tax records and dwelling database information was also used to exclude parcels that did not contain residential buildings with at least one bathroom and bedroom. Additionally, the cesspool inventory was originally created at the TMK level, resulting in tens of thousands of TMK's with multiple cesspool units on some parcels. These units were extracted out and defined as individual geospatial points, thereby ensuring that each individual cesspool was represented as a discrete point on the landscape. While these updates provided greater confidence in the inventory used, significant work on the cesspool inventory is still required to remedy inconsistencies in the database. Future database research development is warranted. However, doing so is outside of this project's scope and is recommended for completion when sufficient time and funding can be made available.

In order to develop a cumulative hazard score, cesspools need to be grouped into appropriate and logical clusters. Several methods were explored, including using watershed or aquifer boundaries. For the final analysis, United States Census tract data was chosen. Census tracts are small, statistical subdivisions updated by local participants prior to each decennial census to provide a stable set of geographic units to present statistical data. (U.S. Census Bureau, 2021). According to the United States Census Bureau, census tracts cover areas with fairly standardized population sizes between 1,200 and 8,000 people. A census tract usually covers a contiguous area, however, the spatial size of census tracts varies widely depending on the density of settlement. Census tract boundaries are defined with the intention of long-term stability so statistical comparisons can be made through time, though census tracts are occasionally split due to population growth or merged following substantial population decline (U.S. Census Bureau, 2021). Additionally, census tract boundaries generally follow visible and identifiable features, though they can follow nonvisible legal boundaries, such as a minor civil division or incorporated place boundaries to allow for census-tract-to-governmental-unit relationships since these boundaries tend to remain unchanged between censuses (U.S. Census Bureau, 2021).

Synthesis: Prioritization and Ranking

To combine data from multiple risk factors, such as depth to groundwater or soil suitability at the individual cesspool level, the tool overlays the individual fifteen input data layers (risk factors) onto each cesspool point's attribute data table. Each layer's data values are then normalized to a 0-100 score specific to the risk factor at each cesspool point. Individual methods used to convert various input data values to 0-100 priority scores are described in the Input Data section below. For clarity, these individual scores will be referred to as **Risk-Factor Scores**.

Next, the fifteen **Risk-Factor Scores** are averaged to generate a single **Cesspool Prioritization Score** for each cesspool. Therefore, each of the 82,000+ cesspools in the inventory has an individual prioritization score, making it possible to resolve differences at the individual cesspool level. However, because the impacts of wastewater effluent are cumulative, the tool then aggregates cesspools into census-based geographic areas, as described in the section above, and uses the arithmetic mean **Cesspool Prioritization Score** of all cesspools within each census unit to assign a **Census Unit Prioritization Score** to every census unit that contains more than a minimum number of twenty-five cesspools. **Census Unit Cesspool Prioritization Scores** are calculated at the census tract, census block group, and census block levels to provide flexibility in management applications. To further digest these scores for management purposes, it was decided to use the final **Census Unit Prioritization Scores** to categorize each census unit into one of three priority levels, which will be referred to as **Prioritization Categories.**

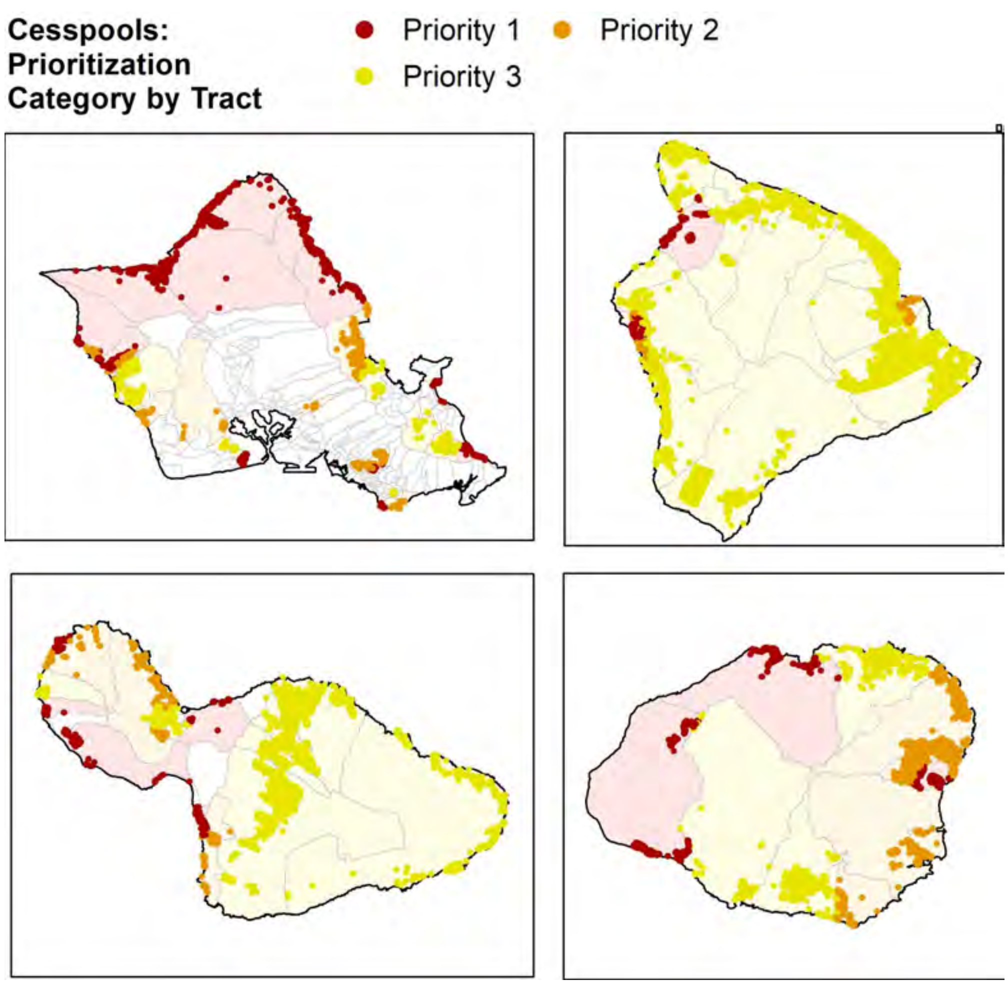

Figure 2. *Statewide map highlighting the simplistic design of the three-tiered categories, census tracts, and their respective colors to signify a priority score. (Updated 2022)*

The new prioritization method (Figure 2) places each geographic area into three Prioritization Categories that include:

4. **Priority Level 1:** Greatest contamination hazard (map color of red).
5. **Priority Level 2:** Significant contamination hazard (map color of orange).
6. **Priority Level 3:** Pronounced contamination hazard (map color of yellow).

After reviewing the prioritization score results, the findings revealed a fairly normally distributed pattern among the three groups. And, through review of Oosting & Joy's (2013) use of raster data preparation and risk contouring –which represent the mean risk and increments of the standard deviation above and below the mean– it was determined that quartiles were an appropriate way to categorize the HCPT results based on our methodology and data. The difference in how to categorize the results may be because of the available HCPT cesspool location data, versus Oosting & Joy's (2013) need to identify a geographic area of risk. HCPT categories are defined by the mathematical quartiles of 25% and 50% with the top 25% highest scoring areas designated with the Priority Level 1 ranking, the next lower 75% to 50% with Priority Level 2, and the bottom 50% as Priority Level 3. The breakpoint categories can be revised based on management strategies, policy needs, or updated research and data.

A cutoff was used to exclude census units with few to no cesspools. Tracts with less than twenty-five cesspools, block groups with less than twenty, and census blocks with less than ten were excluded from the analysis to reduce bias from small sample sizes. They are displayed with a white color. Individual cesspools in these locations were still ranked and results can be visualized in the DOH Input Data application. Additionally, a sensitivity analysis was performed to assess the effect of changing the importance (weights) of the different input data in the overall ranking, and the results are discussed in Appendix B.

Validation Methods

The accuracy of models is typically tested through comparing results to real-world observations. For example, an atmospheric climate model can be adjusted or validated based on rainfall amounts observed throughout the model area. However, the prioritization results produced by the HCPT lack a single observable indicator to compare. Cesspool discharge produces impacts across many sectors such as drinking water aquifers and coastal ecosystems. The impacts on people and the places that are valued manifest in multiple ways that often do not overlap. Therefore, there is no single criteria or tracer dataset that can be used to calibrate elements within the HCPT to determine how important, or not, the factors used actually are. While there is existing precedent from the previous 2017 prioritization efforts to use documented impacts to drinking water or human health as a component in the former prioritization; **the HCPT authors determined that observations or study-based datasets (e.g. water quality data) are too geographically limited to be included in the prioritization algorithm without leading to significant sampling bias and skewing of the results.**

The HCPT team concluded that validation with the Hawaiʻi Act 132 sewage study, was the best method to compare results to a statewide physical indicator dataset. Hawaiʻi Act 132 sought to fill a statewide data gap by funding a study led by Smith et al. (2021) targeted at detecting OSDS wastewater in coastal waters. The study provides the most comprehensive and reliable nearshore nutrient availability and source tracking data of any effort completed to date in the state of Hawaiʻi. While the geographic extent of this study is vast, limitations relating to its sampling extent and the utility of the tracer datasets used (nearshore algal $\delta^{15}N$ and algal %N measurements), still preclude its application as a driving factor in the prioritization score calculation. However, it does provide the best opportunity to validate how reasonable the HCPT prioritization results are in terms of addressing areas with observed impacts from OSDS derived nitrogen. As of August 2021, the Act 132 study is under review by the CCWG, and provisional results were provided for use in validating this prioritization effort.

The authors would also like to acknowledge the existence of other statewide datasets that relate to possible nutrient or pathogen impacts from OSDS. These include nearshore Enterococcus data collected by the DOH Clean Water Branch Hawaiʻi Beach Monitoring Program, groundwater nitrate data collected by water system operators and reported to the DOH Safe Drinking Water Branch in compliance with the federal Clean Water Act, and repositories such as National Water Quality Monitoring Council database which includes data from studies conducted by the United States Geological Survey and the United States Environmental Protection Agency. Every effort was made to analyze available data to test relationships with possible impacts from cesspools. These efforts indicated that either the geographic extent of most study-based tracer datasets was too limited, or that the primary drivers of variability in statewide monitoring datasets were not sufficiently driven by OSDS impacts. Coastal Enterococcus data was found to be primarily driven by surface water runoff quality (Strauch et al. 2014; Byappanahalli, Roll & Fujioka, 2012; Byappanahalli et al. n.d.), and groundwater nitrate data on the statewide scale appears to be primarily driven by agricultural influences (Mair and El-Kadi, 2013; Moon, 2021). While OSDS prevalence may be a factor in these datasets, it was far beyond the scope of this work to deconstruct.

Input Data: Functions

This section will describe the data that was incorporated into the tool as well as provide summaries on why and how certain types of data or methods were used to evaluate and create a prioritization scheme. Formerly, the 2021 HCPT weighted each risk factor equally in the prioritization calculation, with each factor normalized to have a score of zero to one hundred; this process was created through collaborative meetings with DOH and CCWG input. An update was performed in mid-2022 to better represent the disparity in importance of each of the input risk-factors. An expert-informed process was used to identify new weights for each risk factor, see appendix C for details, and the tool was re-run with the new weights. All figures and tabular results in this report reflect this 2022 revision of the tool and present results generated with the new weighting methods.

Threshold-Decay Function

In order to convert scalar data values associated with each risk factor (e.g. the distance in meters to the coast or a stream) to a 0 to 100 prioritization score, customized algorithms were developed. In general, the vector distances or other scalar data geographically derived from cesspool locations was used as a variable in a combination approach that both applies existing regulatory thresholds as well as a more physically based decay function. The decay part of the function approximates the behavior of solute transport through underlying geology via a highly simplified version of the one-dimensional convective-dispersive solute transport equation (Van Genuchten, 1982). This equation describes contaminant concentrations with travel distance through an aquifer (Figure 3). The function is simplified here by excluding the scale-dependent parameters that control the movement and attenuation of individual solutes in aquifers. The simplified function only applies the median value of each risk-factor distribution as a control parameter on the rate of decay with distance from the feature of interest. This method ensures that cesspools just past the threshold values are still deemed to be at higher risk than units that are significantly farther away. For additional information on the threshold-decay function used for calculating priority scores for some risk factors, and for the Python code that executes it, please see the Code Notebook associated with this report.

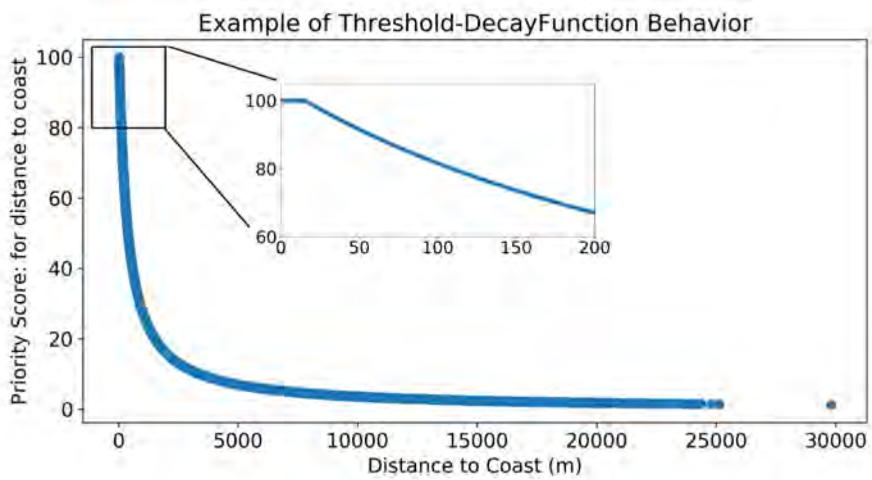

Figure 3: *Plot showing how the threshold decay function converts data from each risk factor (in this case Distance to Coastline in meters) to a 0-100 score. Note the inset showing how the priority score equals 100 for all units within 50 ft (15.24m) from the coast (the state's regulatory threshold), and how the score decays with greater distances from the coast.*

Groundwater Flow Paths

For the HCPT, groundwater flow paths were not considered as an independent risk factor. Instead, they are used to link each cesspool location to a corresponding location along the coastline where the cesspool's effluent is estimated to be discharged. The calculation of flow paths was done by application of island-wide, MODFLOW-based groundwater models provided by DOH and thoroughly documented in Whittier and El-Kadi (2009, 2014). While these groundwater models are the best available models for the entire state, the results are subject to their own assumptions and limitations presented in their respective documentation. Groundwater flow paths originating from model cells containing cesspools were calculated using the MODPATH code within the Groundwater Modeling System (GMS) graphical user interface (Pollock, 2012). Each flow path eventually discharges to the coastline. The flowpath vector traveled from the cesspool-containing cell center to the cell center of the end-cell that intersected the coastline. End cells were defined as square polygons with center points distributed evenly every 250 meters along the coastline of O'ahu, Maui, and Kaua'i, and every 500 meters on Hawai'i Island. **In theory, a cesspool located on the land surface can be linked directly to the coastline location to which its effluent will eventually discharge after traveling through the aquifer.**

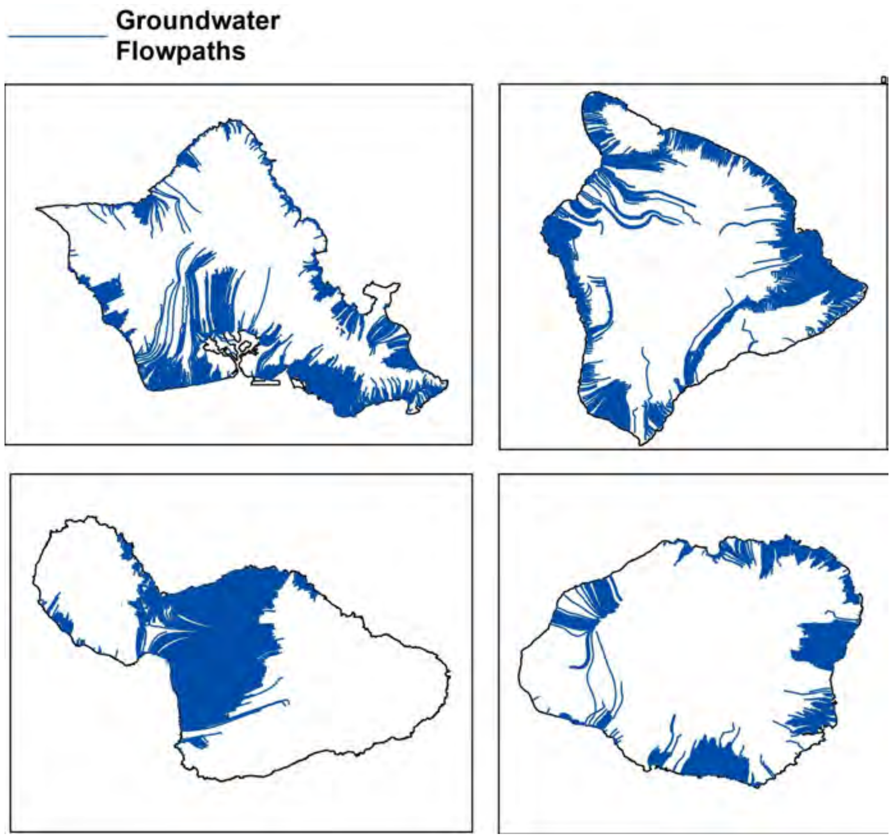

Figure 4. *Example map of four major Hawaiian Islands highlighting groundwater flow paths to the coast.*

Input Data: Risk Factors

Coastline/Distance to Coastline

Cesspools adjacent to the coastline face numerous challenges such as sea level rise, erosion, and shallow depth to groundwater. Studies such as Abaya et al. (2018) have demonstrated that distance to the coast and geology can have dramatic effects on the travel time of wastewater pollution entering the ocean. The HCPT uses a basic geographic distance calculation to the nearest point on a Hawaiʻi coastline GIS shapefile to assign a distance to each cesspool in the inventory.

Coastline Prioritization Score Algorithm

For the conversion of distance to coastline to a prioritization score, the threshold-decay function was applied with the maximum risk score (score of 100) assigned to cesspools located closer to the coast than the regulatory threshold of 50 feet or 15.24 m (HAR 11-62).

For cesspool points farther than 50 feet, the score was exponentially reduced with additional distance.

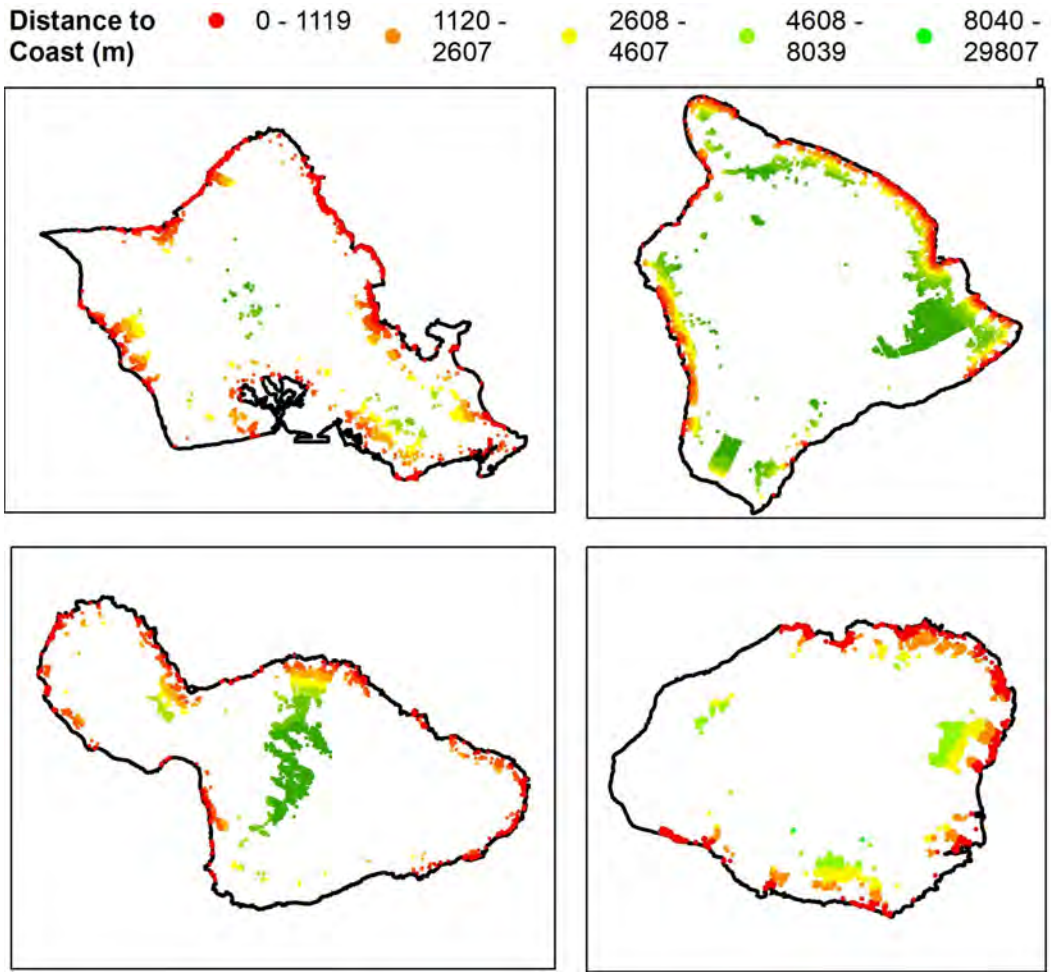

Figure 5. *Example map of four major Hawaiian Islands highlighting cesspool proximity (distance) to the coastline. Red indicates a cesspool is near the coastline, in decreasing order, orange, yellow, and green signify a further distance from the coast.*

Drinking Water Well Locations/Distance to Drinking Water Wells

According to the Environmental Protection Agency (2020), a failing onsite sewage disposal system or cesspool that is located too close to a drinking water well can contaminate the source. Protecting drinking water is especially important in Hawaiʻi, where much of the state's drinking water comes from underground aquifers, some of which are the sole source (Gingerich and Oki, 2000). Previous studies such as Mair and El-Kadi (2013); Verstraeten et al. (2004); Oluwasola et al. (2017); and Schaider et al. (2016) indicate that the OSDS distance to a drinking water well is an important factor to ensure a clean and safe drinking water supply. Additionally, Hawai‘i Administrative Rules Title 11, Chapter 62 (HAR 11-62) dictates that a potable water source serving public water systems must be a minimum horizontal distance of 1,000 feet (304 meters) from a cesspool. The Hawai’i Wellhead Protection Program (Whittier et al., 2010) uses U.S. EPA (2006) guidance to identify near-wellhead (Zone A) and source-water (Zones B and C) zones that require protection from contaminants. Zone A is delineated through a geographic distance from the wellhead and Zones B and C are delineated through modeled capture zones or aquifer boundaries. Finally, the DOH ranks protecting human health and drinking water as one of its most important duties (Pruder, personal communication July 2, 2021). Therefore, this factor is vital in the HCPT updated prioritization scheme.

To incorporate this type of hazard into the tool, locations of pumping wells were acquired from the state well inventory from the Commission on Water Resources Management (CWRM). Each well is associated with a use code (agricultural, domestic, industrial, irrigation, military, and observation) as well as an identifier for abandoned and unused wells. After analysis, 910 of the 5,286 wells within the CWRM dataset were designated as domestic use, and 534 were designated as municipal, for a total of 1,444 active wells that were considered in the HCPT.

Drinking Water Well Prioritization Score Algorithm

The distance to domestic drinking water wells was assessed separately from the distance to municipal wells, and each cesspool received separate scores for proximity to any well and for intersection with municipal well capture zones as described in the section below. This is because municipal wells serve proportionally larger numbers of people, and domestic wells are often within close proximity to homes using OSDS. Each cesspool unit was assigned the distance between its location and the distance to the nearest domestic well, and a separate value for its distance to the nearest municipal well. The threshold value of 56 feet (17 meters) was used for municipal wells based on guidance from the Hawai’i Wellhead Protection Program (EPA, 2006; Whittier et al., 2010), which uses this distance as the Zone-A radius for the near source zone that provides protection against direct introduction of contaminants through and around the well casing. This distance was cut in half to 28 feet (8.5 meters) for domestic wells because of their generally smaller size and proximity to residential units. These threshold distances were applied within the threshold-decay function to calculate separate priority scores at each cesspool point for municipal and for domestic wells.

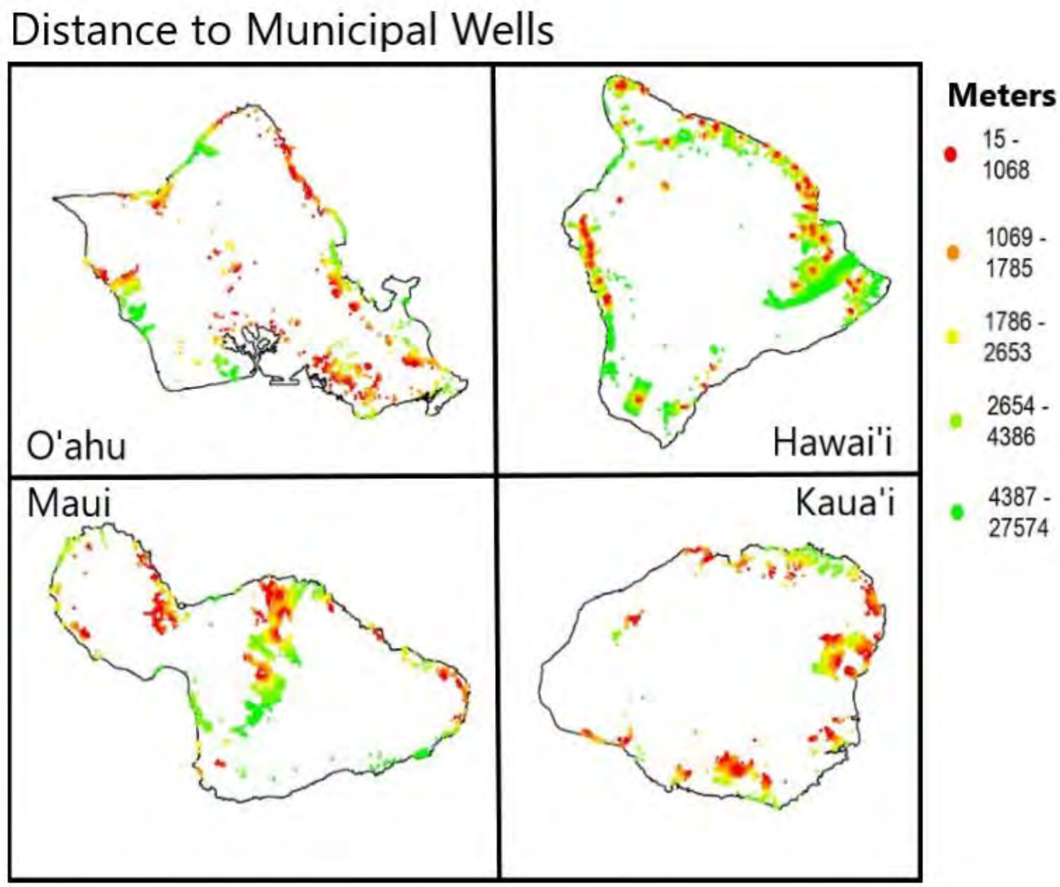

Figure 6. *Example map of four major Hawaiian Islands highlighting cesspool proximity (distance) to a municipal drinking water well. Red indicates a cesspool is near the associated wells, in decreasing order, orange, yellow, and green signify a further distance from a well.*

Well Capture Zones

Knowledge of the location and shape of a well capture zone is a fundamental element of groundwater management (Nagheli, Samani & Barry, 2020). To most accurately convey potential risks to drinking water supplies, the HCPT evaluated if a cesspool was located within a municipal well capture zone. This is largely because cesspool and OSDS effluent have the potential to contaminate drinking water supplies with enteric viruses and other pathogens that can withstand long travel times. Data on capture zone locations was provided by DOH and CWRM.

A capture zone defines the land area from which infiltrated recharge may ultimately contribute to the groundwater produced at a given well. These capture zones were calculated through reverse particle tracking of flow in a groundwater model using MODPATH code. While the inclusion of a geographic distance factor and assessment of the modeled well capture zones has the potential to be duplicative, it was deemed reasonable considering:

1. The importance of drinking water and high risk of contamination cesspools pose to aquifers, and;
2. The inherent uncertainties of, and relatively low resolutions of available groundwater models in critical regions near pumping wells where groundwater gradients are extremely high.

Therefore, the chosen method considers both risks of contamination from nearby cesspools, even if they are not defined to be within a capture zone, as well as risk from geographically distant cesspools located directly upgradient from wells.

Well Capture Zone Prioritization Score Algorithm

Cesspools that fell within a 2-year travel time capture zone (Zone B) and the 10-year travel time capture zone (Zone C), were identified and scored accordingly. A 2-year travel time has the potential to have contamination reach the water supply more rapidly than a 10-year travel time. Units in the 2-year zone are assigned a numerical score of 100, those in the 10-year zone a numerical score of 50, and all other units received a score of 0.

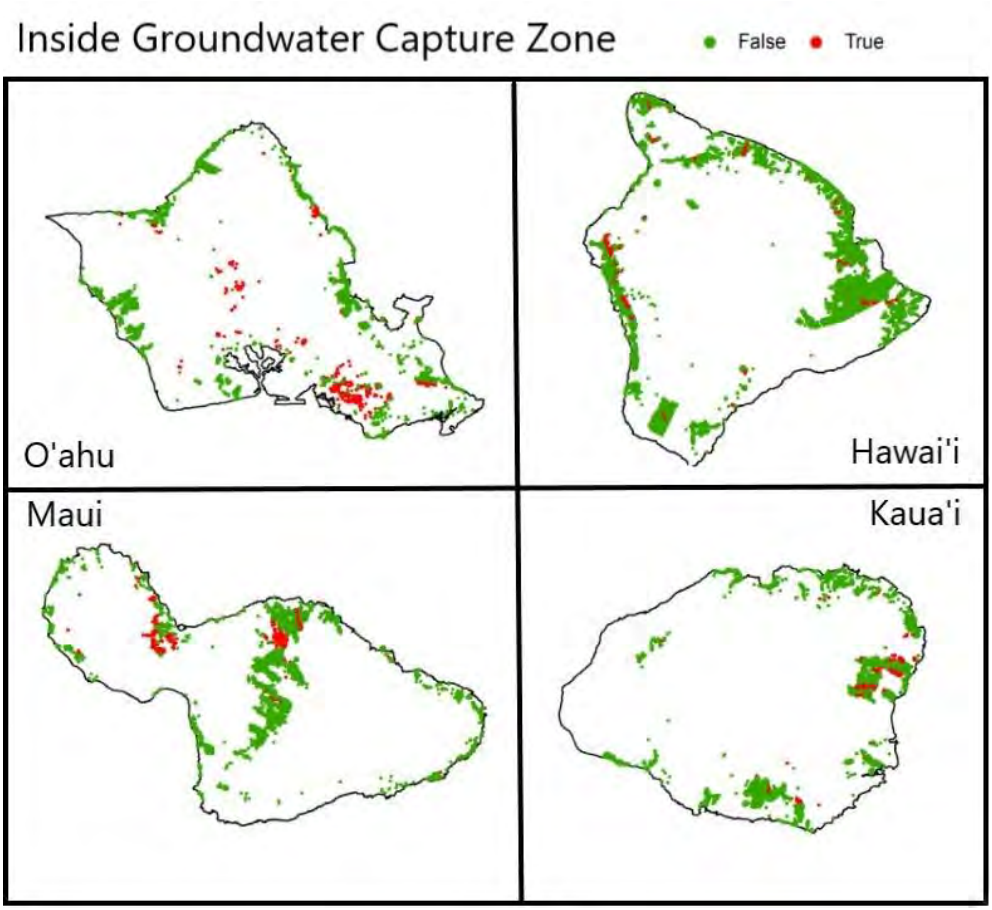

Figure 7. *Example map of four major Hawaiian Islands highlighting if a cesspool is located inside or outside the 10-year well capture zone. Red indicates the cesspool is in a capture zone, while green indicates the cesspool is not.*

Soil/Geological Data

Soil is essential for wastewater treatment systems to function properly and generally a hostile environment for bacteria in sewage (Hygnstrom et al. 2011). In typical onsite wastewater treatment fields, soil provides space for biological activity and filters pathogens and chemicals through its physical characteristics (Hygnstrom et al. 2011). Soil particles provide the necessary surface area for biological treatment to occur.

Soil suitability is an important factor around cesspools. Cesspools are substandard systems because they lack a primary treatment tank where non-oxygen demanding bacteria digest some of the waste and solids settle out. Additionally, cesspools do not have an engineered soil space (treatment field) to complete treatment, as an adequate wastewater treatment system would. The soil surrounding cesspools may provide limited filtration and space for microbial activity, but this depends on the underlying geology and water holding capacity, along with the types of waste inputs from the home. In general, saturated soil or bedrock is a conduit that transmits pollutants to nearby water bodies. Many risk factors must be taken into account when evaluating how soils and geology influence pollution risk. Regulatory horizontal and vertical setback distances away from OSDS, though important, provide limited protection (Borchardt et al. 2010).

Statewide soil data was extracted from the Natural Resources Conservation Service (NRCS) database as part of the HCPT efforts. The NRCS has developed a methodology for assessing the suitability of soil for siting an OSDS unit based on properties recorded in nationwide soil surveys (NRCS, 2020). The NRCS suitability is based on the eight factors that control the treatment and infiltration of OSDS leachate, as well as the ease of treatment field installation. This method was previously used in Hawaiʻi's 2017 cesspool prioritization process (Hawaiʻi State Department of Health: Environmental Management Division, 2017), and its specific use for Hawaiʻi has been documented in Whittier and El-Kadi (2014). The HCPT modifies the methods used by Whittier and El-Kadi (2014) to assign a single soil-suitability score to each cesspool based on the factors and thresholds defined by NRCS, specifically, these parameters include:

1. **Depth to bedrock**: A measurement from the ground surface to the contact with continuous bedrock or cement pan;
2. **Flood frequency**: The degree to which the soil is subject to flooding or ponding;
3. **Filtering characteristics**: How well the soil filters out particulates and bacteria;
4. **Water infiltration rate**: How well water moves through the soil;
5. **Bottom seepage rate**: How quickly water will move from the lowest soil layer to the bedrock;
6. **Slope:** Measurement of the direction and the steepness of the ground surface. A slope of more than 15% is considered problematic for OSDS installation;
7. **Rock fragmentation:** Measurement of the fraction of rock fragments in the soil. A percentage of 3-inch rock fragments of more than 50% is problematic for OSDS pollution.

Consolidated Soil Prioritization Score Algorithm

To incorporate the seven soil parameters into the HCPT framework, a similar approach used by Whittier and El-Kadi (2014) was followed. The specific approach used thresholds based on the NRCS soil suitability assessment with an independent calculation based on the categorical values provided in Table 1. Specifically, a value for each parameter (except subsidence) was extracted from the soil-survey GIS polygon features. Then a categorical value (1 to 4) based on the limitation classes below were assigned to each. The parameter values were averaged with Depth to Bedrock, Flooding, Filtering Capacity, and Slow Water Movement each having a weight of 1. Seepage From Bottom Layer, Slope, and Percent Rock Fragments (> 3 inches) each were given a weight of 0.33 in order to score these less important parameters together with a lower weight each. The averaged soil suitability score for each cesspool unit was then scaled through a minimum to maximum scaler to obtain relative values between 0-100.

Described below are the methods used to fill the flood-frequency parameter, which is important in terms of surface transport of contamination from OSDS and cesspools. The flood frequency of many locations is already defined by the NRCS soils database, though about fifty percent of the cesspool points were missing the data from the NRCS database. Therefore, rainfall amounts (from data described in the Rainfall section below) and saturated hydraulic conductivity (known as ksat in the tool) values from the NRCS soil parameters were used to fill in the likelihood of flooding only in those areas where it was not defined by the NRCS database. The following logic was established through consultation with DOH and engineering professionals to fill in the flood frequency values where they were missing.

- If rainfall is above 135 inches AND ksat is less than 1.1 = Frequent Flooding
- If rainfall is below 15 inches AND ksat is less than 1.1 = Frequent Flooding
- If rainfall is above 135 inches OR ksat is less than 1.1 = Occasional Flooding

Table 1. *Limitation class thresholds for soil characteristics as they relate to the appropriateness of siting OSDS in soils with different properties. Where soil parameters are favorable for OSDS development, the limitation classification is slight or none. Where soil parameters are unfavorable for OSDS placement, functioning limitation classifications are moderate to severe. Total subsidence, the amount the soil sinks after treatment field installation, was not considered to be relevant in Hawai'i's young volcanic soils. Table taken directly from Whittier and El-Kadi (2014).*

Soil Property	**Limitation Class**			
	None	***Slight***	***Moderate***	***Severe***
Depth to Bedrock or Cemented Pan (ft)	>6	----	3.3-6	<3.3
Flooding or Ponding	None	Rare	Occasional	Frequent
Filtering Capacity (soil hydraulic conductivity (ft/d)	----	----	----	>12
Slow Water Movement (ft/d)	>12	4-12	1.2-4	<1.2
Soil Suitability Factors – Scored Together				
Seepage From Bottom Layer (ft/d)	>2.8	----	1.1-2.8	<1.1
Total Subsidence (ft)	<=2	----	----	>2
Slope (percent)	<8	----	8-15	>15
Percent Rock Fragments > 3"	<25	----	25-50	>50

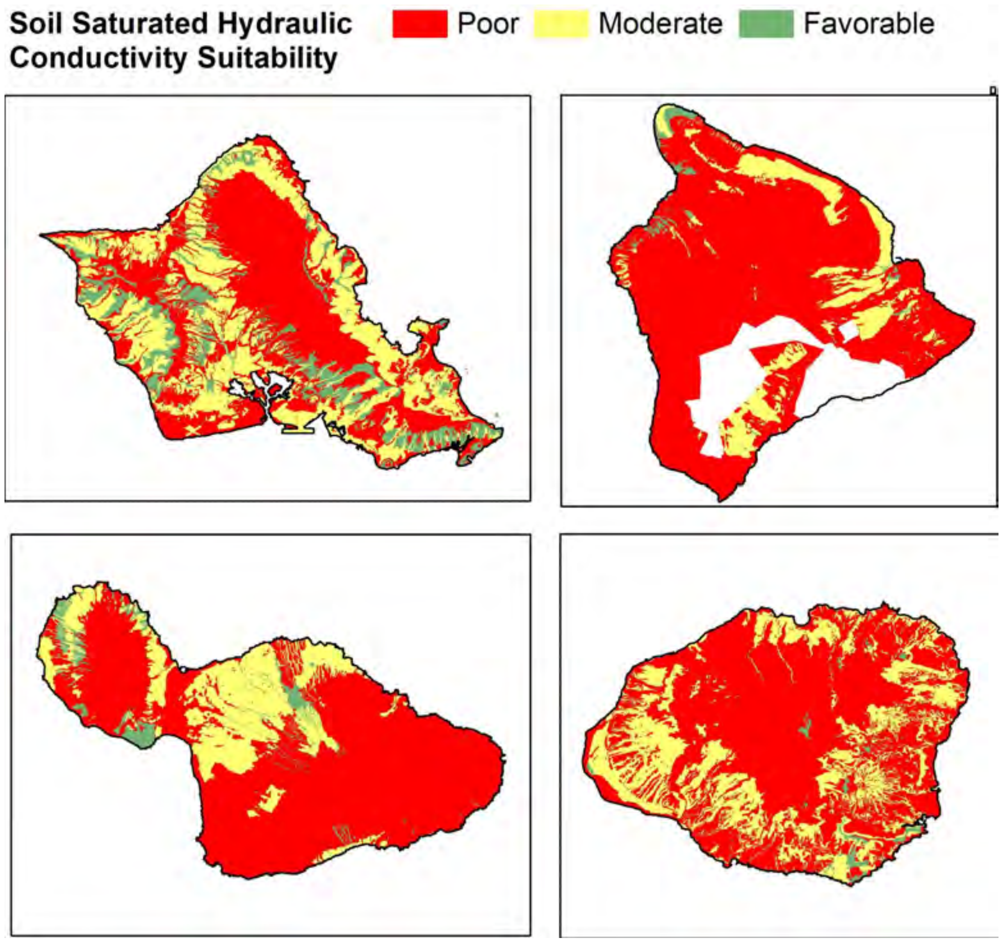

Figure 8. *Example map of the geographic distribution of one of the most important soil properties (hydraulic conductivity) in the soil suitability analysis. The values on this map show where saturated hydraulic conductivity values are favorable in consideration of the parameter values from numbers 3, 4, and 5 in Table 1 above. Red is least favorable, yellow is moderately favorable, and green is most favorable.*

Precipitation (Rainfall)

It was determined through research and consultation with engineers that local rainfall by itself does not directly affect the suitability of OSDS placement. However, once wastewater effluent is in the subsurface aquifer, the amount of effluent compared to the quantity of groundwater recharge controls how diluted the pollution will be and how concentrated and impactful contaminants from each system are upon discharge. The best proxy to estimate groundwater recharge in the Hawaiian Islands is rainfall. The HCPT assumes that areas with high rainfall were considered to be more favorable, or less impacted, by each cesspool. Average annual rainfall datasets were collected from the Hawaiʻi Climate Atlas (Giambelluca et al. 2013) as statewide grids of annual rainfall totals and rainfall rates were extracted at each cesspool location.

Rainfall Prioritization Score Algorithm

Because there is no established relationship between the acceptable amount of groundwater recharge (and thus rainfall) to sufficiently dilute effluent from an OSDS unit, the threshold-decay function was applied to determine a relative score for each cesspool, with the threshold value set at 8 inches (0.2m)/year, the lowest value in the rainfall dataset.

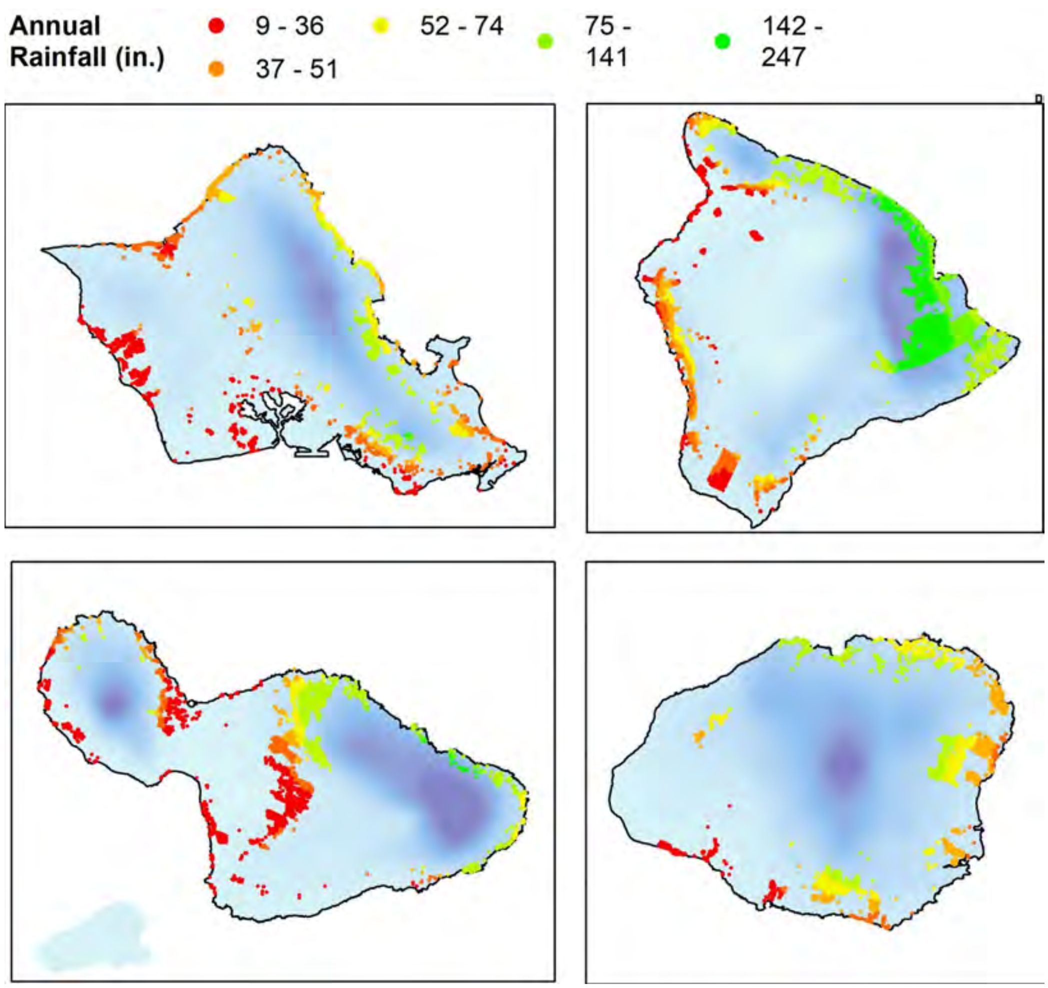

Figure 9. *Example map of the geographic distribution of rainfall amounts as it relates to cesspool impact. Rainfall is used as a proxy for groundwater recharge, and higher recharge rates will dilute the effluent from OSDS, potentially reducing the impact of pollution in areas of higher rainfall. Red locations indicate unfavorable rainfall conditions, with orange, yellow, and green indicating increased favorability, in that order.*

Stream/Wetland Locations & Distance to Streams or Wetlands

The benefits of streams and wetlands are numerous and include trapping floodwaters, recharging groundwater supplies, filtering pollution, and providing habitat for fish and wildlife (EPA, 2017). Studies show that streams and wetlands are vitally important to the health of larger downstream waterways like lakes and oceans (EPA, 2017; McKenzie et al. 2019). The DOH recognizes that wastewater can increase the biologic productivity in streams and nearshore waters, causing problems like eutrophication (Whittier & El-Kadi, 2009). Because of the complexity of environmental processes, it is difficult to quantify specific risk to these systems from wastewater pollution. Instead, we identify hazards through distance to understand the potential risks to these systems. The HCPT uses a basic geographic distance calculation to the nearest stream or wetland by using data from the statewide Hawaiʻi GIS Portal. The stream's layer is generally representative of perennial flowing waters in the state. Streams were ultimately joined with wetland features, including emergent ponds, to simplify the score. The HCPT assumes that streams and wetlands are equally important even though certain streams or wetlands may be of greater importance based upon location, cultural significance, development, and ecosystem services provided.

Streams and Wetlands Prioritization Score Algorithm

The threshold-decay function was used to calculate priority scores at each cesspool point according to the distance from either a stream or a wetland. The distance of 50 feet (15.24 meters) was used as the threshold based on the regulatory limit in HAR 11-62.

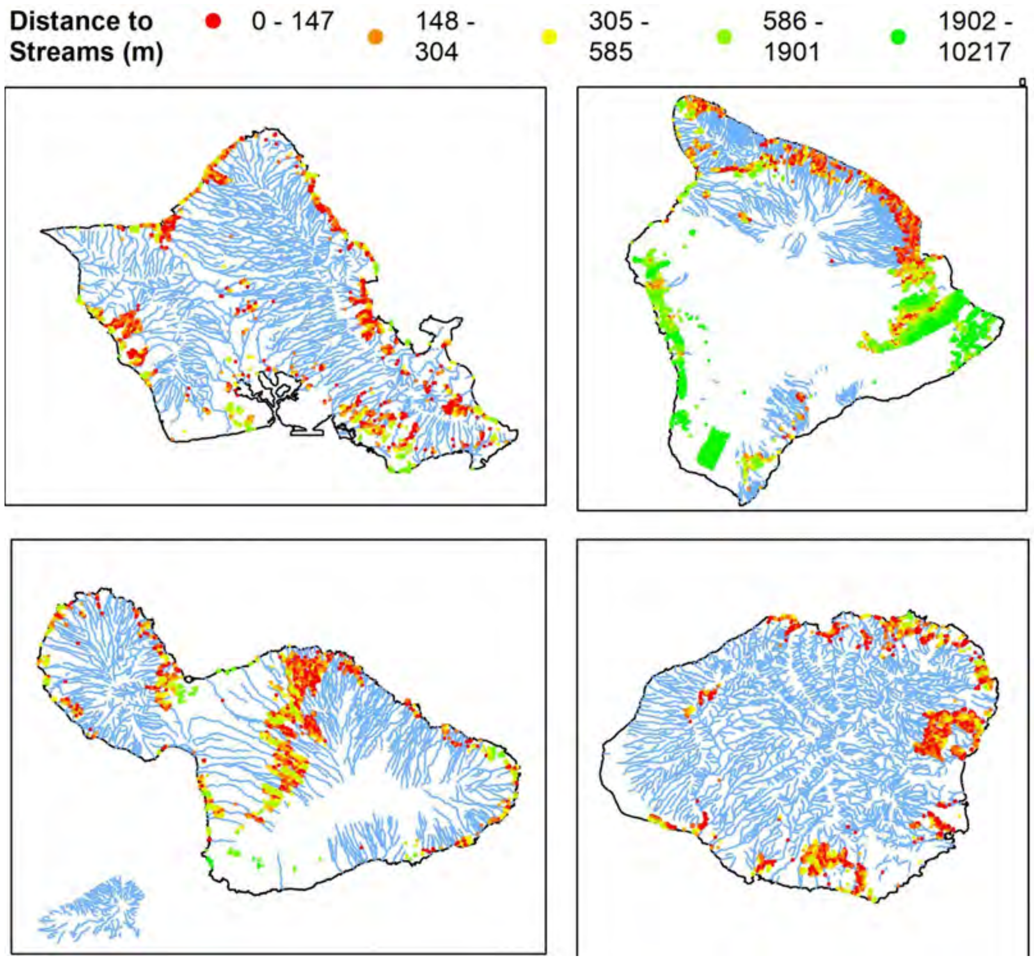

Figure 10. *Example map of the distance from each cesspool point to a nearby stream or wetland. Red locations indicate cesspools near a stream or wetland, with orange, yellow, and green indicating increasing distance to a stream or wetland, in that order.*

Cesspool Density

Density calculation/analysis is subject to bias based on the available landmass and the thresholds set in a calculation. Density is defined as the number of cesspools per unit of land area. Many of the calculations to establish density-dependent risk factors are based upon studies outside of Hawaiʻi. However, the density of OSDS is a critical variable and has been subject to debate for decades. A 1977 report from the U.S. EPA identified density of OSDS greater than 15.4/km^2 (40/mi^2) could result in groundwater contamination (Flanagan et al. 2019). Density is often a question of both wastewater science and policy decisions.

Though the minimum lot size to install an OSDS in Hawaiʻi is 10,000sqft, that does not mean that all systems will perform equally, nor that environmental damage will not occur at the minimum standards. Wastewater systems are inherently site-dependent (geographic, climatic, etc.). Hawaiʻi has limited land and requiring minimum lot sizes of one acre (as done in places like Suffolk County, NY) is not feasible for future or current development. Calculating the recommended OSDS density for Hawaiʻi is beyond the scope of this project. However, there are examples of successful development of local density per acre recommendations. Hansen Allen and Luce Engineers Incorporated (2016) identified recommended densities for an area in Utah using local risk analysis, mass balance calculation, and local regulatory management/development review. **The authors recommend the state of Hawaiʻi conduct such analysis for a more accurate prioritization output and future planning.** However, for this statewide tool, a single density cutoff was used to estimate the impacts across the landscape from cesspools.

To develop the density calculation for the HCPT, the authors investigated current and past literature. Bicki and Brown (1991) conclude that groundwater monitoring and modeling demonstrate a correlation between contamination and septic system density, suggesting a minimum lot size of one-half (0.5) to one (1) acre is needed to prevent groundwater contamination. These recommendations may be true if an area has lower hazards (drinking water aquifer is not a factor/not adjacent to ecologically sensitive areas). Advanced technology may allow smaller lot sizes to meet water quality standards. However, because cesspools have no primary treatment mechanism and have limited/no soil treatment field, the recommended density for OSDS does not neatly apply when evaluating cesspool hazards for priority areas. Previous density calculations in Whittier and El-Kadi (2009) identified an estimated OSDS density that should not exceed 40 units/mi^2 (1 system per 16 acres) based upon EPA reports. The HCPT uses a density calculation of the number of cesspools per acre.

Cesspool Density Prioritization Score Algorithm

To calculate a density hazard score, the threshold-decay function was applied to calculate priority scores at each cesspool point based on the number of cesspools per acre. The threshold value was set at one cesspool per acre, meaning that cesspools in areas with a greater density were assigned a score of 100.

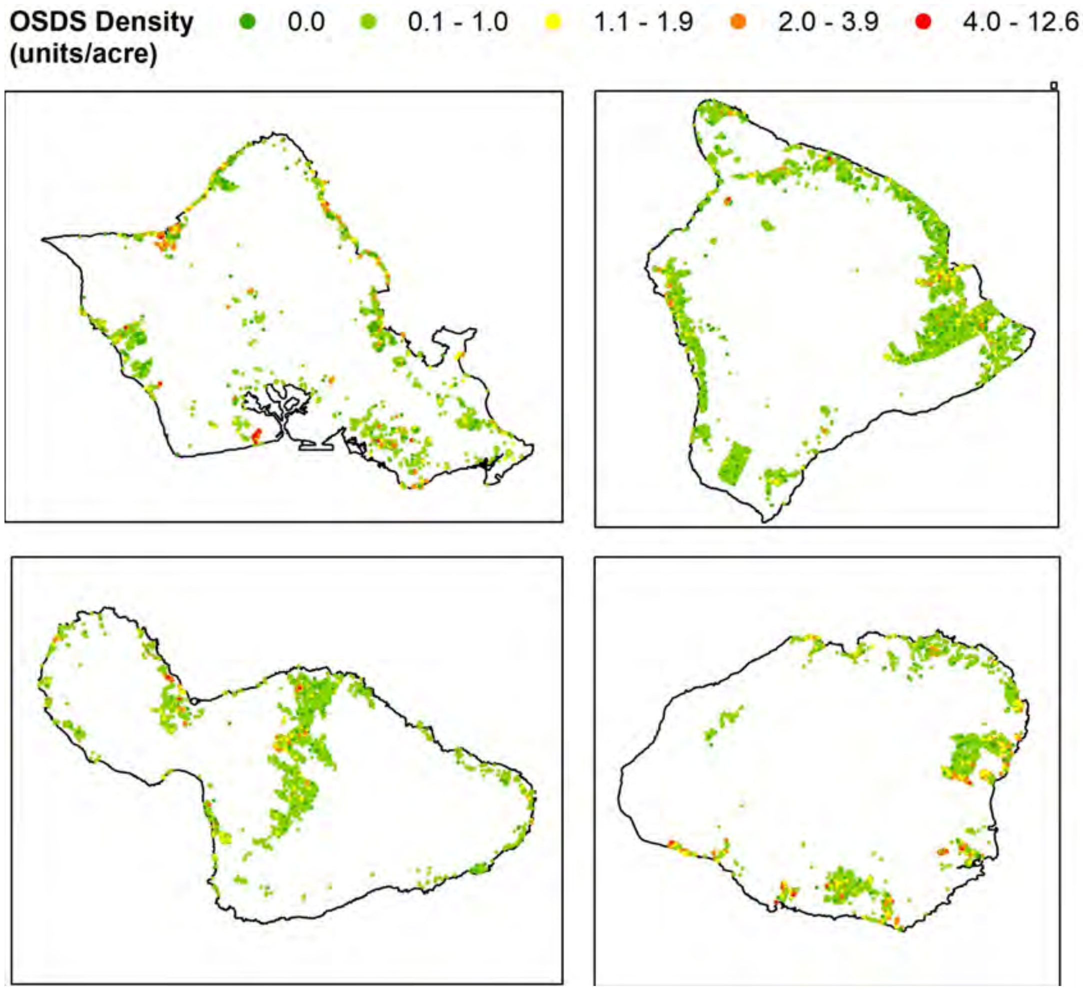

Figure 11. *Example map of cesspool density. Red locations indicate the highest density areas, with orange, yellow, and green indicating lower density per acre, in that order.*

Water Table Elevation (Depth to Groundwater)

Unsaturated soil space is essential for proper wastewater treatment. The unsaturated soil zone (dry area) underlying a cesspool or treatment field is the primary site of subsurface treatment and contaminant reduction. The thickness of the unsaturated zone below a wastewater treatment technology is a limiting factor in the ability of a given system to treat wastewater and limit the transport of contaminants. Recent rises in the groundwater table are already impacting subsurface infrastructure, such as cesspools and sewer lines, in Hawaiʻi (Habel et al. 2020). Sea level rise considerations are discussed in its respective section.

To obtain an estimate of the depth to groundwater below all cesspools in the state, island-wide groundwater models developed by DOH and documented in Whittier and

El-Kadi (2009; 2014) were evaluated for the HCPT. These models were developed to calculate statewide nutrient transport to the coast. The models have a large spatial scale which imparts low resolutions on their outputs. Regardless, the water table elevation is a key output provided by these models and useful for this exercise. To assess the depth to groundwater, or thickness of the unsaturated zone below each cesspool, the water table elevation at each point was subtracted from the land surface elevation at the cesspool location. Land surface elevations were calculated along the coastline using a statewide high-resolution (<1 meter) LiDAR Digital Elevation Model (DEM) obtained from Hawai'i GIS Online Portal. Where the LiDAR DEM was missing elevation data, it was filled with lower resolution (10 meter) data. Statewide-coverage 10 meter-DEMs are readily available from the UH Coastal Geology Group. The calculated depth to groundwater through the use of the high-confidence land surface elevation data with modeled water table elevations should be considered an estimate, subject to the assumptions and limitations of the groundwater models. Currently, this method contains the best available data for a parameter that is difficult to accurately measure.

Depth to Water Table Prioritization Score Algorithm

To calculate the depth to water table hazard score the threshold-decay function was applied to calculate priority scores based on the calculated thickness of the unsaturated zone beneath each cesspool point. The threshold value was set at 14.4 feet (4.4 meters), which is a regulatory threshold set forth by HAR 11-62. Priority scores exponentially decayed with greater unsaturated zone thickness.

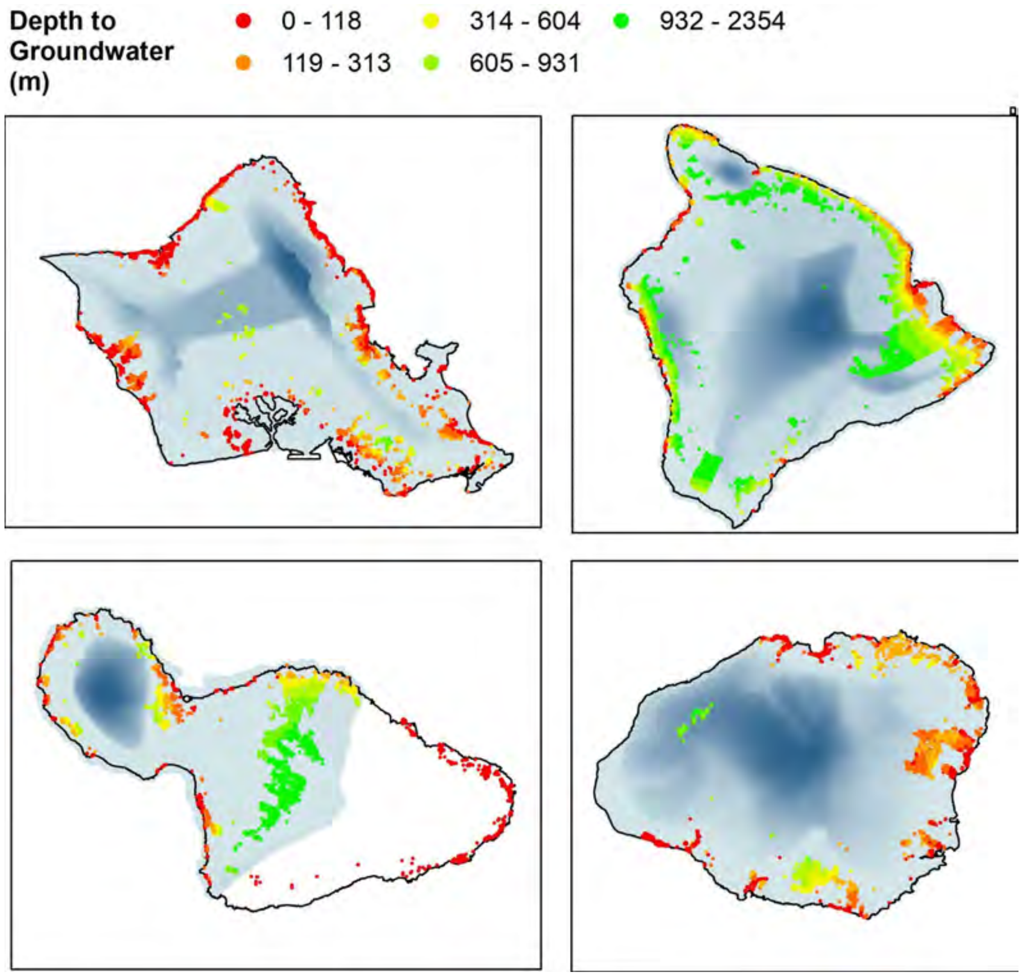

Figure 12. *Example map of the depth to the groundwater table for each cesspool. Red locations indicate the narrowest depth to the groundwater table, with orange, yellow, and green indicating increasing depth, in that order. Dark blue areas indicate an overall deeper depth to groundwater, lighter colors indicate a shallower depth.*

Sea Level-Rise Projections

Sea level rise (SLR) has the potential to impact surface and subsurface infrastructure like cesspools and other types of OSDS through mechanisms such as groundwater inundation and flooding (Cooper et al. 2016; Habel et al. 2020). Habel et al. (2020) provide a framework to understand the hazards cesspools and OSDS pose from SLR-induced flooding in Hawaiʻi. An OSDS that is flooded cannot function properly and poses a hazard to public safety and human health (National Agricultural Safety Database, N.D.) Because OSDS have life spans between 30-60 years, it is important to plan for future scenarios to ensure proper operation, cost efficiency for the homeowner, and environmental protection (Schneider, personal communication, July 2, 2021). Thus, SLR projections are an important data point in evaluating cesspool hazards and prioritization.

The available data was based on the methodology/modeling used in the Hawai'i Sea Level Rise Vulnerability and Adaptation Report and the Hawai'i Sea Level Rise Viewer. The products have undergone peer review and publication in the Scientific Reports Journal: Nature. The hazard and vulnerability data and maps provided were based on observational data and computer-based models. According to data layer authors, the data modeling did not account for: (1) existing seawalls or other coastal armoring in the backshore; (2) increasing wave energy across the fringing reef with sea level rise; (3) possible changes in reef accretion and nearshore sediment processes with sea level rise; and (4) possible changes to sediment supply from future shoreline development and engineering, such as construction or removal of coastal armoring or other coastal engineering. This project incorporates sea level rise projection data layers for the years 2030, 2050, and 2100. The 2030 layer depicts coastal flooding using the 0.5 feet (0.15-meters) sea level rise scenario. The 2050 layer depicts coastal flooding using the 1.1 feet (0.33-meters) scenario. The 2100 layer depicts coastal flooding using the 3.2 feet (0.9767-meters) scenario.

Additionally, since cesspools are located underground, the distribution of direct surface flooding does not completely capture the effects of subsurface groundwater inundation, which essentially reduces the unsaturated zone underneath a unit to either nothing or an unacceptable depth, defined as 14.4 feet (4.4 meters) below ground surface based on regulatory standards outlined in HAR 11-62. Therefore, to assess whether a cesspool will be affected by SLR at the dates of calculated projections, both the horizontal extent of surface flooding and the vertical extent of subsurface inundation were considered. Specifically, a cesspool was deemed to be impacted by SLR either if it is located in a surface flooding zone defined by data from the Hawai'i Sea Level Rise Viewer, or if the unsaturated zone below the cesspool as calculated in the Depth to Water Table section is reduced to less than 14.4 feet (4.4 meters) with a given increase in sea level (assuming purely linear hydrodynamic buoyancy of the freshwater lens under an increase in present-day base sea level).

Sea Level-Rise Projection Prioritization Score Algorithm

Cesspool units are assigned the highest priority score (100) if located within the 2030 sea level rise zone with descending ranks if located in the 2050 zone (score of 66) or 2100 zone (score of 33).

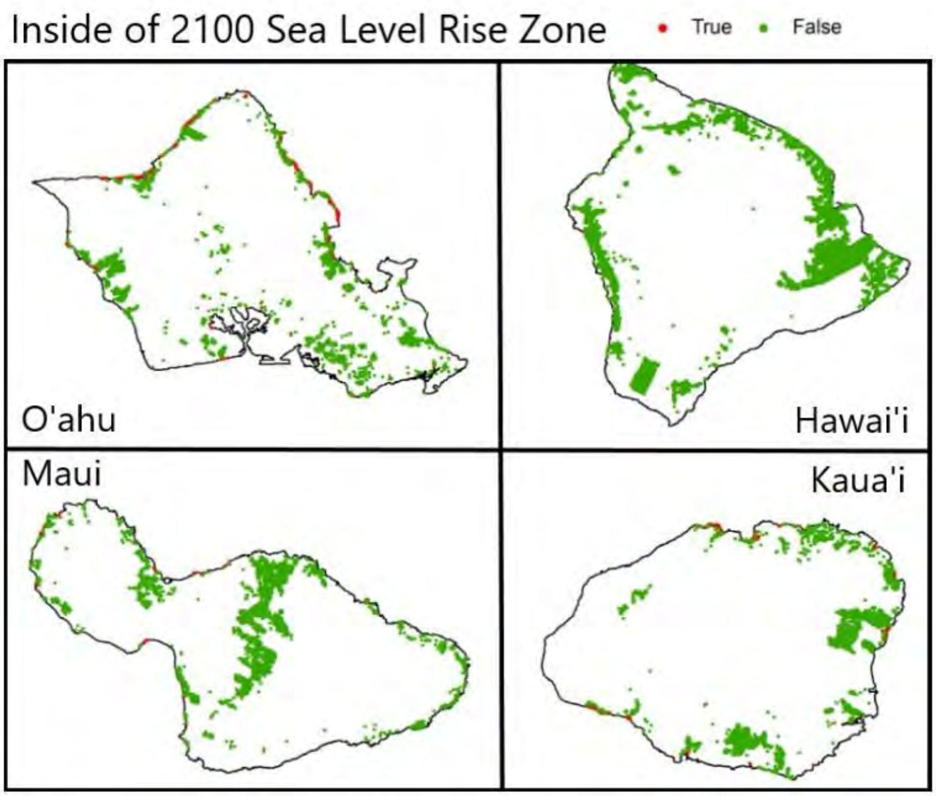

Figure 13. *Example map of four major Hawaiian Islands highlighting areas within the predicted zone of the 2100 SLR scenario, based on the methodology/modeling from the Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report and the Hawaiʻi Sea Level Rise Viewer. Red indicates that the cesspool is within the SLR zone, green indicates the cesspool is not within a SLR zone.*

Coral Cover

Coral is essential to the habitat of most tropical reef ecosystems, supporting biological diversity throughout the ocean. However, corals are undergoing rapid change from ocean warming and nearshore human activities (Reef Advisory Group, personal communication, July 20, 2021). Corals provide a host of ecosystem services for societies including coastal erosion protection, fishing, and cultural practices. Recent work by Asner et al. (2020) and others have shown that wastewater pollution from OSDS (namely cesspools) negatively impacts live coral across the main Hawaiian Islands.

To ensure the importance of coral is included in the cesspool conversion prioritization process, the authors worked with the Hawai'i Monitoring and Reporting Collaborative (HIMARC) and the Reef Advisory Group (Jamison Gove, Ph.D., Joey Lecky, Greg Asner, Ph.D., Mary Donovan, Ph.D., Tom Oliver, Ph.D., Eric Conklin, Ph.D., and Kim Falinski Ph.D.) to develop a coral reef condition metric specifically for use in this study. The metric was developed by combining two spatially continuous live coral datasets for the four main islands. The first dataset represented intact habitat through current live coral cover, and the second represented baseline coral via historical coral cover data, taken before the 2015 coral bleaching event.

The current live coral information was provided by Arizona State University's Global Airborne Observatory (GAO). GAO used state-of-the-art high-resolution aerial mapping to provide near-continuous information on live coral cover across the main Hawaiian Islands in 2019 (Asner et al., 2020). Historical coral data are provided by HIMARC, which were derived from in-water observations from a broad network of monitoring programs and agencies, including the Division of Aquatic Resources (DAR), spanning the 2004 - 2014 date range (Donovan et al., 2020). The historical coral cover data is representative of reefs before the mass coral mortality event stemming from the 2015 marine heatwave and thereby represents baseline conditions from before the devastating 2015 event that caused widespread coral mortality in several locations.

Coral Prioritization Score Algorithm

The two coral datasets were summarized by median coral cover within zones spanning 0 - 15 meter depth corresponding to 1 km segments of shoreline. These values were then lumped into four categories according to the following percentile breaks:

Table 2. *Table describing the coral prioritization ranking methods through specific percentiles and associated values.*

Rank	Percentile	Value
1	95 - 100	**Highest priority**
2	80 - 95	↓
3	50 - 80	↓
4	0 - 50	**Lowest priority**

Then the two ranked datasets were combined into a single one-through-four ranking where shoreline segments with differing rank values between the two datasets were assigned the higher priority rank of the two, as illustrated below:

GAO Coral (Rank) \ HIMARC Coral (Rank)	1	2	3	4
1	1	1	1	1
2	1	2	2	2
3	1	2	3	3
4	1	2	3	4

Figure 14. *Visualization of how coral ranking datasets were combined to form a single 1-4 ranking scheme.*

To format the categorical ranks into a 0-100 prioritization score, all priority one shoreline segments were given a score of 100, all priority two shoreline segments were given a score of 66, all priority three shoreline segments were given a score of 33, and all priority four shoreline segments given a prioritization score of 0. This data was linked to individual cesspools by connecting individual cesspool points to their coastal discharge locations via the model calculated groundwater flow paths, as described in the Groundwater Flowpaths section above. This allowed a coral cover value to be assigned to each cesspool based on the corals offshore of the part of the coastline to which each cesspool's effluent drains.

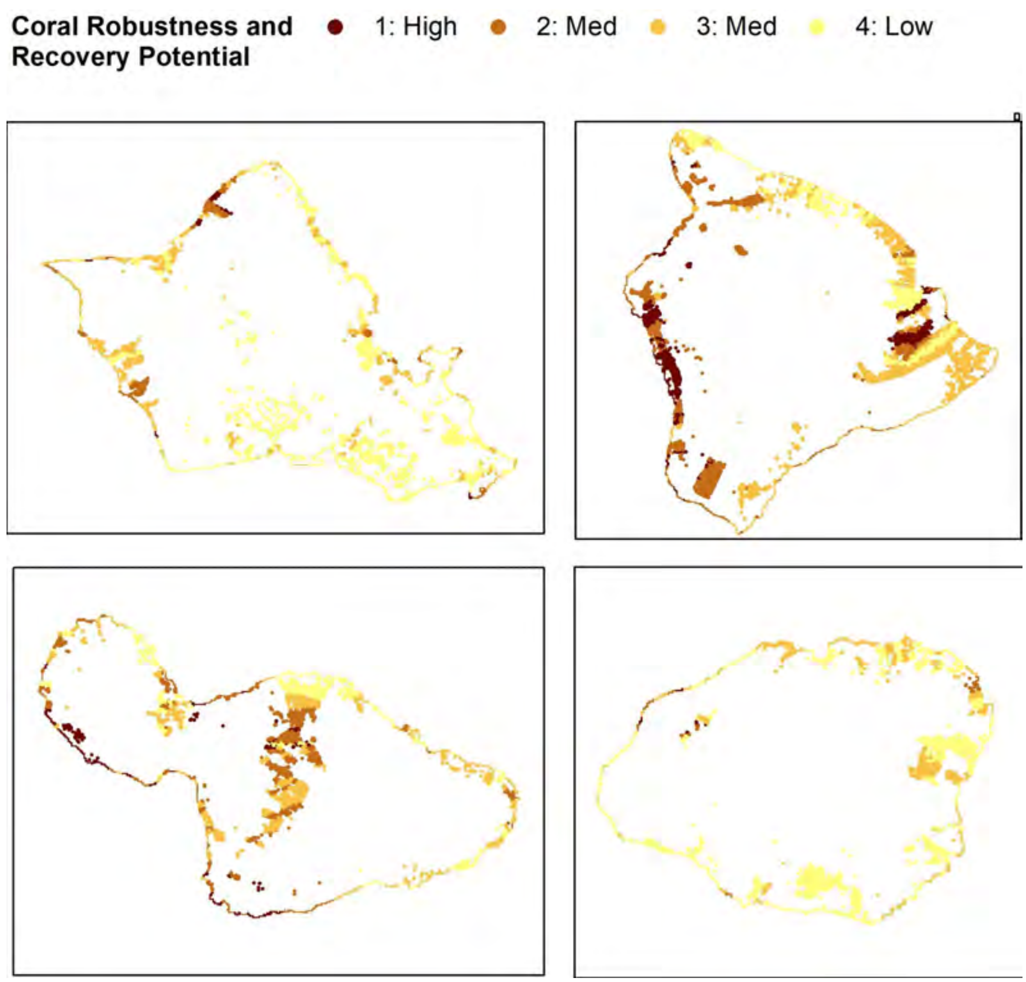

Figure 15. *Example map of four major Hawaiian Islands highlighting areas within the highest current and historical coral cover. Red areas indicate areas with the greatest baseline and current coral cover, while orange and yellow areas indicate areas with lower current or baseline cover.*

Resource Fish Biomass / Recovery Potential

The Resource Fish Biomass layer describes coral reef fish species that make up a substantial proportion of the non-commercial and commercial catch. Therefore, this does not represent total fish biomass on the reef, but the subset of fish biomass that directly supports fishing and feeds local communities. Reef fish biomass has been shown to negatively correlate with effluent from OSDS in the Hawaiian Islands (Donovan et al. 2020 & Foo et al., 2021).

The Reef Advisory Group produced predictive maps of standing resource fish biomass and the theoretical recovery potential of resource fish biomass if effluent from OSDS were eliminated (Donovan et al., 2020). Recovery potential from reducing OSDS effluent therefore represents the areas with the greatest potential for restoration of fisheries most directly related to cesspool remediation.

Resource Fish Prioritization Score Algorithm

A combined ranking of these two resource fish biomass datasets was derived for the cesspool conversion prioritization. Each of these datasets was summarized by median biomass within zones spanning 0 - 15 meter depth corresponding to 1 km segments of shoreline. These values were then lumped into four categories according to the following percentile breaks:

Table 3. *Table describing the fish prioritization ranking methods through specific percentiles and associated value priority.*

Rank	Percentile	Value
1	95 - 100	**Highest priority**
2	80 - 95	↓
3	50 - 80	↓
4	0 - 50	**Lowest priority**

Then the two ranked datasets were combined into a single 1-4 ranking where shoreline segments with differing rank values between the two datasets were assigned the higher priority rank of the two, as illustrated below:

Resource Biomass Recovery Potential (Rank) \ Resource Biomass (Rank)	**1**	**2**	**3**	**4**
1	1	1	1	1
2	1	2	2	2
3	1	2	3	3
4	1	2	3	4

Figure 16. *Visualization of how resource biomass datasets were combined to form a single 1-4 ranking scheme.*

Assignment of priority scores based on categorical ranks was done in the same way as above for corals where all priority number one were given a score of 100, all number two were given a score of 66, all number three given a score of 33, and all number 4 given a prioritization score of 0. This data was linked to individual cesspools by connecting individual cesspool points to their coastal discharge locations via the model calculated groundwater flow paths as described in the Groundwater Flowpaths section above. This allowed a resource fish value to be assigned to each cesspool based on the fish data offshore of the part of the coastline to which each cesspool's effluent drains.

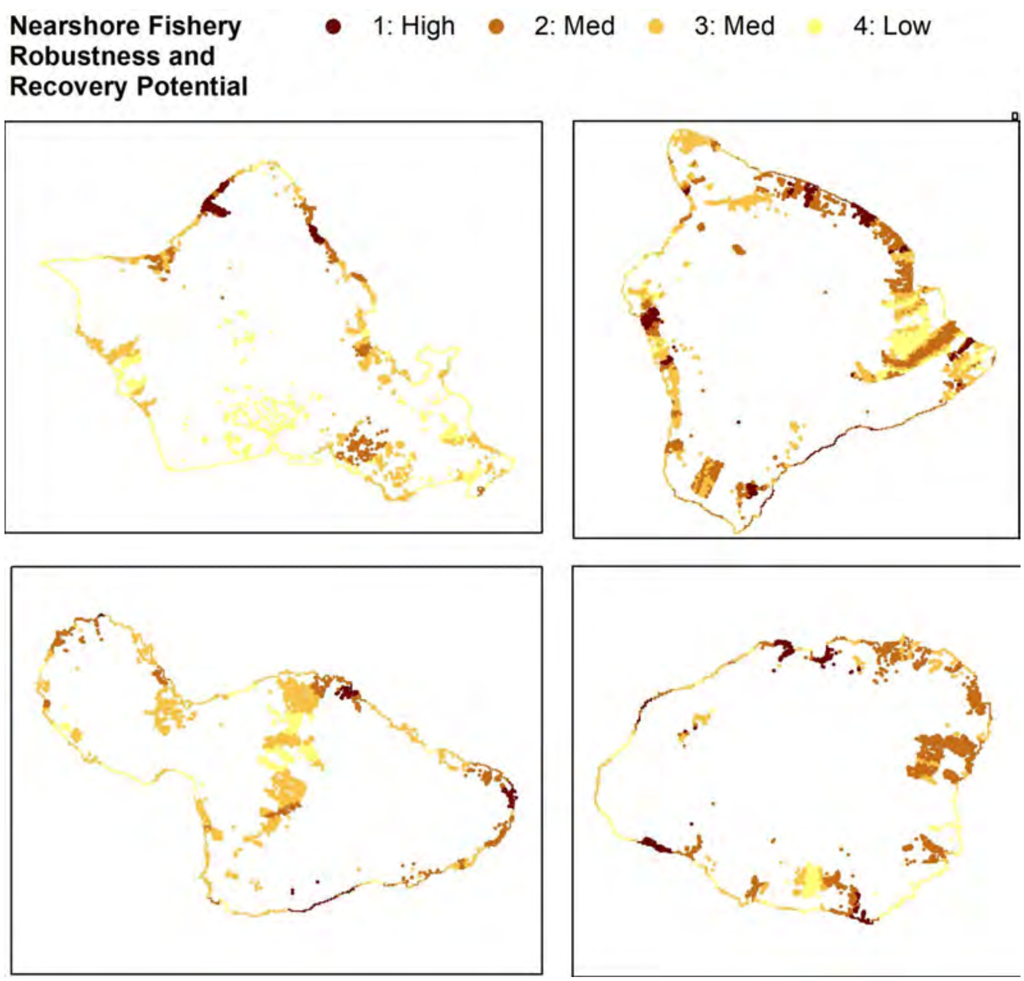

Figure 17. *Example map of four major Hawaiian Islands highlighting areas within the highest fish biomass robustness and recovery potential. Red areas indicate the greatest biomass of resource fishes and the greatest potential to improve biomass through cesspool remediation, while orange and yellow areas indicate a reduced robustness and recovery potential when OSDS effluent is eliminated.*

Coastline Visitation (User-days)

The DOH Wastewater Branches' mission is to protect public health and the environment (Hawaiʻi State Department of Health: Wastewater Branch, 2021). To best update the previous priority areas, it was essential to develop inputs that incorporate recreational, subsistence, and other human-associated values relating to the usage of the coastal zone into the prioritization scheme. These are a critical driver of prioritization as they are part of both public and environmental health. A widely used method to assess the usage of a geographic location is crowdsourcing information from either cell phone data or social media applications. For the HCPT, the peer-reviewed methodology of Wood et al. (2013) was chosen to calculate the relative visitation rate to areas along the coastline through a proxy of photo-sharing data scraped from the popular website Flickr. These methods are robust and have been widely applied as the core framework of the recreational module of the INVeST Model. The method essentially tracks human visitation along the coastline, and with this data, it is possible to apply the logic that the more visitation to an area, the more important it is, both in terms of public health and protection of ecological value.

The online photo-sharing website, Flickr, offers an application programming interface (API) which is a service that allows users to search photos based on their geotagged locations. The authors developed computer code to assign points every 250 meters along the coastline of Oʻahu, Maui, and Kauaʻi, and every 500 meters on Hawaiʻi Island. A search was run for all photos uploaded onto Flickr that fell within 250/500 meters of each point along the coast between the years 2010 and 2020. Photo metadata was then converted to a usable form by calculating the average number of user-days recorded at each location. A user-day is a count of the number of unique users visiting a given site on a given day so that the count would not be biased by users who took large amounts of photos at one location. For example, if a tourist takes any number of photos at any one location and uploads it to Flickr, this is considered one user-day for that location. The data was refined by evaluating the username of the photo owner and date to calculate the user-days for each point.

This data was linked to individual cesspools by connecting individual cesspool points to their coastal discharge locations via the model calculated groundwater flow paths as described in the Groundwater Flowpaths section above. This allowed a coastline user-days value to be assigned to each cesspool based on the visitation experienced by the part of the coastline to which each cesspool's effluent drains.

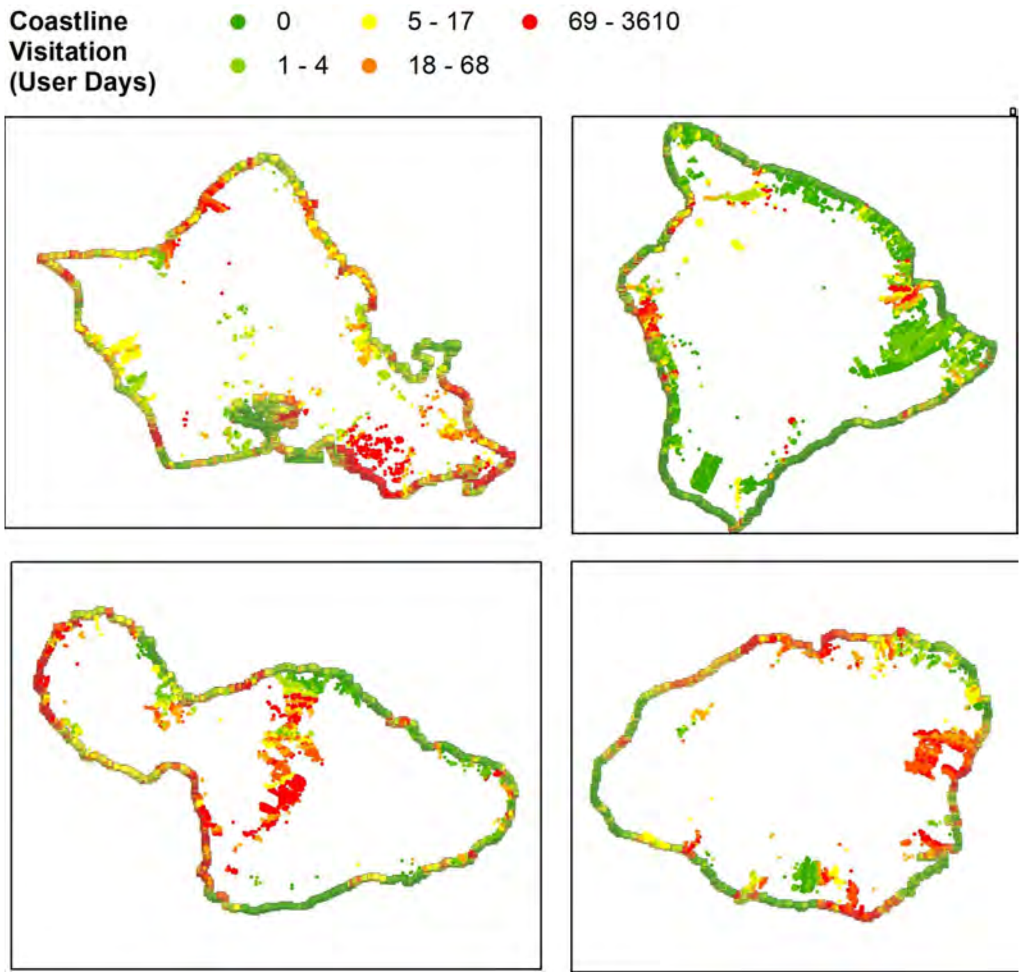

Figure 18. *Example map of four major Hawaiian Islands highlighting areas with the highest coastline usage (units of user-days). Cesspools are colored based on the coastline usage in the area to which their effluent drains, via groundwater flow paths. Red indicates the highest coastline usage, and orange, yellow, and green represent decreasing numbers of user-days.*

Coastline Visitation Prioritization Score Algorithm

Because of the highly skewed distribution of coastline usage (see associated Code Notebook for specifics) the threshold-decay function was applied to calculate priority scores and a carefully chosen threshold was then applied. Specifically, the authors used a trial and error approach to examine how different threshold values produced different numbers of 'hot-spot' areas or locations with high-value visitation characteristics.

The threshold value was chosen by assuming that if one percent of Oʻahu's approximately 200,000-250,000 visitors/day are using Flickr (a total of 2,000-2,500 people per day), and that if each visitor only visits one 'location' per day, this should yield 20-25 'hotspot' areas where those visits are concentrated. By taking the low end of this range, the Flickr data shows that a 'hotspot' or 'top-priority visitation area' should be defined as a location where 100 or more Flickr users visit the site every day. Thus the value of 100 user-days was chosen as the threshold value in the threshold-decay function. Results yielded about nine percent of the total number of cesspools in the state receiving a visitation priority score of 100, with other cesspools receiving scores that exponentially decay with a decrease in the number of user-days at the coastline locations to which their effluent drains.

Lifeguard Tower Location/Swim Beaches

Recreational water quality, both for residents and visitors, is vitally important to the state of Hawaiʻi. According to Conservation International (2021), about eighty percent of visitors to Hawaiʻi participate in some type of beach activity, and more than half snorkel or dive. Though access to all beaches is guaranteed by a constitutional right (HRS 115), it is assumed that lifeguarded beaches are favored and more frequented than others. However, each county determines which areas have staffed lifeguard towers, and only a handful of state parks have lifeguard towers. Placement of lifeguard towers may be determined due to the number of incidents responded to at sites, visitation levels, or requests by the state government. Because it is assumed that lifeguarded beaches have a higher in-water activity usage (swimming, surfing, diving, wading) than unguarded beaches, cesspools discharging to these beaches are ranked a higher priority in the assessment. This metric is assessed separately from coastline usage because the prevalence of in-water activities at these sites greatly increases the human-health risks from exposure to contamination from wastewater effluent.

Swimming Beaches Prioritization Score Algorithm

For this study, the authors examined county websites and databases to compile a statewide inventory of lifeguard towers. Any area of coastline within 500 meters on either side of a lifeguard tower was considered to be a swimming beach. A binary value (100 or 0) was assigned to each cesspool depending on if its groundwater flow path terminated at a swimming beach or not. Those cesspools draining to swim beaches received a priority score of 100, whereas those not draining to swim beaches received a score of 0.

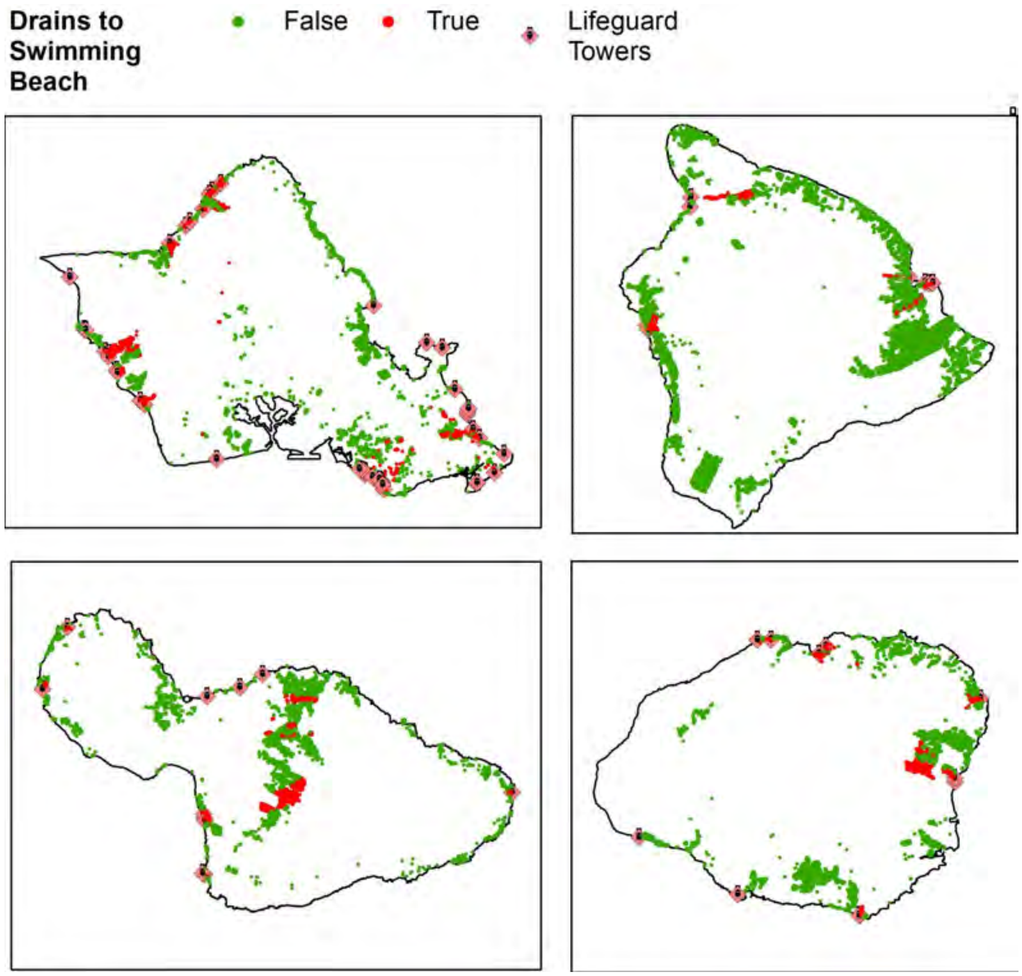

Figure 19. *Example map of four major Hawaiian Islands highlighting each cesspool point as it corresponds to the lifeguarded beach along the coast via groundwater flow path locations. Red dots indicate a cesspool effluent drains near a lifeguard tower, green indicates the cesspool effluent does not drain near a lifeguard tower.*

Coastal Ocean Circulation and Residence Time Proxy

Incorporating coastal geography and specifically the residence time of coastal features such as bays or inlets is an important element to include in the HCPT. However, after reviewing available data and consulting with oceanography experts, it was determined that accurate, statewide data regarding the residence time of coastal waters do not meet the standards and format needed for use in the HCPT. The most feasible way to incorporate an element of ocean circulation was to use wave power as a best-available proxy. This proxy will help determine whether coastal areas are either more exposed or sheltered to ocean currents. In general, this is based on the theory that wave power is correlated with nearshore water movement, and thus will correspond with factors that control mixing and dispersion of pollution, including that of cesspools.

The authors acknowledge that wave power is highly seasonal in Hawaiʻi and may vary significantly throughout the year. Coastal residence time is not simply a function of the wave field, but is also controlled by tidal, wind-driven, and larger-scale currents. Furthermore, the latest science doesn't fully understand the time-dependent aspects of wastewater pollution on reefs and the potential impact on coral reef ecosystem function and thus, cannot be used in the HCPT. However, there is a strong policy-based need to include a factor regarding ocean circulation. Therefore, even a proxy dataset provides value to the overall prioritization process and was included at the request of CCWG members.

The HCPT uses a statewide wave power (in KW/m) long-term mean dataset from the years 2000-2013. Although coastal currents and transport are extremely complicated, scale-dependent, and vary widely depending on the timing of measurements, wave energy is generally correlated with the primary drivers of currents such as wind-swell, and rip currents driven by groundswell. Wedding et al., (2018) developed a statewide long-term mean wave power dataset, which was made publicly available through the Ocean Tipping Points Project. This dataset was determined by the authors to be the best available proxy for determining if a coastal area was geographically sheltered versus exposed at the scale examined in this report. Originally, wave power data were developed by the University of Hawaiʻi at Mānoa School of Ocean and Earth Science and Technology SWAN model (Simulating WAves Nearshore). Hourly 500 meter SWAN model runs of wave power were converted to maximum daily wave power from 1979-2013, and the long-term mean wave power was calculated by taking the average of the maximum daily time series of wave power data from 2000-2013 for each 500 meter grid cell.

Coastal Ocean Circulation / Wave Power Prioritization Score Algorithm

Raster-based (matrix of cells organized into rows and columns) wave power values (in KW/m) were mapped to gridded 250/500 meter cells along the coastline which are related to individual cesspools through groundwater flow paths. To calculate a priority score, the threshold-decay function was applied with the threshold set at the ten percent quartile of the wave power dataset (1.59 KW/m) with the idea that this would capture the top ten percent of most sheltered areas as the highest priority.

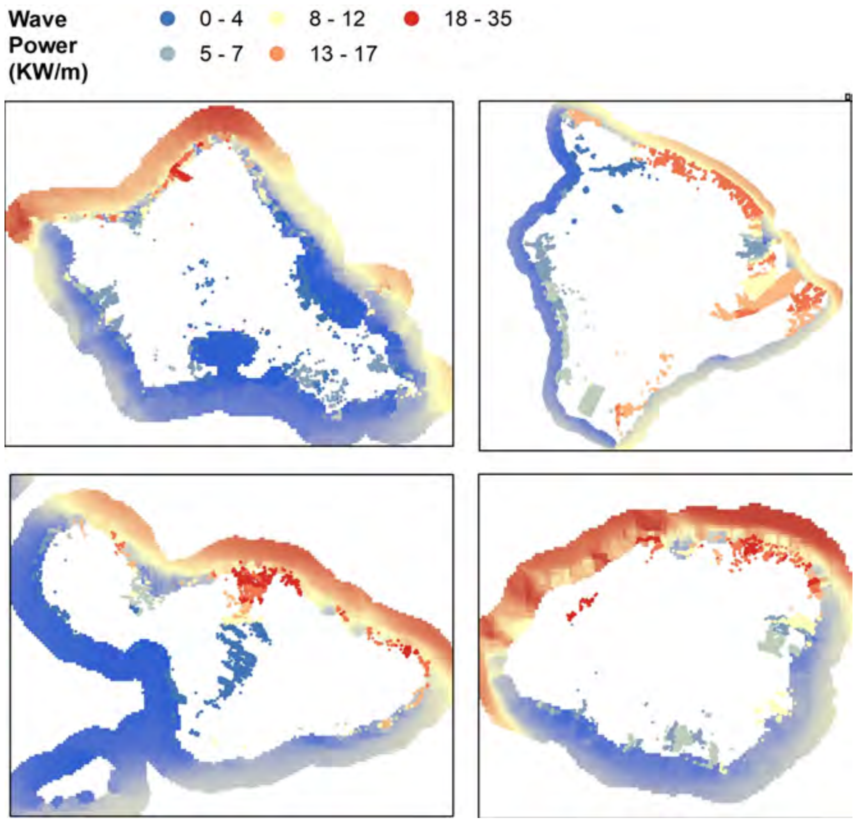

Figure 20. *Example map of four major Hawaiian Islands highlighting wave power mapped to each of the gridded 250/500 meter coastal cells, red indicates greater wave power, blue indicates lower wave power.*

Results and Validation

A major goal in the design of the HCPT was to be able to assess and prioritize every cesspool in the state. To accomplish this goal, the HCPT used a site-based process to evaluate relevant factors that help determine if a cesspool at any given location has a higher or lower potential to cause negative social and environmental impacts. The tool considers credible hazardous outcomes from cesspool contamination through a lumped interdisciplinary approach. The end result is a single prioritization scheme that organizes census-based regions into Priority Level 1, Priority Level 2, and Priority Level 3 categories.

Categories are defined by the mathematical quantiles of 25% and 50% with the top 25% highest scoring areas designated with Priority Level 1, the next lower 75% to 50% with Priority Level 2, and the bottom 50% as Priority Level 3. Figures 21 - 24 provide island-specific maps of the statewide prioritization categories, synthesized by census tracts. Appendix A provides similar maps, but synthesized by census block-group and census block areas. Block-groups provide a higher resolution for ranking at the neighborhood scale, however, the quantity of prioritized block-groups (252) makes this resolution more difficult to manage through a policy lens. Prioritization by census blocks provides ranking at the individual city block level, but results in almost 2,000 individually ranked areas. Tables 4-7 below display a tabular inventory of the census tract prioritization categories and ranks. Appendix B also presents state- and island-wide risk-factor pivot tables that show how final prioritization scores were calculated based on the averaged scores for each of the fifteen Risk Factors.

The four main Hawaiian Islands contain an estimated 82,141 cesspools and have a total of 319 census tracts, although only 103 tracts contained more than 25 cesspools and were categorized within the HCPT. All results are updated as of 2022, See Appendix C for details.

Statewide Breakdown:
25% (26 tracts)**/13,821** cesspools (17%) = **Priority Level 1**
25% (26 tracts)**/12,367** cesspools (15%) = **Priority Level 2**
50% (51 tracts)**/55,237** cesspools (69%) = **Priority Level 3** (*Updated* 2022)

Results: Oʻahu

The island of Oʻahu contains an estimated 7,491 cesspools and has a total of 242 census tracts, although only 34 tracts contained more than 25 cesspools and were categorized within the HCPT.

<u>Oʻahu Breakdown:</u>

38% (13 tracts)**/4,779** cesspools (64%) = **Priority Level 1**

32% (11 tracts)**/1,640** cesspools (22%) = **Priority Level 2**

28% (10 tracts)**/1,072** cesspools (14%) = **Priority Level 3** *(Updated* 2022)

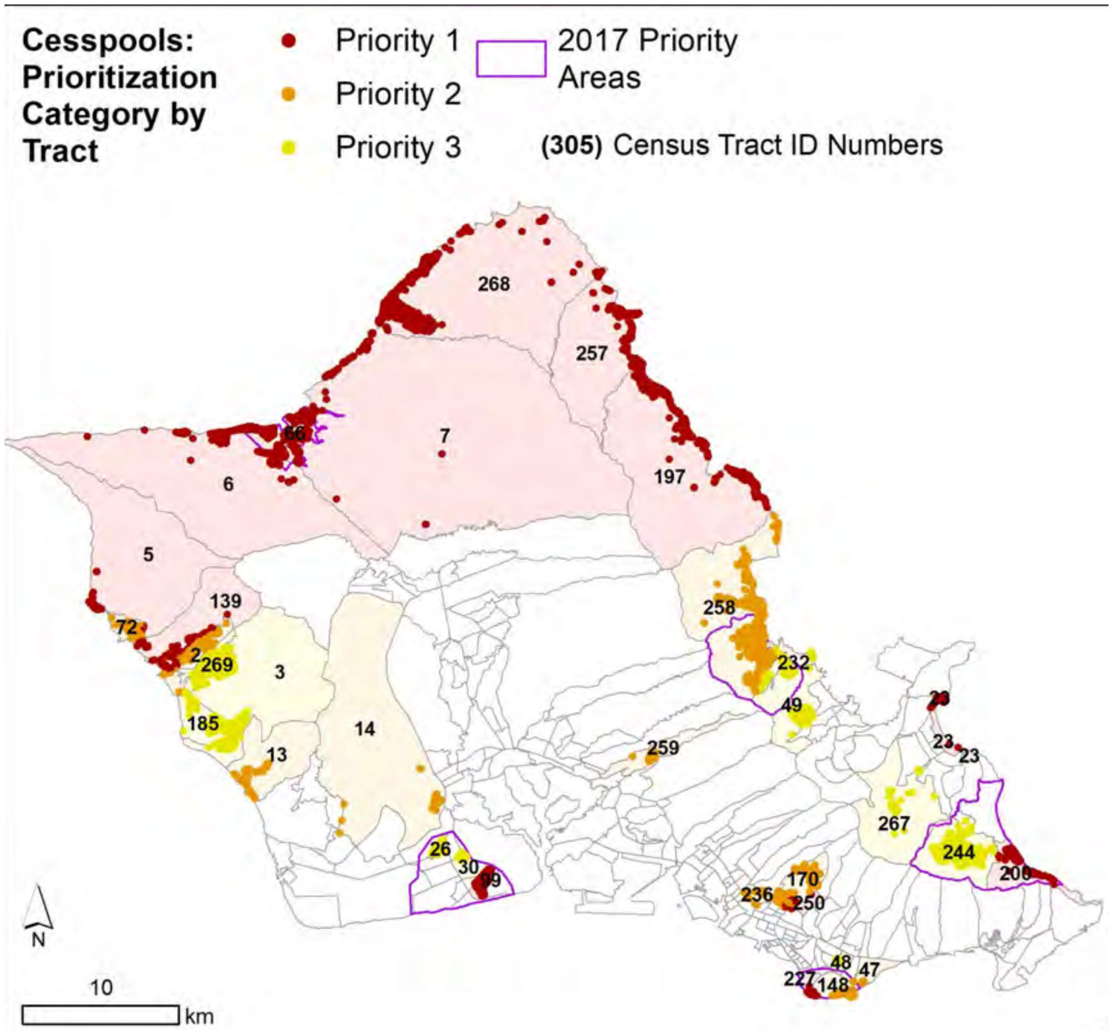

Figure 21: *Oʻahu cesspools (dots) colored by prioritization category, arranged by census tracts. Tracts are shown as lightly colored areas where the tract contains greater than 25 cesspools, and are shown as white areas where the tract contains less than 25 cesspools (not assessed by the HCPT). Purple boundary indicates previous 2017 priority upgrade areas. (Updated 2022)*

Table 4: *Prioritization categories and island-specific ranks for Oʻahu tracts. (Update 2022)*

Tract Name	Tract ID	Cesspool Count	Priority Category	Island-Specific Priority Rank
Hauula-Kaaawa	197	628	**Priority 1**	1
Haleiwa	66	324	**Priority 1**	2
Makua Valley	5	98	**Priority 1**	3
Laie	257	338	**Priority 1**	4
Waimanalo Beach-Homesteads	200	255	**Priority 1**	5
Kaena Point	6	847	**Priority 1**	6
Waimea-Kahuku	268	773	**Priority 1**	7
Kalaheo Avenue	23	132	**Priority 1**	8
Kawailoa	7	209	**Priority 1**	9
Campbell High School	99	893	**Priority 1**	10
Judd Hillside-Lowrey Avenue	250	78	**Priority 1**	11
Waianae Kai	139	172	**Priority 1**	12
Kapiolani Park	227	32	**Priority 1**	13
Nanakuli	13	96	**Priority 2**	14
Diamond Head	148	120	**Priority 2**	15
Kahaluu-Waikane	258	670	**Priority 2**	16
Lualualei-Camp Waianae	2	213	**Priority 2**	17
Makaha	72	89	**Priority 2**	18
Kunia West	14	54	**Priority 2**	19
Waialae-Kahala	47	39	**Priority 2**	20
Makiki Heights	176	55	**Priority 2**	21
Aiea Heights	259	106	**Priority 2**	22
Punchbowl	236	39	**Priority 2**	23
Round Top-Tantalus	170	159	**Priority 2**	24
Maili	185	100	**Priority 3**	25
Hawaii Prince Golf Course	30	51	**Priority 3**	26
Lualualei Transmitter	3	88	**Priority 3**	27
Haiku	49	146	**Priority 3**	28
Lualualei: Halona Road	269	232	**Priority 3**	29
Ahuimanu	232	99	**Priority 3**	30
Waimanalo	244	159	**Priority 3**	31
Ewa Gentry	26	94	**Priority 3**	32
Kapiolani Community College	48	65	**Priority 3**	33
Maunawili	267	38	**Priority 3**	34

Results: Maui

The island of Maui contains an estimated 11,038 cesspools and has a total of 31 census tracts, although only 23 tracts contained more than 25 cesspools and were categorized within the HCPT.

Maui Breakdown:

30% (7 tracts)**/924** cesspools (8%) = **Priority Level 1**

17% (4 tracts)**/3,148** cesspools (12%) = **Priority Level 2**

52% (12 tracts)**/6,971** cesspools (79%) = **Priority Level 3** *(Updated 2022)*

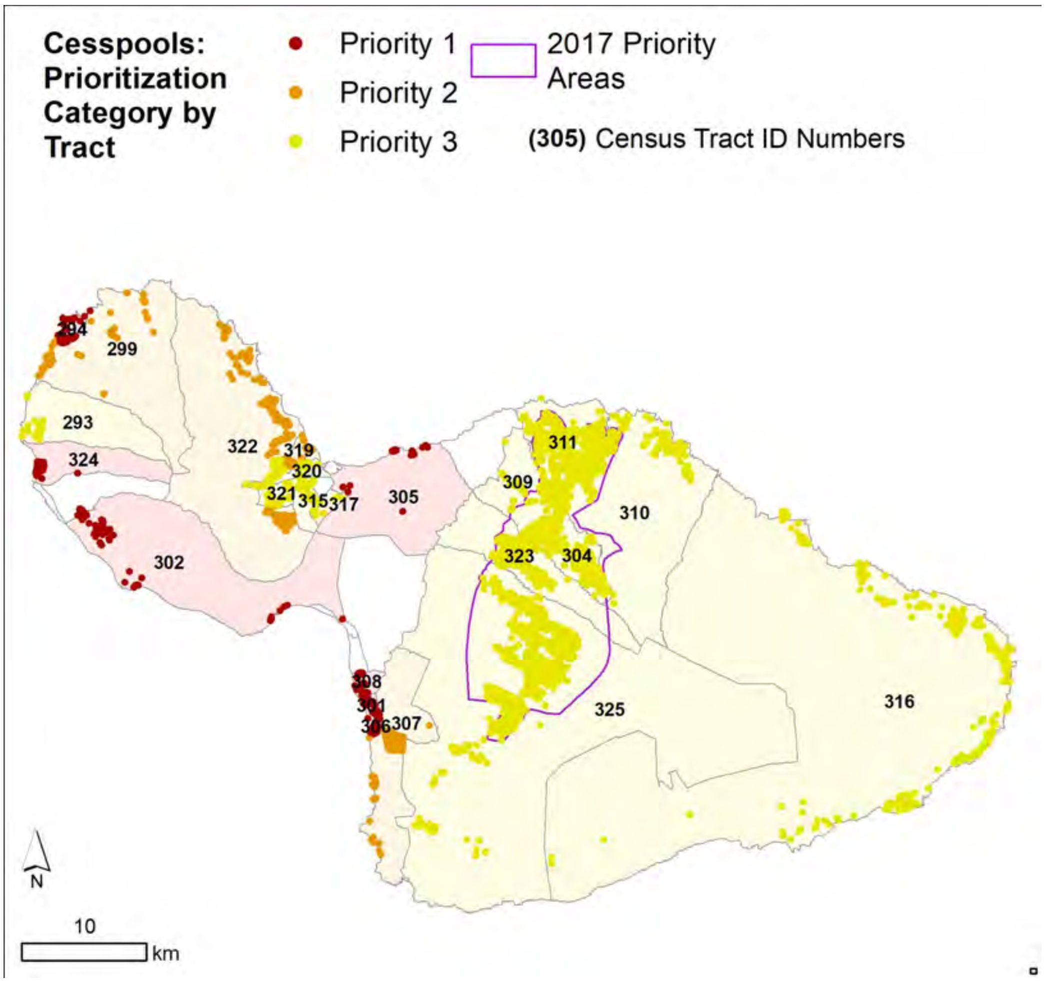

Figure 22: *Maui cesspools (dots) colored by prioritization category, arranged by census tracts. Tracts are shown as lightly colored areas where the tract contains greater than 25 cesspools, and are shown as white areas where the tract contains less than 25 cesspools (not assessed by the HCPT). Purple boundary indicates previous 2017 priority upgrade areas. (Updated 2022)*

Table 5: *Prioritization categories and island-specific ranks for Maui tracts. (Updated 2022)*

Tract Name	Tract ID	Cesspool Count	Priority Category	Island-Specific Priority Rank
Halama	308	84	**Priority 1**	1
Kahoma	324	280	**Priority 1**	2
Spreckelsville	305	35	**Priority 1**	3
Kamaole	301	134	**Priority 1**	4
Kapalua	294	223	**Priority 1**	5
Keawakapu	306	90	**Priority 1**	6
Launiupoko	302	78	**Priority 1**	7
Honokahua	299	85	**Priority 2**	8
Wailea	307	659	**Priority 2**	9
North Wailuku	319	69	**Priority 2**	10
Waihee-Waikapu	322	590	**Priority 2**	11
Honokowai	293	62	**Priority 3**	12
Kula	325	2268	**Priority 3**	13
Hana	316	537	**Priority 3**	14
West Kahului	315	60	**Priority 3**	15
Hali'imaile	309	1146	**Priority 3**	16
South Wailuku	321	281	**Priority 3**	17
Southeast Kahului	317	31	**Priority 3**	18
East Central Wailuku	320	64	**Priority 3**	19
Pukalani	323	1492	**Priority 3**	20
Makawao	304	891	**Priority 3**	21
Ha'iku	311	1413	**Priority 3**	22
Huelo	310	466	**Priority 3**	23

Results: Hawaiʻi Island

Hawaiʻi Island contains an estimated 48,596 cesspools and has a total of 33 census tracts. All 33 tracts contained more than 25 cesspools and were categorized within the HCPT.

Hawaiʻi Island Breakdown:

9% (3 tracts)**/5,119** cesspools (11%) = **Priority Level 1**

15% (5 tracts)**/2,619** cesspools (6%) = **Priority Level 2**

76% (25 tracts)**/40,858** cesspools (84%) = **Priority Level 3** *(Updated 2022)*

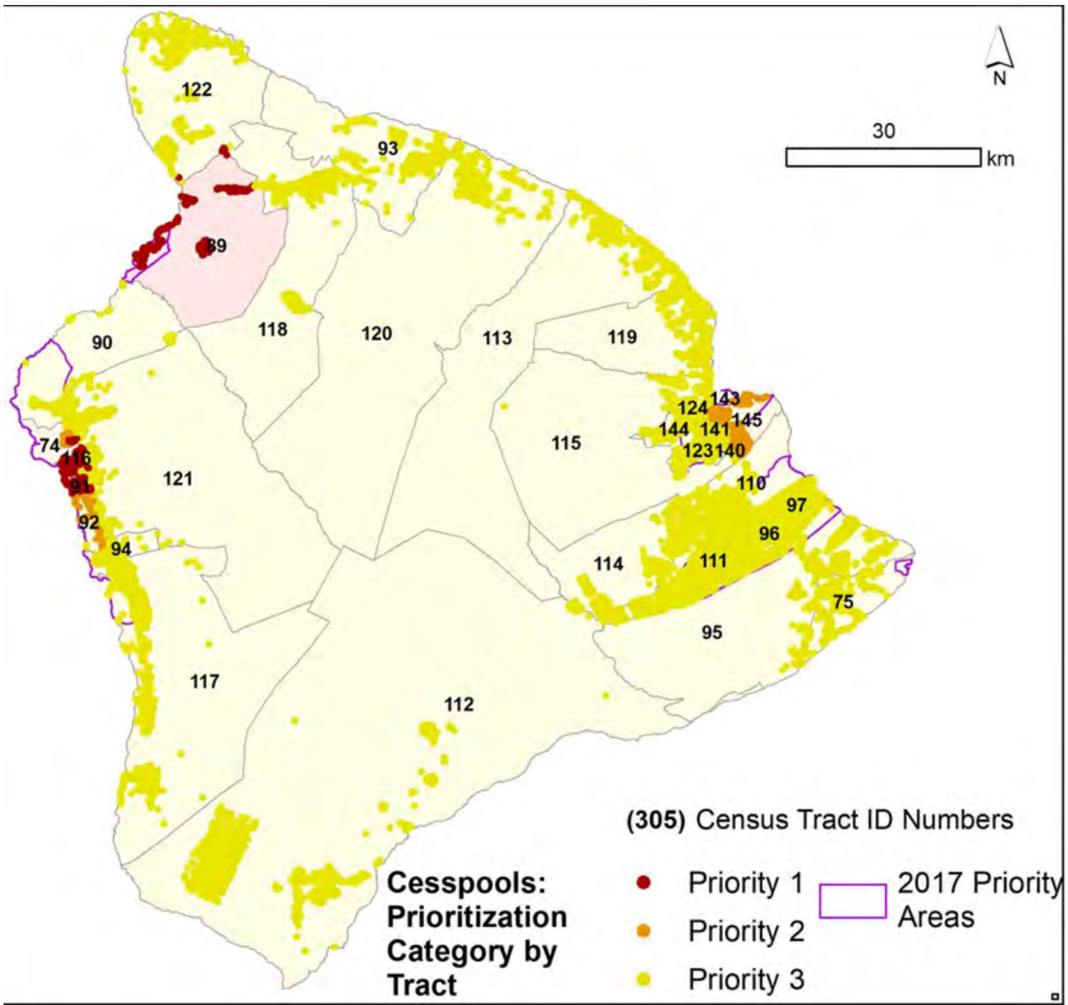

Figure 23: *Hawaiʻi Island cesspools (dots) colored by prioritization category, arranged by census tracts. Tracts are shown as lightly colored areas where the tract contains greater than 25 cesspools, and are shown as white areas where the tract contains less than 25 cesspools (not assessed by the HCPT). Purple boundary indicates previous 2017 priority upgrade areas. (Updated 2022)*

Table 6: *Prioritization categories & island-specific ranks for Hawaiʻi tracts. (Updated 2022)*

Tract Name	Tract ID	Cesspool Count	Priority Category	Island-Specific Priority Rank
Holualoa	91	1761	**Priority 1**	1
Kailua	116	1334	**Priority 1**	2
Kawaihae-Waikoloa	89	2024	**Priority 1**	3
Hilo: Keaukaha-Pana'ewa	145	934	**Priority 2**	4
Hilo: Villa Franca-Kaiko'o	142	151	**Priority 2**	5
Kaumalumalu-Keahou	92	654	**Priority 2**	6
Hilo: University-Houselots	141	549	**Priority 2**	7
Kealakehe	74	530	**Priority 2**	8
Hilo: Puainako	140	1582	**Priority 3**	9
Hilo: Pu'u'eo-Downtown	143	350	**Priority 3**	10
Hualalai	121	1141	**Priority 3**	11
Pauka'a-Wailea	119	963	**Priority 3**	12
Konawaena	94	1059	**Priority 3**	13
Waimea-Pu'u Anahulu	118	2375	**Priority 3**	14
North Hilo	113	855	**Priority 3**	15
Upper Waiakea Forest Reserve	115	670	**Priority 3**	16
Kalaoa	90	1916	**Priority 3**	17
Hilo: Haihai	123	1510	**Priority 3**	18
South Kona	117	1999	**Priority 3**	19
Hilo: Kawailani	125	1608	**Priority 3**	20
Hilo: Piihonua-Kaumana	124	1828	**Priority 3**	21
Hawaiian Paradise Park	97	4187	**Priority 3**	22
North Kohala	122	2131	**Priority 3**	23
Honoka'a-Kukuihaele	93	1329	**Priority 3**	24
Pahoa	95	2137	**Priority 3**	25
Hilo: Kahuku-Kaumana	144	1192	**Priority 3**	26
Ka'u	112	2481	**Priority 3**	27
Kea'au	110	1515	**Priority 3**	28
Pa'auhau-Pa'auilo	120	971	**Priority 3**	29
Kalapana-Kapoho	75	1175	**Priority 3**	30
Orchidland-Ainaloa	96	1663	**Priority 3**	31
Volcano-Mt. View	114	1371	**Priority 3**	32
Upper Puna (Puna Mauka)	111	2651	**Priority 3**	33

Results: Kauaʻi

The island of Kauaʻi contains an estimated 14,300 cesspools and has a total of 13 census tracts. All 13 tracts contained more than 25 cesspools and were categorized within the HCPT.

Kauaʻi Breakdown:

23% (3 tracts)/**2,999** cesspools (20%) = **Priority Level 1**
46% (6 tracts)/**6,144** cesspools (45%) = **Priority Level 2**
31% (4 tracts)/**5,157** cesspools (33%) = **Priority Level 3** *(Updated 2022)*

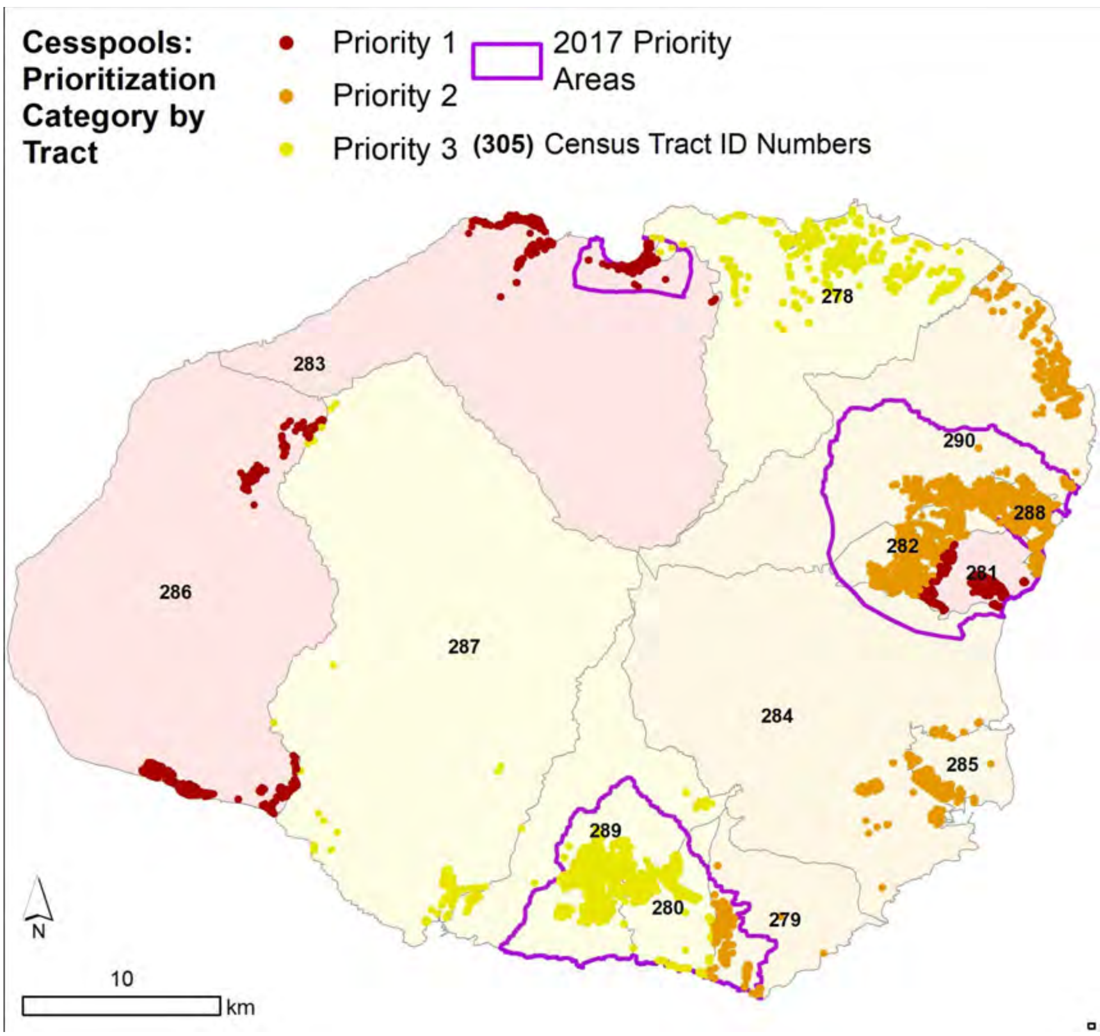

Figure 24: *Kauaʻi cesspools (dots) colored by prioritization category, arranged by census tracts. Tracts are shown as lightly colored areas where the tract contains greater than 25 cesspools, and are shown as white areas where the tract contains less than 25 cesspools. Purple boundary indicates previous 2017 priority upgrade areas. (Updated 2022)*

Table 7: *Prioritization categories and island-specific ranks for Kauaʻi tracts. (Updated 2022)*

Tract Name	Tract ID	Cesspool Count	Priority Category	Island-Specific Priority Rank
Ha'ena-Hanalei	283	554	**Priority 1**	1
Kekaha-Waimea	286	1210	**Priority 1**	2
Wailua Homesteads	281	1235	**Priority 1**	3
Kapa'a	288	2276	**Priority 2**	4
Wailua Houselots	282	1616	**Priority 2**	5
Koloa-Po'ipu	279	671	**Priority 2**	6
Anahola	290	980	**Priority 2**	7
Lihu'e	285	601	**Priority 2**	8
Puhi-Hanama'ulu	284	362	**Priority 2**	9
Kaumakani-Hanapepe	287	457	**Priority 3**	10
Omao-Kukui'ula	280	916	**Priority 3**	11
Princeville-Kilauea	278	1233	**Priority 3**	12
Eleele-Kalaheo	289	2189	**Priority 3**	13

Validation of Results

Hawaiʻi Act 132 funded a study led by Smith et al. (2021) to detect OSDS pollution in coastal waters. The study titled, the State-Wide Assessment of Wastewater Pollution Intrusion Into Coastal Regions of the Hawaiian Islands, used the $\delta^{15}N$ values of algal tissue collected in the nearshore environment to determine where nitrogen from wastewater was chronically present within the coastal water column. The study represents the most comprehensive and geographically widespread assessment of nearshore nitrogen source tracing in the state. The authors determined its value is most appropriately applied to a qualitative validation of the prioritization results. Though Smith et al. (2021) provides the best validation dataset available, it should be remembered that the geographic scale and physical drivers of the dataset have significant differences from the statewide, multi-factor extent of the HCPT.

Smith et al. (2021) were able to sample across approximately 50 km of coastline. However, this is still only a small percentage of the state's 1,600 km of coastline. These algal sampling results are extremely high resolution, showing high variability between sites within hundreds of meters of each other. This exemplifies the complexity and spatial variability of water chemistry and OSDS impacts across large and complicated ecosystems. Nonetheless, generalizations can be made. Act 132 study results were formatted to be comparable to the HCPT results by averaging algal sample site $\delta^{15}N$ values into sample 'swath' averages, which represent swaths of coastline roughly 2 km in length. These were categorized by Smith et al. into:

1. Areas dominated by wastewater nitrogen ($\delta^{15}N$ values > 6‰);
2. Areas with mixed inputs of nitrogen ($\delta^{15}N$ values > 4‰ and < 6‰), and;
3. Areas with limited detection of wastewater N ($\delta^{15}N$ values < 4‰), based on breakpoints listed here.

$\delta^{15}N$ can inform us of the amount of bioavailable nitrogen from different sources. However, it is not necessarily representative of the level of nitrogen flux. Additionally, the $\delta^{15}N$ indicator is subject to limitations, most importantly mixing of nitrogen from other sources, especially agriculture which reduces the clarity of the wastewater nitrogen signature. This tracer only provides information related to coastal water nitrogen chemistry in the immediate sampling location, whereas the HCPT includes multiple other factors, including value-based considerations, that are not related to nitrogen flux. Therefore, algal data results cannot, and should not, fully explain the HCPT categorization results. However, the qualitative comparison remains a useful and thought-provoking exercise.

Table 8 provides a qualitative assessment of how prioritization categories from the HCPT match with the Smith et al. (2021) wastewater impact categories based on the geographic proximity of cesspools and known nitrogen transport factors such as groundwater flow paths and coastal water movement. Overall, the results of this validation indicate 25 of 33 swaths (≈75%) have HCPT prioritization and wastewater impact categories that match reasonably well. Whereas, eight swaths (≈25%) have differing categorizations. Explanations for a number of these outliers are provided in Smith et al. (2021). There are many limitations to comparing very different types of data. Differences in results should be expected. Figure 25 provides a map view of cesspool prioritization categories, aggregated by census blocks alongside the wastewater impact categories of algal sampling swaths produced by Smith et al. (2021).

Table 8: *Qualitative validation results comparison between HCPT prioritization categories and Smith et al. (2021) wastewater impact categories. Wastewater impact categories are based on observed algal δ^{15}N values averaged across 2 km nearshore swaths and are compared to the HCPT calculated categories of proximal cesspools.*

Swath	Average Algal δ^{15}N value (‰)	Wastewater Impact Category	HCPT Prioritization of Nearby Cesspools	Matching	Comments for non-matching areas
HPP, Puna	2.12	Limited	3	yes	--
Hamakua Coast	3.17	Limited	3	yes	--
Holualoa, Kona	4.9	Mixed	1/2	yes	--
Kailapa, S.Kohala	4.14	Mixed	3/2/1	yes	--
Keaukaha, Hilo	3.48	Limited	3/1	no	Flow paths may not intersect
Mahaiula, Kona	2.4	Limited	3/None	yes	--
Mauna Lani, Kohala	4.33	Mixed	1	yes	--
NELHA,Kailua-Kona	4.22	Mixed	3	no	Large numbers of upslope CP
Puako, S. Kohala	6.48	Dominated	1	yes	--
Wailoa River, Hilo	4.98	Mixed	3/2/1	yes	--
Kapaa	5.86	Mixed	3/2/1	yes	--
Nawiliwili	8.11	Dominated	2	yes	--
Waiohai	8.44	Dominated	1/2	yes	--
Paia	3.2	Limited	3/None	yes	--
Kihei North	1.91	Limited	3/None	yes	--
Kihei South	5.11	Mixed	1/2	yes	--
Lahaina Control	2.21	Limited	No CP	yes	--
North Shore Control	1.9	Limited	1	no	Few cesspools, high water currents.
South Maui Control	2.58	Limited	3/None	yes	--
Waiehu	6.88	Dominated	3	no	Wetland denitrification
Waihee Control	1.71	Limited	3	yes	--
Wailea	6.36	Dominated	1/2	yes	--
Wailea South	4.81	Mixed	2	yes	--
Diamond Head	5.96	Mixed	2	yes	--
Hauula	9.23	Dominated	1	yes	--
Kaaawa	10.3	Dominated	1	yes	--
Kalaeloa	5.37	Mixed	1/None	unclear	Other sources, undocumented OSDS?
Makua	2.29	Limited	3	yes	--
Mokapu	2.89	Limited	1	no	Unclear, complex geology?
Sunset Beach	3.67	Limited	1	no	Unclear, complex currents?
Waialua	9.81	Dominated	1	yes	--
Waianae	5.43	Mixed	2	yes	--
Wailupe	6.09	Dominated	No CP	no	Other, undocumented OSDS?

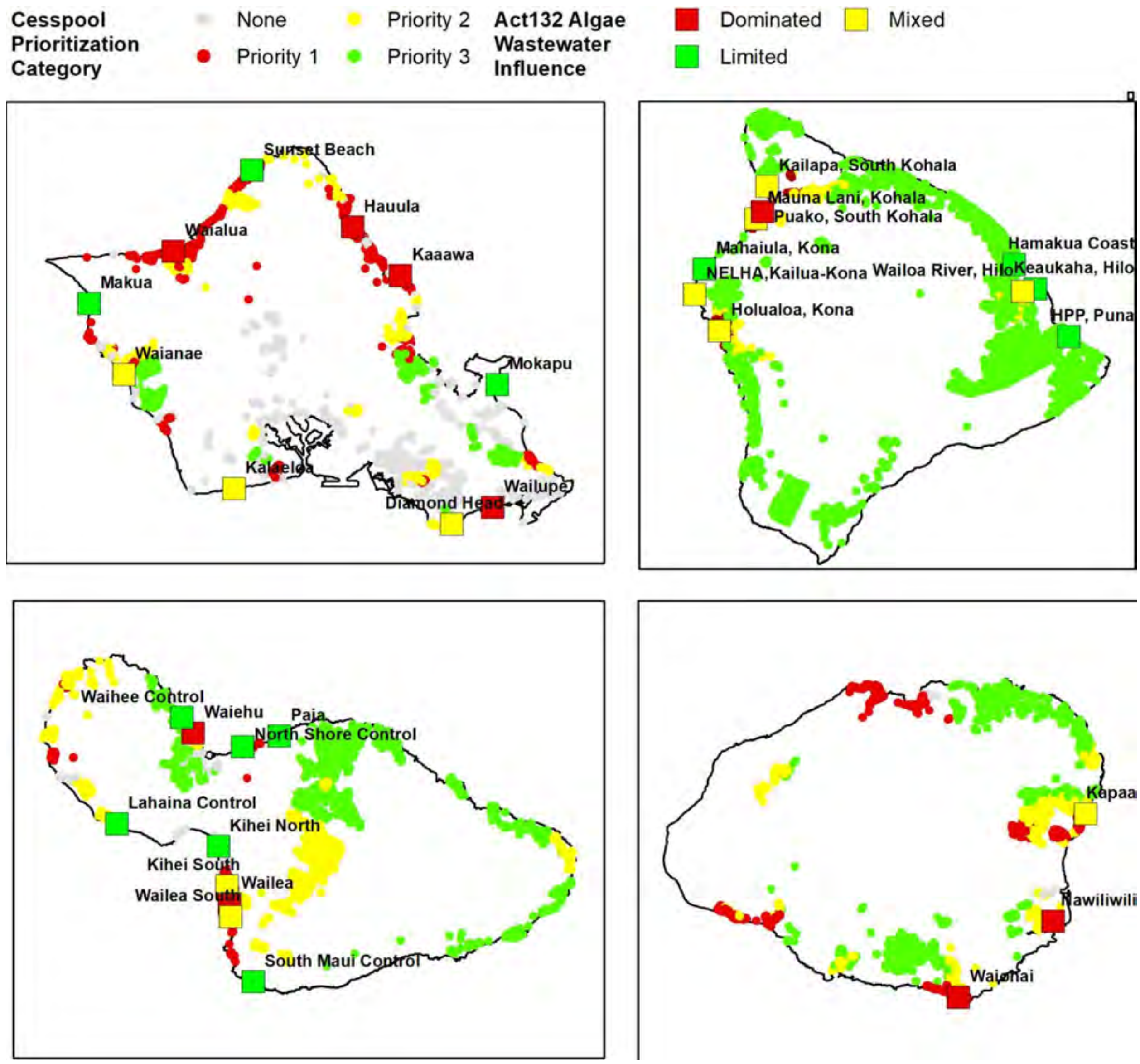

Figure 25: *Cesspool locations (circles) color coded by HCPT prioritization categories and aggregated by census blocks alongside algal sampling swaths (squares) from Smith et al. (2021) color coded by observed wastewater impact categories.*

Sensitivity Analysis of Priorities

Each factor used in the HCPT interacts with the environment in various ways and has different levels of importance to stakeholders and the community. For example, ocean conservation organizations may heavily prioritize coral reef protection, whereas the Board of Water Supply may prioritize impacts to drinking water wells more heavily. Unfortunately, it is impossible to weigh the factors proportionally to meet the demands of all stakeholders. Yet, it is acknowledged that each factor isn't equal in terms of its potential hazard and impact on the environment or human health. Because DOH is tasked with protecting human health and the environment, the tool includes factors that relate to these outcomes (i.e. distance to drinking water wells). A sensitivity analysis was performed to understand how weighting different factors may or may not change the score results. The process is an important way to test the robustness of the method and the types of factors chosen. If the weight of one factor disrupted the overall results disproportionately, it could compromise the structure of the tool. The sensitivity analysis was conducted using three scenarios where different weights were assigned to each risk factor, based on a hypothetical conceptual model of how different priorities might be expressed through adjustment of weights to different factors based upon the DOH mission and need.

The three weighting scenarios that were developed include:

1. **All inputs equally weighted:** Base scenario to which all others are compared.
2. **Human health priority:** Drinking water and human recreation are prioritized.
3. **Ecological health priority:** Ecosystem services and wildlife are prioritized.

It is recognized that some overlap exists between the scenarios, for example, factors that support ecological health often also benefit human health. Every effort was made to thoughtfully categorize the scenarios. Though imperfect, this method allows comparison for use and lends validity to future policy development. Ideally, the science in this tool would be straightforward enough for 'evidence-based policymaking.' However, with that, there is a level of pragmatism needed and an ability to combine scientific evidence with governance principles to translate the complex scientific principles into simple explanations for decision-making (Cairney & Oliver, 2017). The authors recognize the balance needed between robustness of the scientific methodology and the ability to make informed decisions to overcome problems.

Overall, it is the authors' opinions that using an equal weight method is feasible and acceptable for this exercise at this time. Sensitivity testing suggested that there may be about a six to seven percent uncertainty in the final ranks of the census tracts if different risk factors are weighted reasonably, as was done with these three scenarios. Individual census tracts can change more, warranting further exercises to determine appropriate weighting. Specifically, through this type of test, the authors found that the rank of individual census tracts (when tracts are ordered by priority score) has a standard deviation of 6.2 ranks when the ecological health scenario is compared to the base scenario, and 6.3 ranks when the human health scenario is compared to the base scenario. Essentially, the further this deviation is from zero, the less the scenarios match or agree. Complete results and specifics about the sensitivity testing are provided in Appendix B.

Conclusion/Next Steps

The current report and the HCPT expand on the previous efforts to provide a sound, quantitative, up-to-date hazard assessment of geographic areas at risk from cesspool pollution. The hazard categories provide a framework to prioritize cesspool conversions by the CCWG. The HCPT uses the best available data and method, developed in consultation with local experts and DOH associates, to prioritize cesspools in the allotted time frame of the contract and CCWG needs. Though the prioritization process is inherently contextual, every effort has been made to create an objective evaluation of cesspool hazards in an equitable and fact-based methodology. The HCPT should be used in consultation with a suite of iterative decision-making strategies.

The HCPT is a dynamic data tool that can support additional analysis of cesspool conversion strategies and policies. Because additional data can be layered onto the prioritization results, there are numerous possibilities to explore interdisciplinary connections between cesspool conversion and social factors such as household income, language spoken, or internet connectivity. By analyzing various data types with priority conversion areas, outreach and education methods can become highly specialized and targeted to have the greatest impacts, saving money, time, and human resources.

Because the HCPT relies on accurate cesspool numbers and locations, future database refinement is warranted and recommended, including some level of ground-truthing. This will ensure that the HCPT results are accurate, but also allow DOH to track maintenance and upgrades more efficiently and effectively. The identified hazard areas can also inform future permit requirements and prioritization plans, including mandating larger lot sizes for future development, increased setback distances to the coast, and requiring advanced technologies where appropriate. County offices may wish to use the tool for future planning of subdivisions to avoid carrying capacity issues on the land, such as poor soil or proximity to sensitive habitat or drinking water. Watershed or conservation organizations may find value in understanding areas most at risk from cesspool pollution and use the data for educational or management strategies. Finally, the HCPT can also identify areas where maintenance and inspection of OSDS will be critical to preserving water quality.

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Appendix A: Additional Results

Additional Figures and tables are provided below. All results are updated as of 2022, See Appendix C for details.

Additional Results: O'ahu

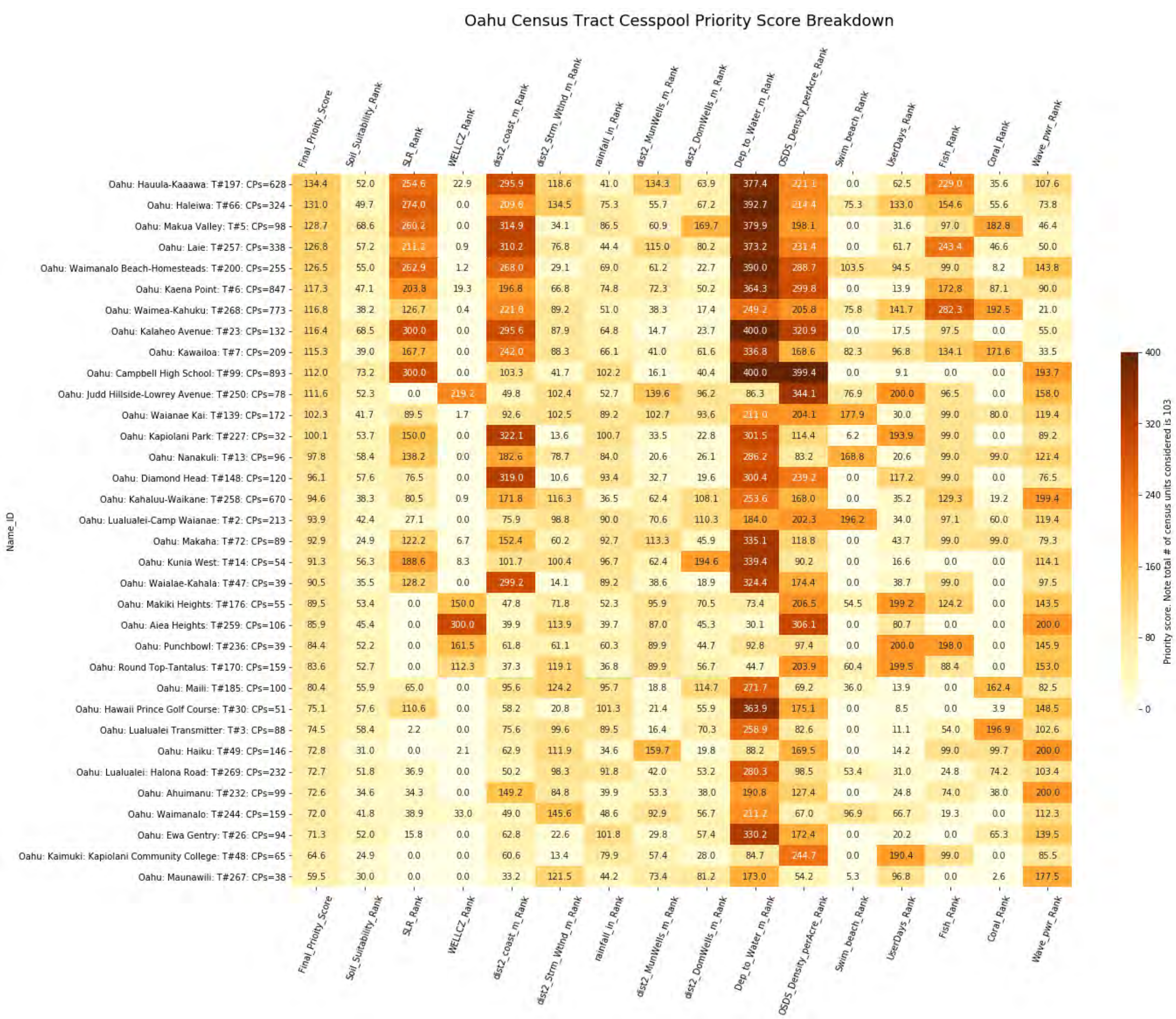

Figure A1: *Pivot table showing census-tract based priority scores, (leftmost column) and individual risk factor scores, which were averaged to calculate the overall priority score of each census tract for O'ahu. (Updated 2022)*

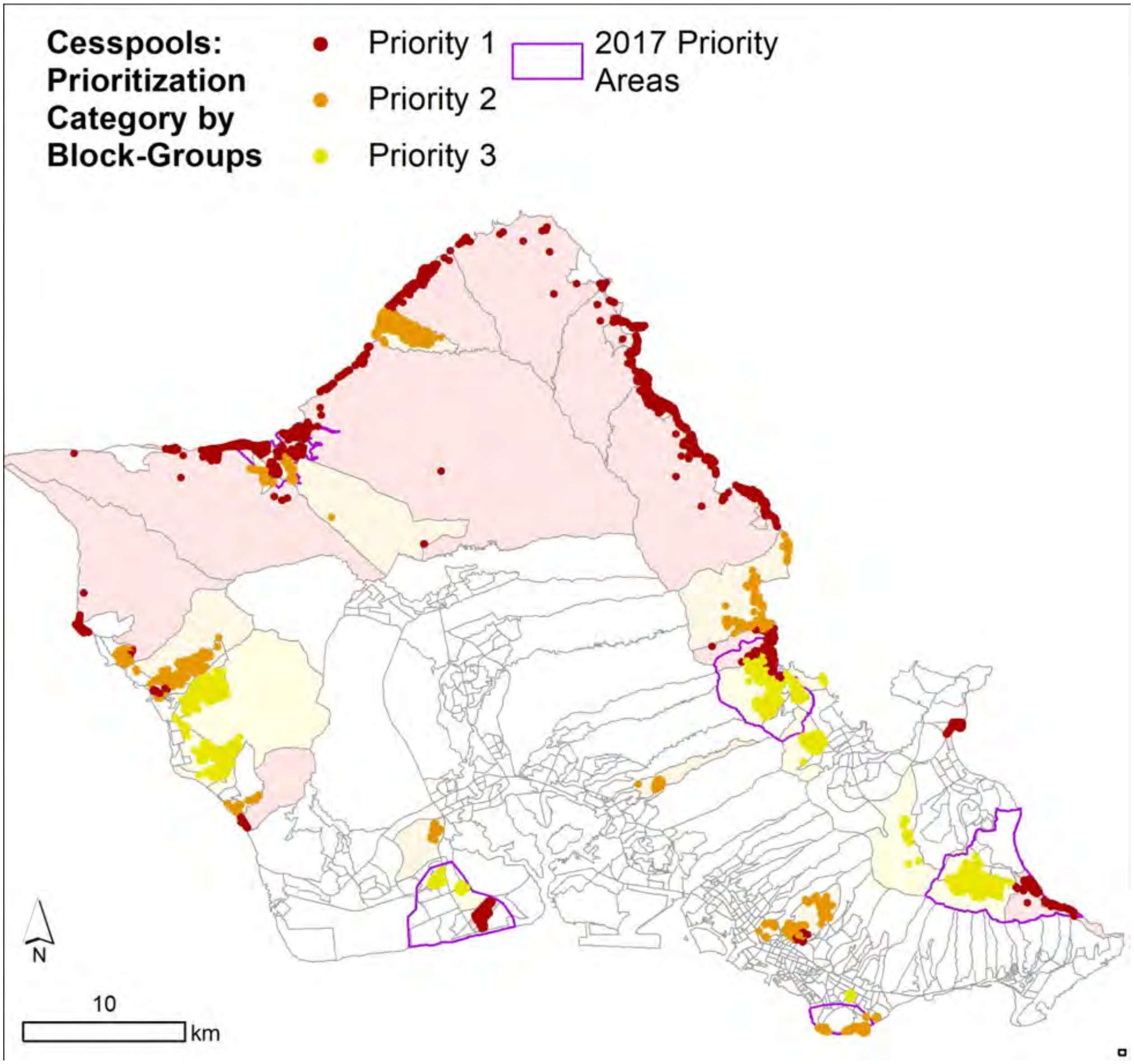

Figure A2: *O'ahu cesspools (dots) colored by prioritization category, arranged by census block-groups. Block-groups are shown as lightly colored areas where the block-group contains >20 cesspools. White areas signify the block-group contains <20 cesspools (not assessed by the HCPT). Purple boundary indicates previous 2017 priority upgrade areas. (Updated 2022)*

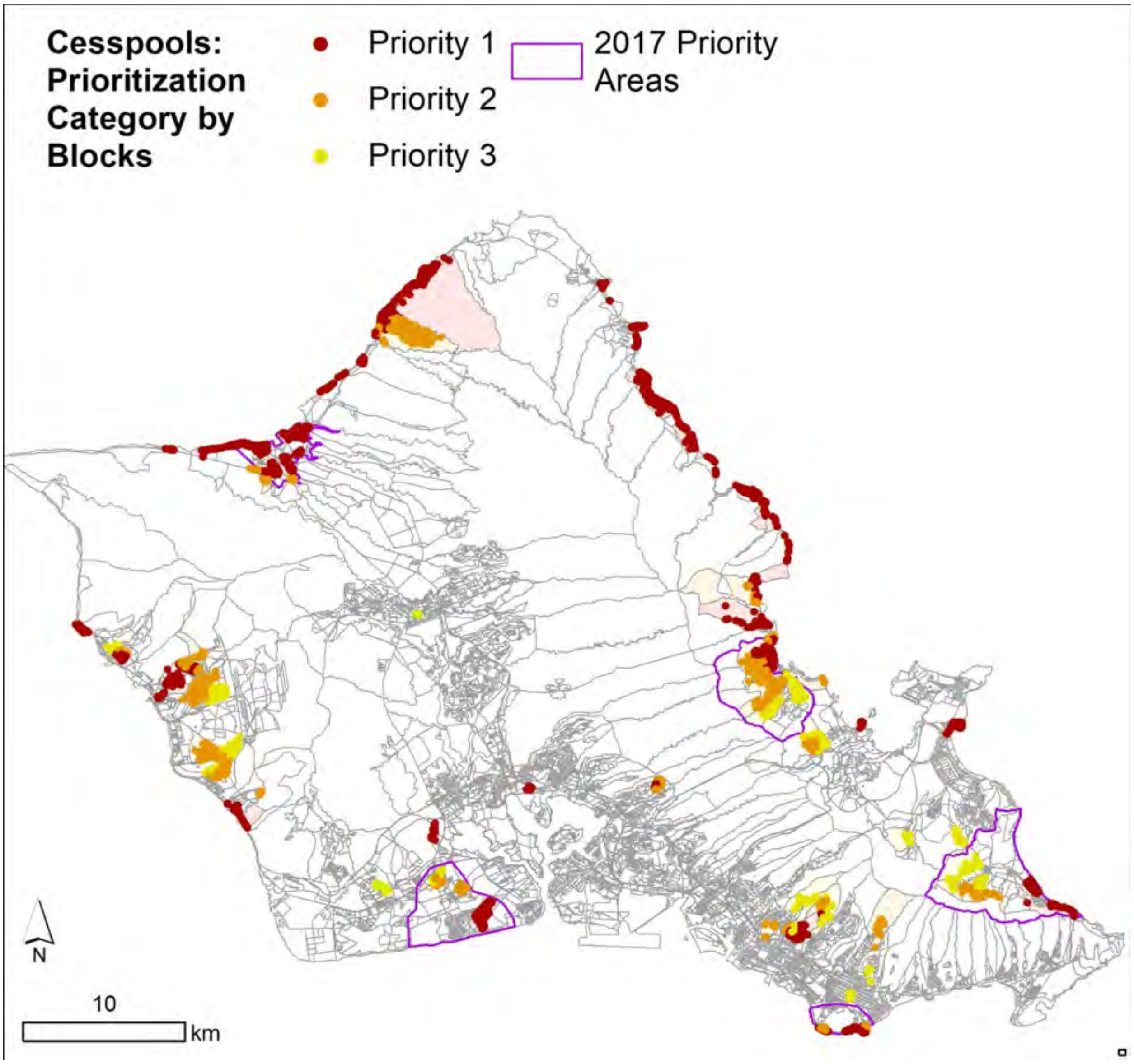

Figure A3: *O'ahu cesspools (dots) colored by prioritization category, arranged by census blocks. Blocks are shown as lightly colored areas where the block contains >10 cesspools. White areas signify the block contains <10 cesspools (not assessed by the HCPT). Purple boundary indicates previous 2017 priority upgrade areas.* (Updated 2022)

Additional Results: Maui

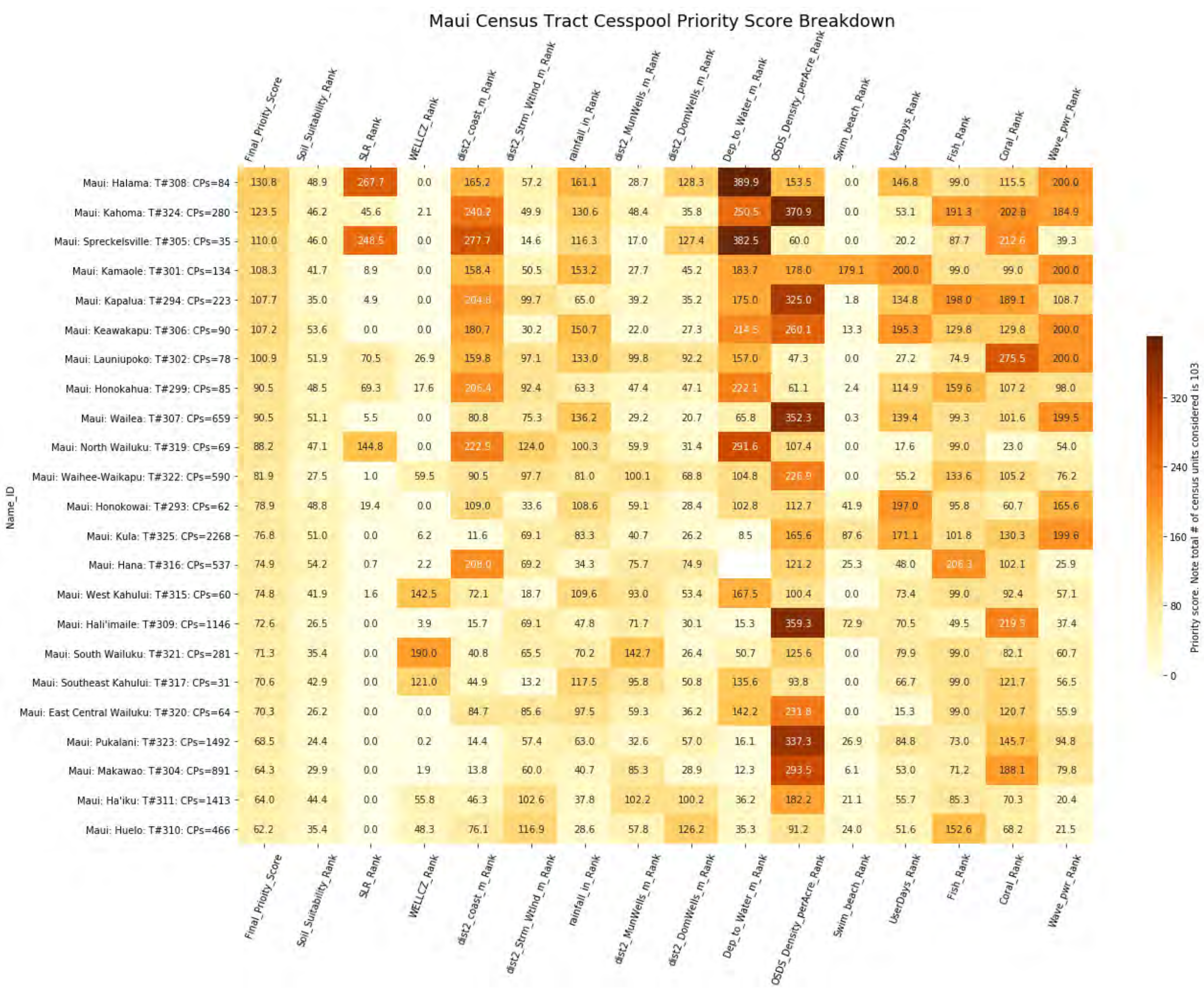

Figure A4: *Pivot table showing census-tract based priority scores, (leftmost column) and individual risk factor scores, which were averaged to calculate the overall priority score of each census tract for Maui. (Updated 2022)*

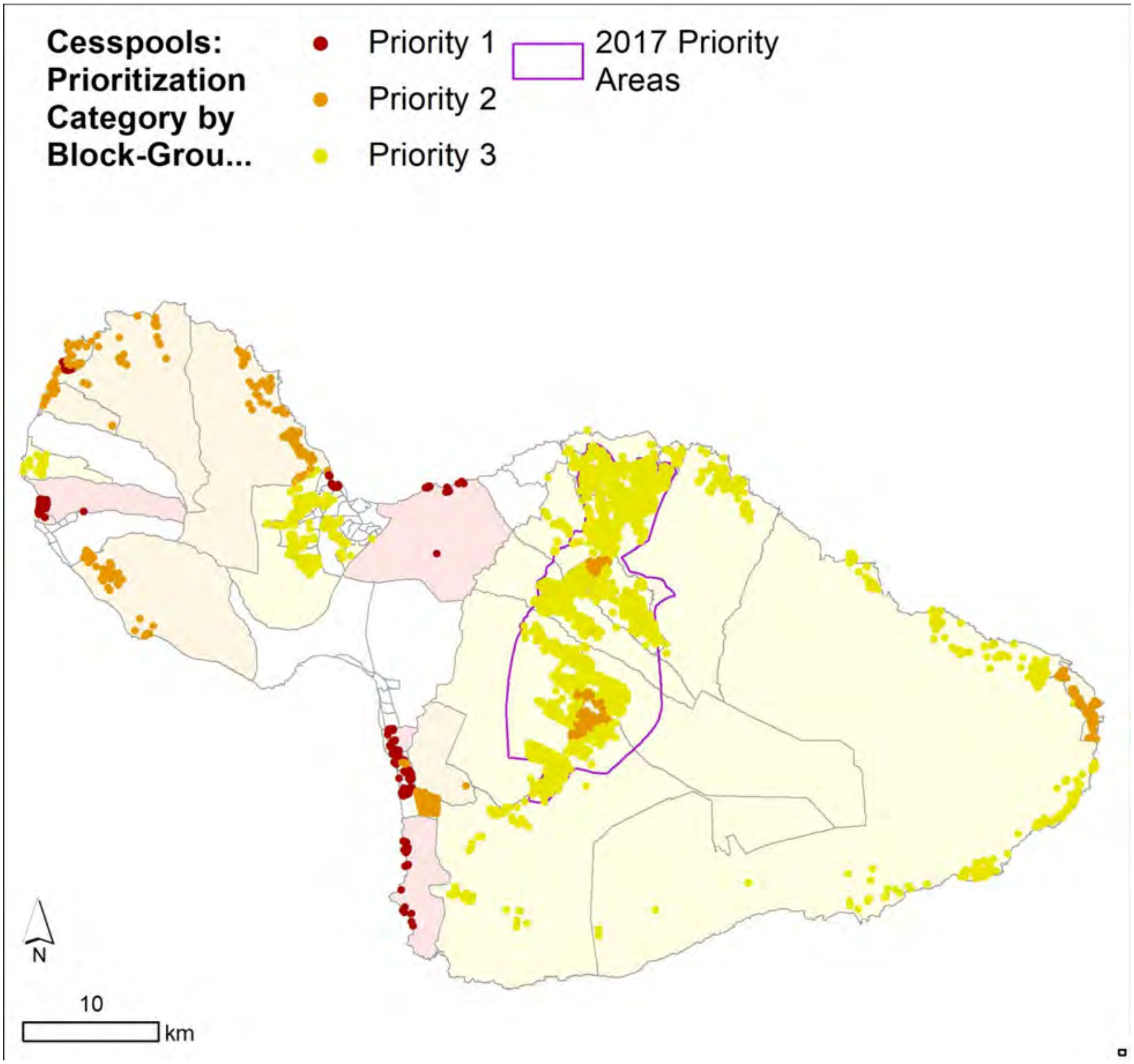

Figure A5: *Maui cesspools (dots) colored by prioritization category, arranged by census block-groups. Block-groups are shown as lightly colored areas where the block-group contains >20 cesspools. White areas signify the block-group contains <20 cesspools (not assessed by the HCPT). Purple boundary indicates previous 2017 priority upgrade areas. (Updated 2022)*

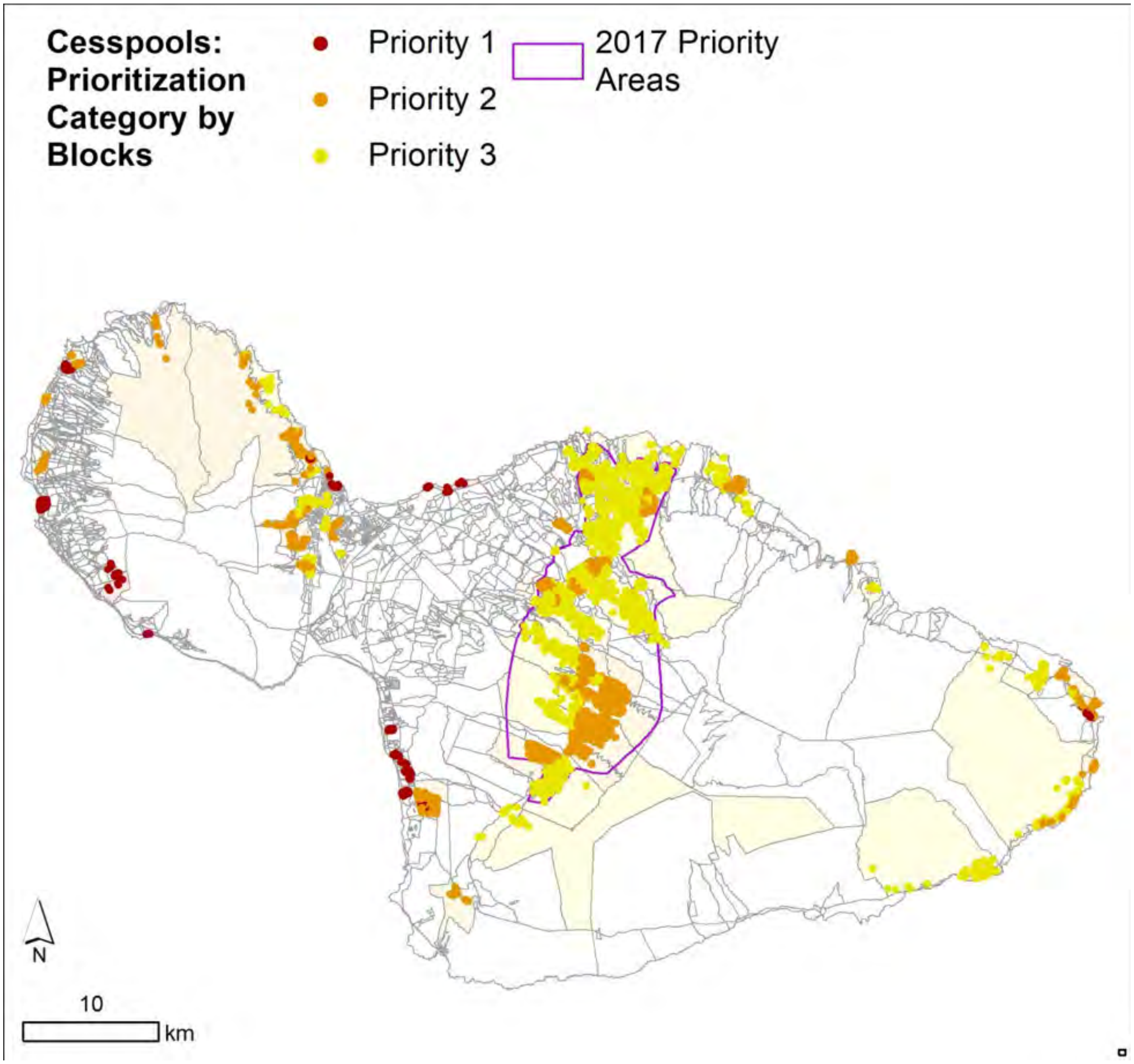

Figure A6: *Maui cesspools (dots) colored by prioritization category, arranged by census blocks. Blocks are shown as lightly colored areas where the block contains >10 cesspools. White areas signify the block contains <10 cesspools (not assessed by the HCPT). Purple boundary indicates previous 2017 priority upgrade areas. (Updated 2022)*

Additional Results: Hawaiʻi Island

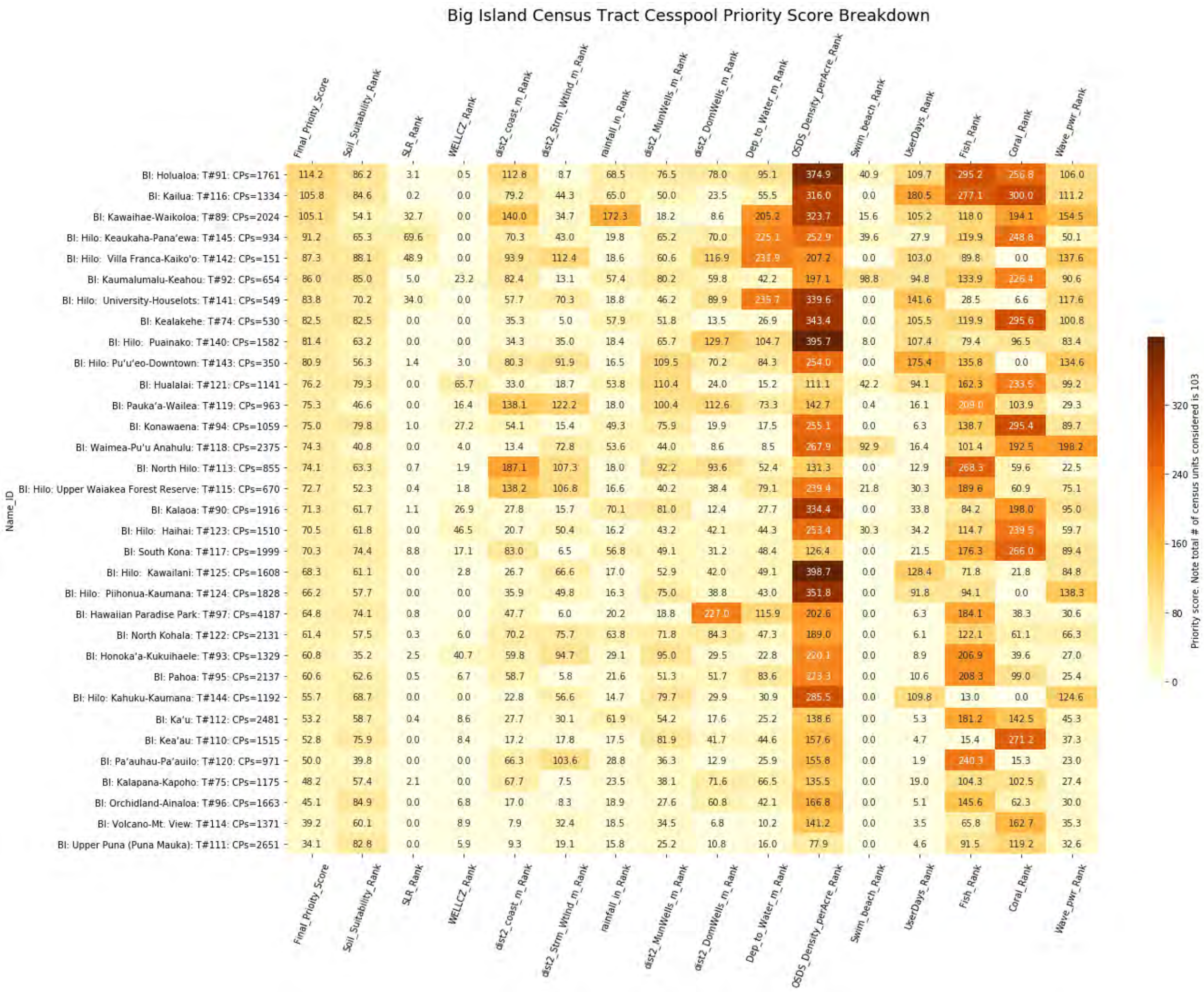

Figure A7: *Pivot table showing census-tract based priority scores, (leftmost column) and individual risk factor scores, which were averaged to calculate the overall priority score of each census tract for Hawaiʻi Island. (Updated 2022)*

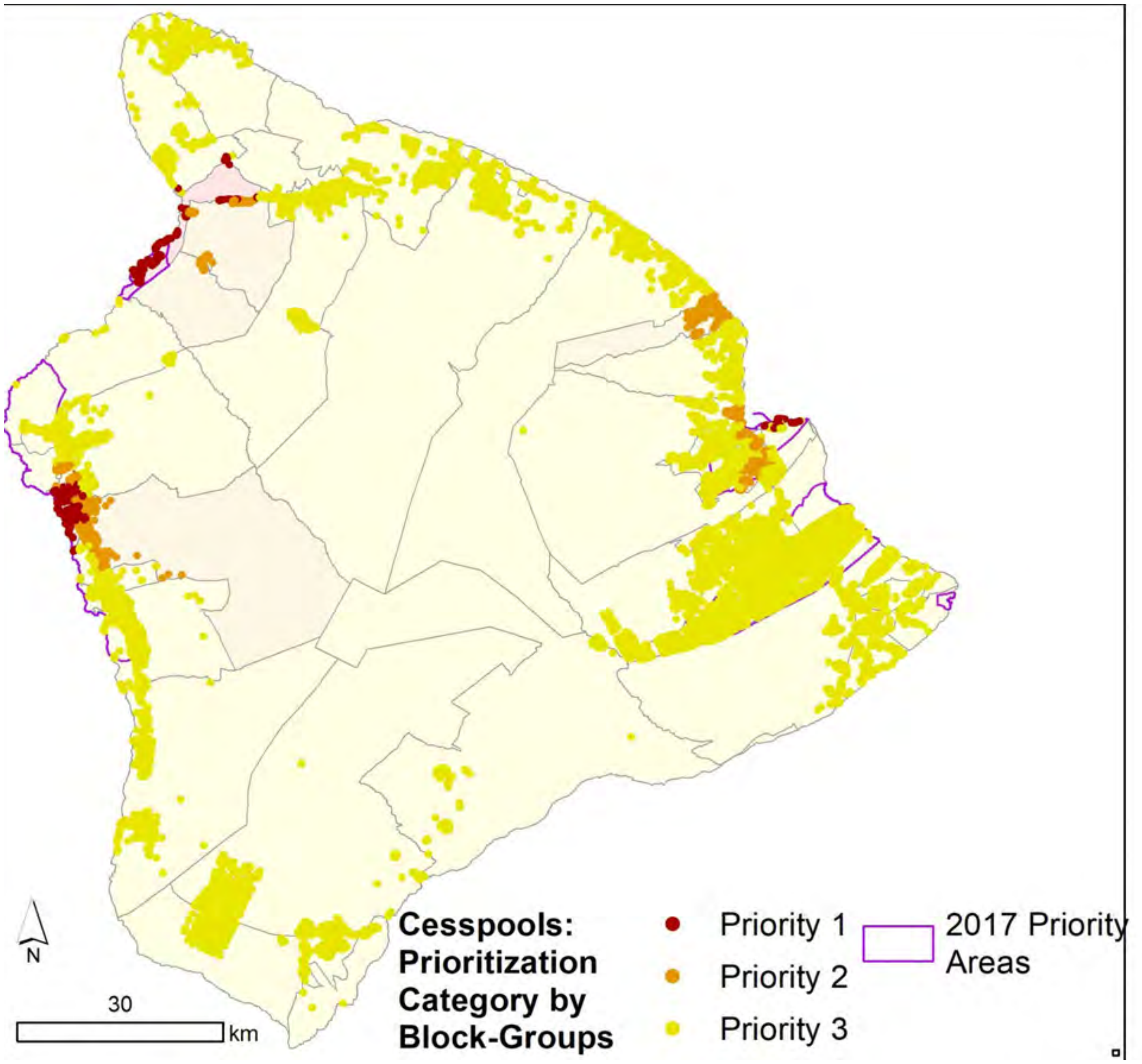

Figure A8: *Hawai'i Island cesspools (dots) colored by prioritization category, arranged by census block-groups. Block-groups are shown as lightly colored areas where the block-group contains >20 cesspools. White areas signify the block-group contains <20 cesspools (not assessed by the HCPT). Purple boundary indicates previous 2017 priority upgrade areas. (Updated 2022)*

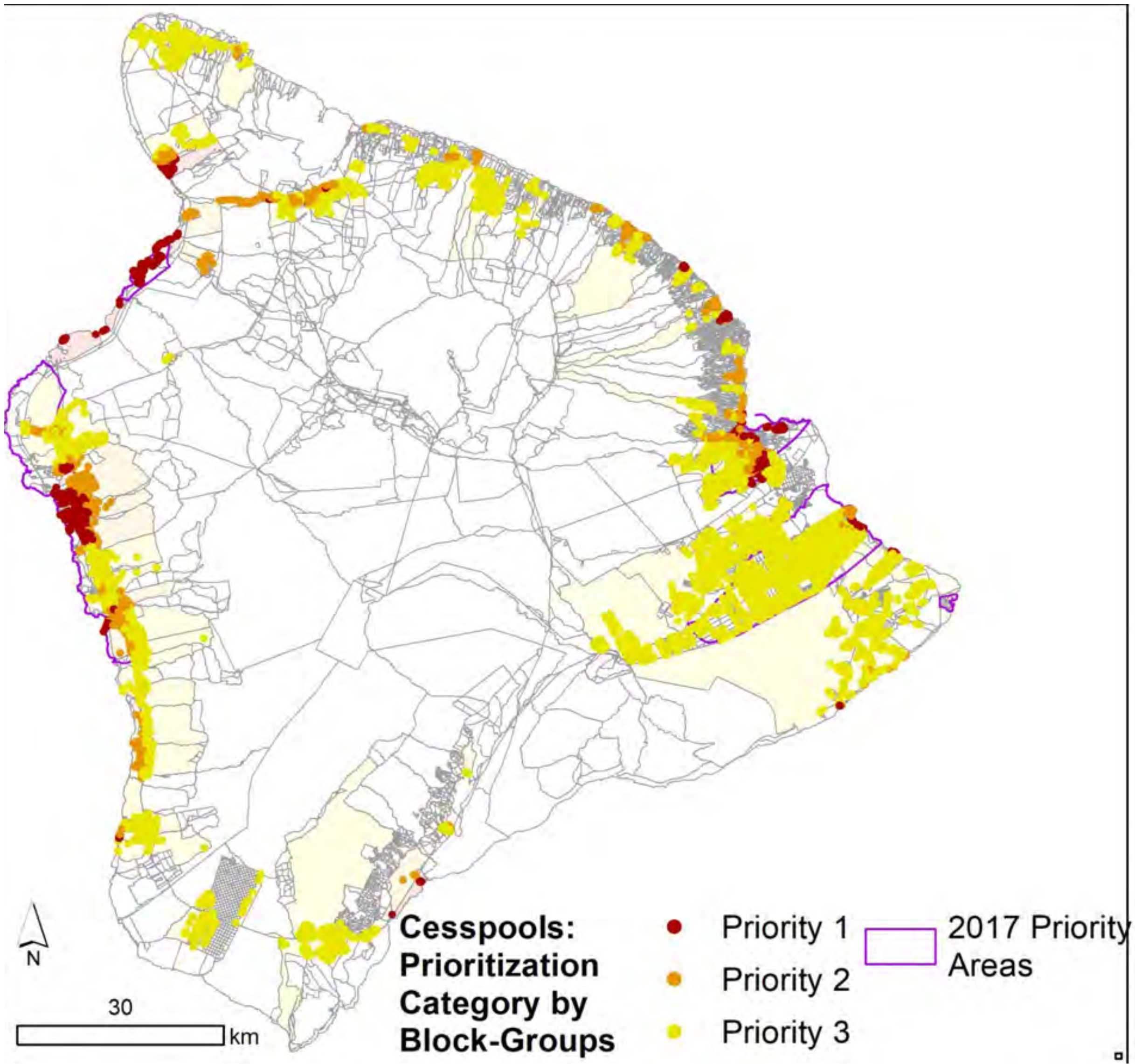

Figure A9: *Hawaiʻi Island cesspools (dots) colored by prioritization category, arranged by census blocks. Blocks are shown as lightly colored areas where the block contains >10 cesspools. White areas signify the block contains <10 cesspools (not assessed by the HCPT). Purple boundary indicates previous 2017 priority upgrade areas. (Updated 2022)*

Additional Results: Kaua'i

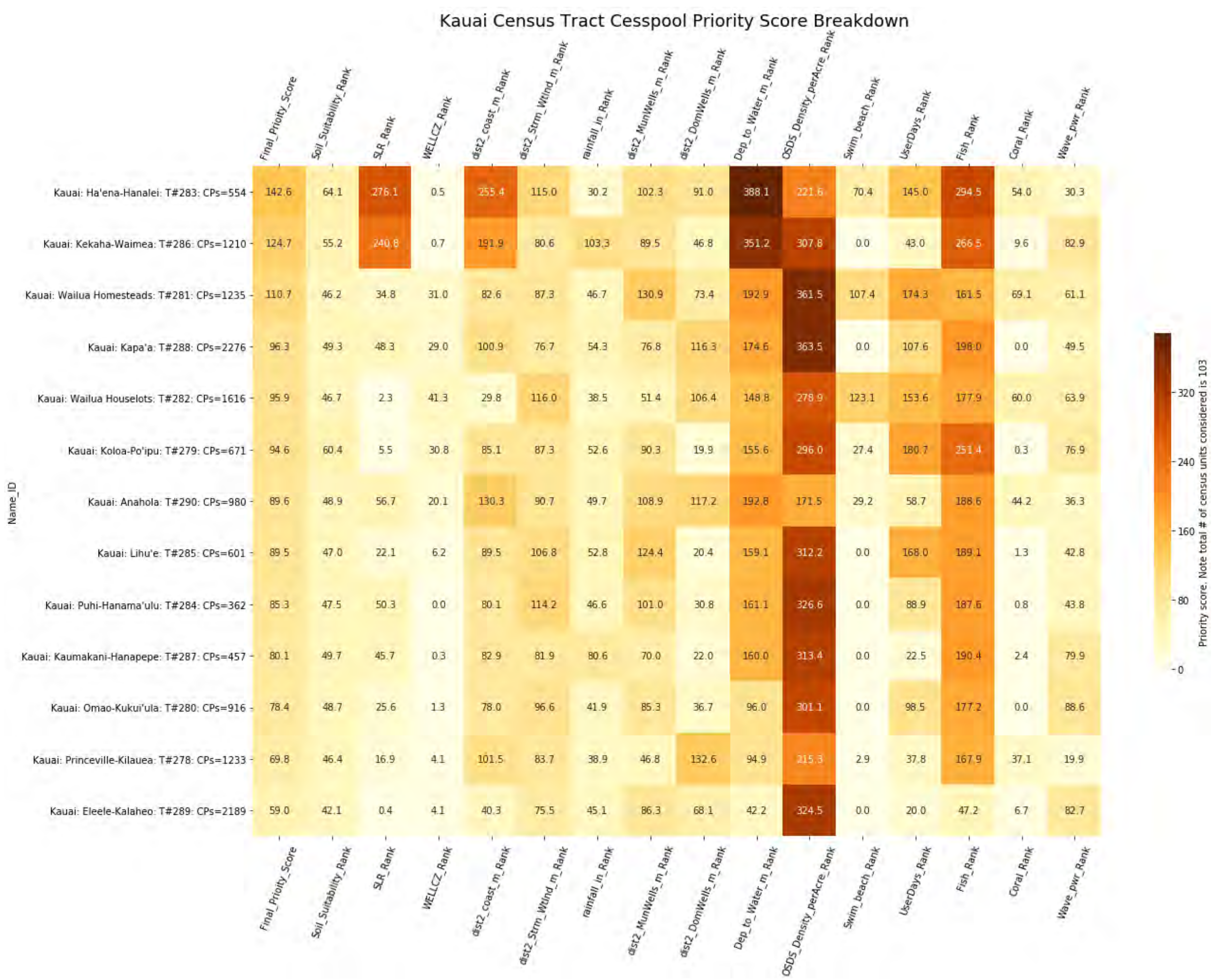

Figure A10: *Pivot table showing census-tract based priority scores, (leftmost column) and individual risk factor scores, which were averaged to calculate the overall priority score of each census tract for Kaua'i. (Updated 2022)*

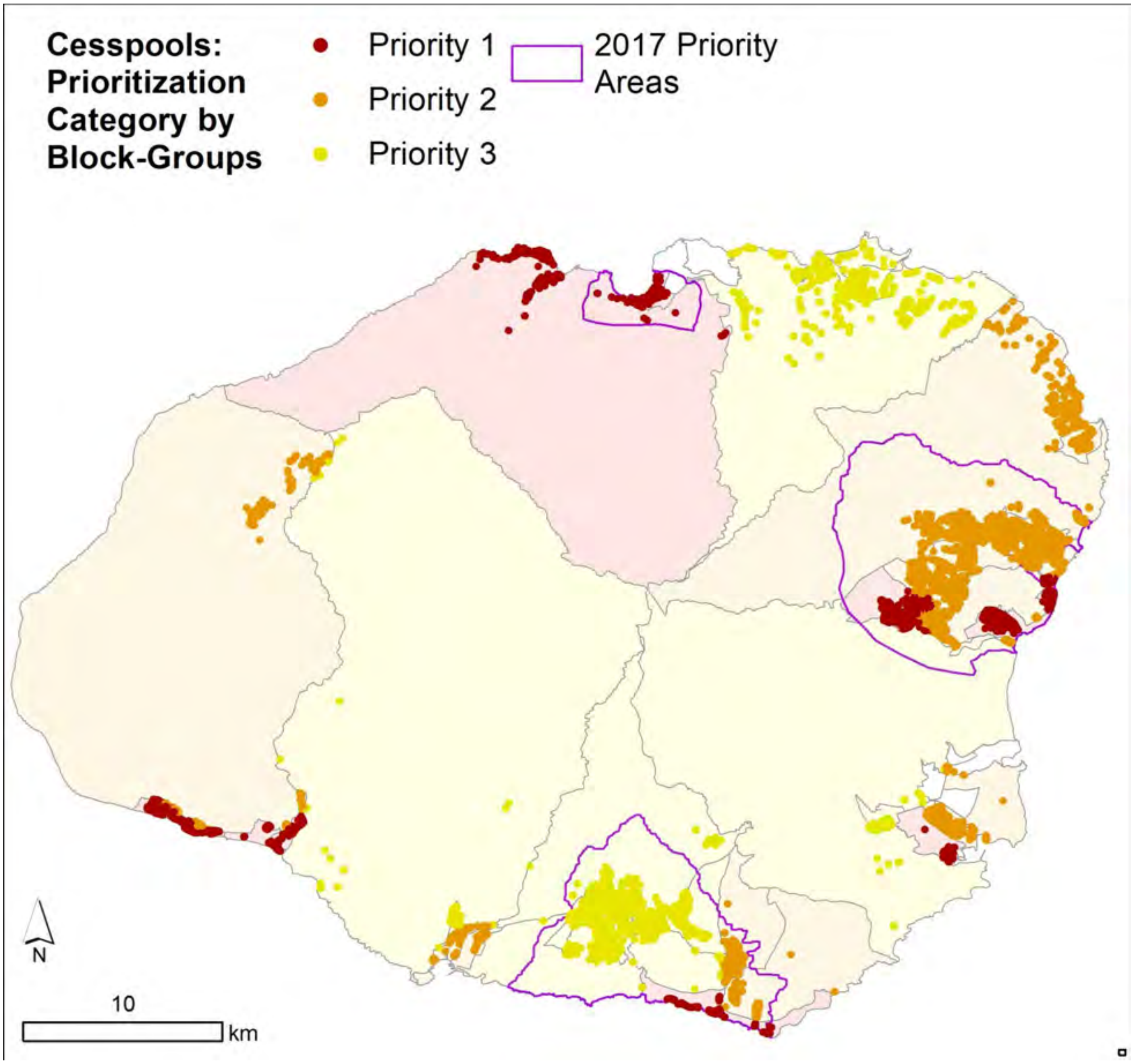

Figure A11: *Kaua'i cesspools (dots) colored by prioritization category, arranged by census block-groups. Block-groups are shown as lightly colored areas where the block-group contains >20 cesspools. White areas signify the block-group contains <20 cesspools (not assessed by the HCPT). Purple boundary indicates previous 2017 priority upgrade areas. (Updated 2022)*

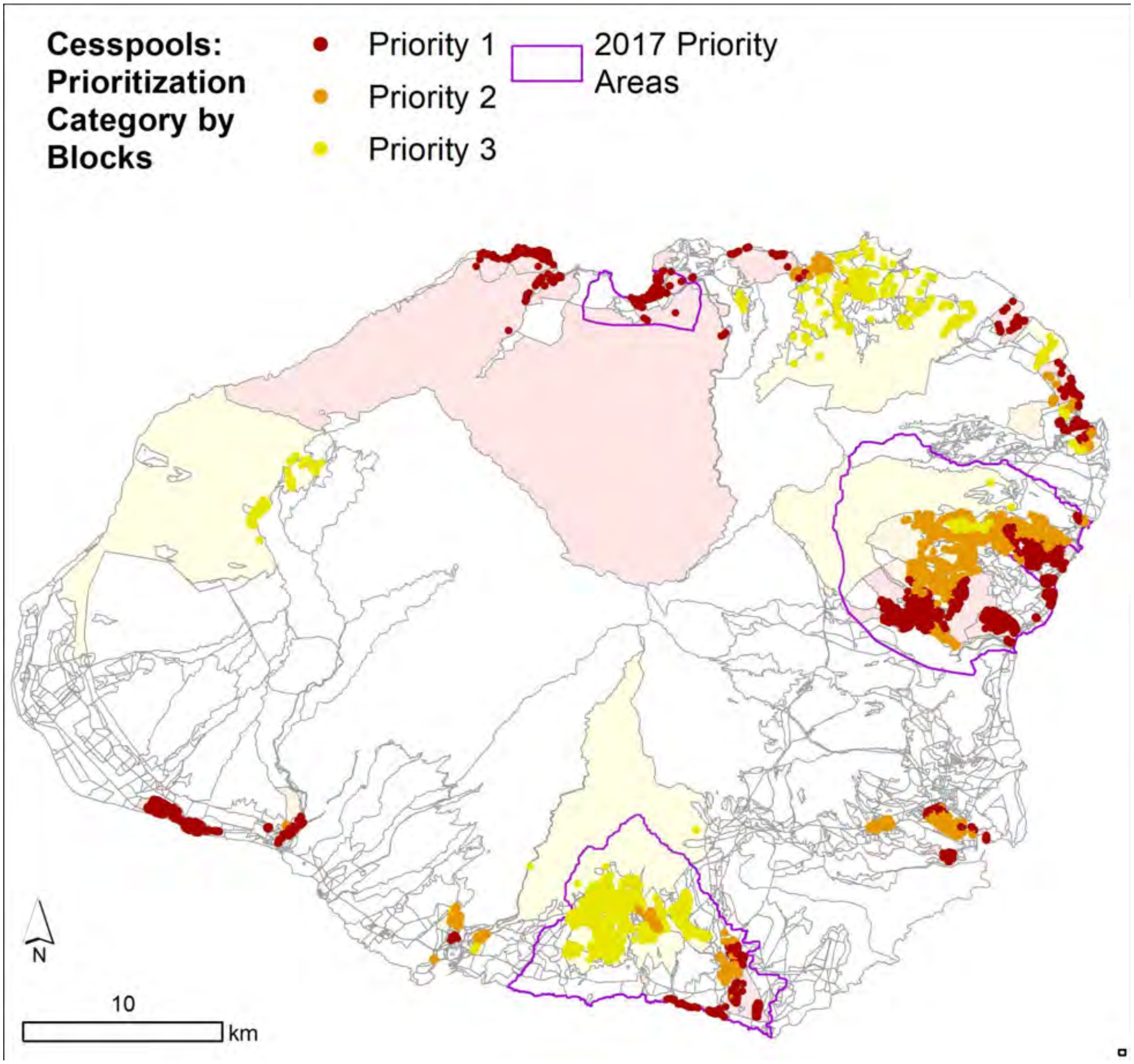

Figure A12: *Kaua'i cesspools (dots) colored by prioritization category, arranged by census blocks. Blocks are shown as lightly colored areas where the block contains >10 cesspools. White areas signify the block contains <10 cesspools (not assessed by the HCPT). Purple boundary indicates previous 2017 priority upgrade areas.* (Updated 2022)

Additional Results: Statewide

Figure A13 (full page) below provides a pivot table consisting of all 103 census tracts.

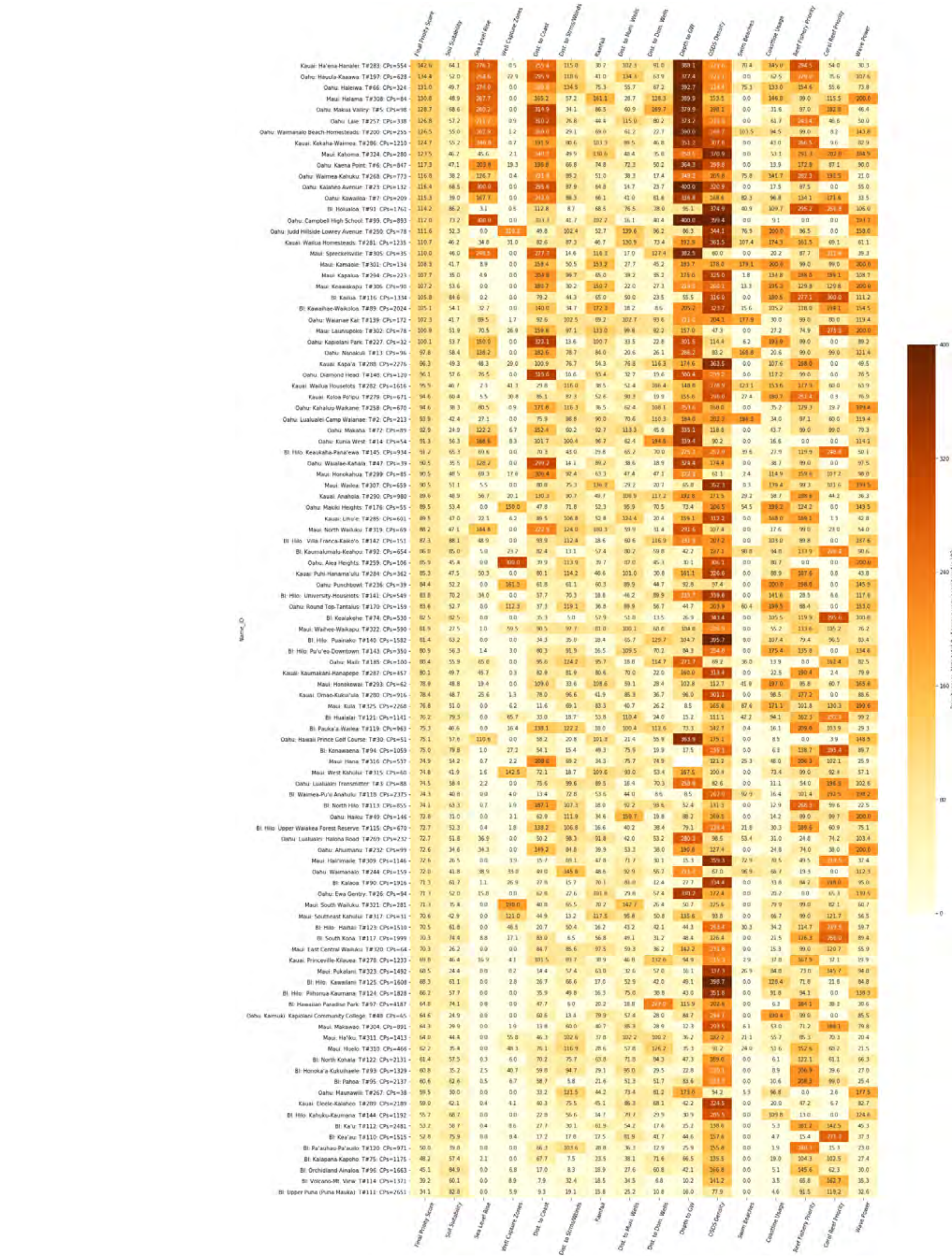

Figure A13. *Pivot table showing statewide census-tract based priority scores, (leftmost column) and individual risk factor scores, which were averaged to calculate the overall priority score of each census tract.* (Updated 2022)

Comparative Analysis with 2017 Priority Areas

To indicate where new priority areas from this work overlap with 2017 priority areas, additional information was appended to the prioritization by adding a + sign and differing darker color categories (Fig. A14). This overlap was defined as an area with greater than 50% of its cesspools falling within a 2017 priority zone. The comparative analysis for all Priority Categories is defined for each census unit as:

1. Priority Level 1 (+): The top 25% of the Census Unit Priority Scores that also have 50% or more of their cesspool units falling within a 2017 priority zone.
2. Priority Level 1: The top 25% of the Census Unit Priority Scores that do not have 50% or more of their cesspool units falling within a 2017 priority zone.
3. Priority Level 2 (+): The middle 25% (50%-25%) of the Census Unit Priority Scores that also have 50% or more of their cesspool units falling within a 2017 priority zone.
4. Priority Level 2: The middle 40% (50%-25%) of the Census Unit Priority Scores that do not have 50% or more of their cesspool units falling within a 2017 priority zone.
5. Priority Level 3 (+): The bottom 50% of the Census Unit Priority Scores that do have 50% or more of their cesspool units falling within a 2017 priority zone.
6. Priority Level 3: The bottom 50% of the Census Unit Priority Scores that do have 50% or more of their cesspool units falling within a 2017 priority zone.

While these categories are not used in the primary results, the tool does make them available should they be useful for future prioritization or management purposes.

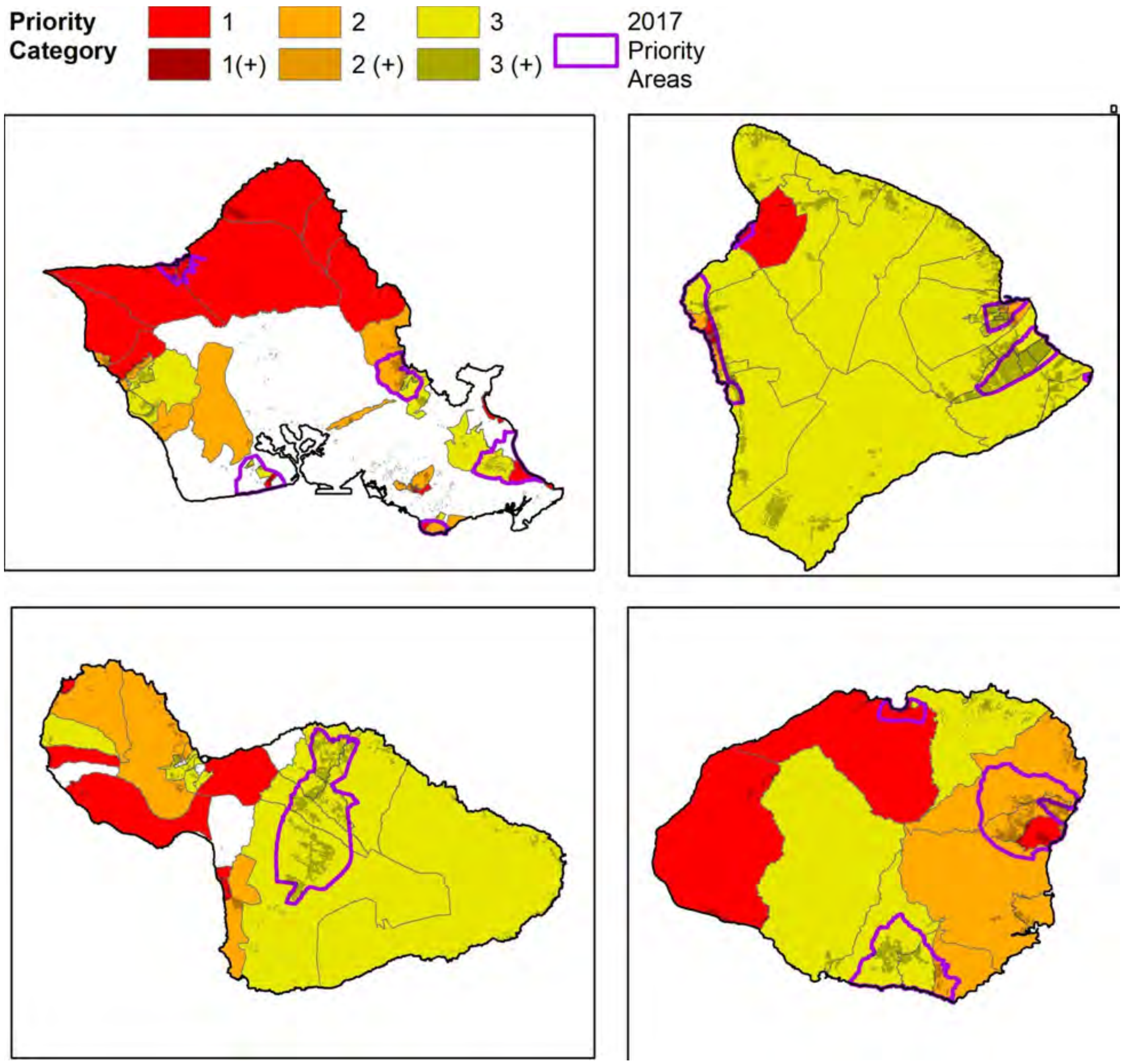

Figure A14: *Statewide prioritization at the census tract level showing added data from comparative analysis with 2017 Priority Areas. This data is for informational purposes and not used in the final results of the HCPT. (Updated 2022)*

Appendix B

Sensitivity Analysis of Priorities

The final Census Unit Aggregated Prioritization Score is derived from a simple average of all of the risk-factor (Input Section) prioritization scores that go into the analysis. This method of calculation rests on the implicit assumption that each factor is just as important as all of the other factors. However, in reality, each factor likely has a different degree of importance to different stakeholders, based on their overall objectives. While the HCPT provides the ability to apply weights to each factor in order to change the relative importance of each, the actual determination of appropriate weights is no simple matter. This is complicated by the fact that there is not a single end goal for cesspool upgrades. For example, optimizing the prioritization for human health factors (e.g. reducing contamination to drinking water wells or reducing pathogens at beaches) may sacrifice benefits to ecological systems such as coral and fish. Negative effects from cesspools manifest through multiple different hazard outcomes, including but not limited to drinking water quality degradation, coastal water quality impacts, human exposures to pathogens, and discharge of contaminants of emerging concern. The HCPT considers all of these hazard outcomes through a lumped approach. In reality, all of these outcomes are interconnected as human health is ultimately dependent on maintaining healthy ecosystems.

To explore how assigning different degrees of importance to different factors may skew outcomes of statewide prioritization, a sensitivity analysis was conducted. The sensitivity analysis compared three different scenarios where different weights were assigned to each risk factor, based on a hypothetical conceptual model of how different priorities might be expressed through the adjustment of weights to different factors.

Table B1 presents the different weights used to generate results for the sensitivity testing. It should be noted that weights applied in these scenarios are to be considered as examples only and do not constitute an actual prioritization process.

Table B1. *Example sensitivity testing scenario weights.*

Risk Factor	Base Scenario	Ecological Scenario	Human Health Scenario
Distance to Coastline (m)	1	3	1
Distance to Streams+Wetlands (m)	1	3	1
Distance to Municipal Wells (m)	1	1	4
Distance to Domestic Wells (m)	1	1	2
Well capture zones	1	1	3
Depth to Groundwater (m)	1	2	2
Cesspool Density (Units per Acre)	1	2	2
Sea Level Rise	1	2	2
Soil Suitability	1	2	2
Rainfall (in.)	1	1	1
Coastline Usage	1	1	3
Coral Reef Priority	1	4	1
Reef Fishery Priority	1	2	1
Swimming Beaches	1	1	3
Ocean Circulation(wave energy)	1	3	2

Figure B1 below shows the sensitivity test results graphically, whereas each census tract is represented by a row, labeled by the tract name, ID number, and the number of cesspools on the inventory falling within its borders. Each column is the final priority rank (where tracts are ranked based on their final priority scores) of the tract within each sensitivity test scenario. The heatmap is sorted by the base scenario rank with the most impacted tracts at the top of the figure. Note the figure is broken into two halves to fit the page.

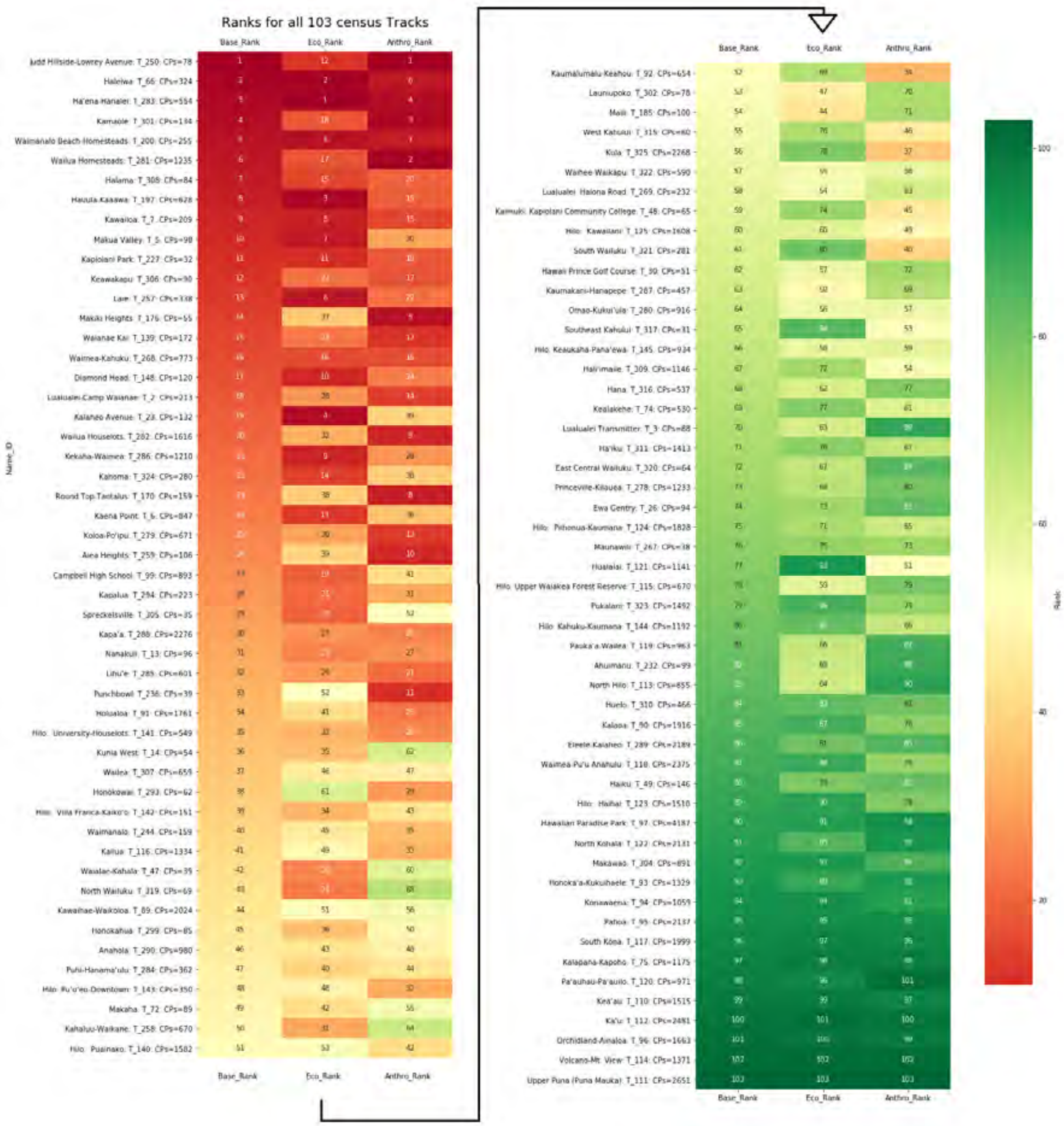

Figure B1. *Results of the sensitivity analysis, where each column represents how census tracts are prioritized (via a statewide ranking) for each of the three scenarios. The leftmost being the base scenario where all weights are equal to one, the middle column represents the Ecological Scenario and the rightmost represents the human health scenario.*

To quantify the difference between the sensitivity test scenarios numerically, the deviation from the base scenario was calculated for each tract by simply subtracting the rank of the tract in the test scenario by its rank in the base scenario and taking the absolute value of the result. This metric shows how far up or down the ranking an individual track will move given the changes in the risk-factor weights. Relevant statistics are compiled in Table B2 below. These statistics indicate that the average expected change in ranking if the risk factor weights were modified to the extent they were in this test, would be on the average order of 6 to 9 places, though it could change up to 26 places in the maximum case. Overall, considering the rankings cover 103 census tracts, this translates into an ‘uncertainty’ of less than 10% on the final results, thereby lending greater confidence to the final priority rankings (using the base scenario) presented in this report.

Table B2. *Statistical table describing the deviations in ranking values of individual census tracts between the Base Scenario and the other test scenarios. Higher mean or median (50th percentile) deviations indicate that the test scenario, on average, yields a prioritization result that has a higher degree of difference when compared to the base scenario.*

Statistics for Deviations in Ranks	Ecological Scenario Deviations	Human Health Scenario Deviations
Mean	6.93	8.35
Standard Dev.	6.25	6.37
Min	0	0
25th percentile	1	3
50th percentile	5	8
75th percentile	11	12
Max	25	26

Appendix C

Risk-Factor Weighting Workshops and Addendum

After the publication of the 2021 Hawaiʻi Cesspool Hazard Assessment & Prioritization Tool Report & Technical Appendices an update was performed in mid-2022 to better represent the disparity in importance of each of the input risk-factors. All figures and tabular results in this 2022 Updated version of the Hawaiʻi Cesspool Hazard Assessment & Prioritization Tool Report & Technical Appendices reflect the revision of the tool and present results generated using weights derived from the methodology described in the addendum below, the Hawaiʻi Cesspool Hazard Assessment & Prioritization Tool: Risk-Factor Assessment Survey and Workshops: Addendum to 2021 Report & Technical Appendices, June 2022, by Melanie Lander, Michael Mezzacapo, and Christopher Shuler.

Hawaiʻi Cesspool Hazard Assessment & Prioritization Tool

Risk-Factor Assessment Survey and Workshops

Addendum to 2021 Report & Technical Appendices

June 2022

Prepared For:

State of Hawaiʻi Department of Health Wastewater Branch
State of Hawaiʻi Cesspool Conversion Working Group

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Table of Contents

1. Project Purpose and Background

This document describes ongoing efforts to assist the cesspool conversion process since the release of the publication, the ‘Hawai‘i Cesspool Hazard Assessment & Prioritization Tool Report & Technical Appendices’ in August 2021. In particular, this report addendum provides updates to the iterative cesspool prioritization methodology and expert opinion workshops held in early 2022. The prioritization of cesspools presents a useful method to quantify their relative impact on human and environmental health. Prioritization will also inform timetables recommended by the State of Hawai‘i Cesspool Conversion Working Group (CCWG) for conversion to more advanced forms of wastewater treatment. This work was undertaken on behalf of the State of Hawai‘i Department of Health (DOH) Wastewater Branch to inform ongoing DOH and CCWG planning processes for statewide cesspool conversion plan development.

In 2021, the ‘Hawai‘i Cesspool Hazard Assessment & Prioritization Tool Report & Technical Appendices’ was created to provide the DOH and CCWG with a comprehensive and data driven method to prioritize which cesspools likely have the most impact on human and environmental health. The report included consideration of fifteen risk-factors used to assess each geographic area’s vulnerability to contamination from cesspools. The factors were intended to be used to inform cesspool conversion prioritization and onsite wastewater planning throughout the state of Hawai‘i.

These factors included:

1. Distance to municipal drinking water wells;
2. Distance to domestic drinking water wells;
3. Well capture zones
4. Distance to streams and wetlands;
5. Distance to coastline;
6. Sea level rise zones;
7. Precipitation;
8. Depth to groundwater;
9. Soil characteristics;
10. Cesspool density;
11. Coral cover;
12. Fish biomass/recovery potential;
13. Beach user-days;
14. Proximity to lifeguarded beach; and
15. Coastal ocean circulation proxy

This information and associated data were included in a geographic information system (GIS) tool titled: the Hawaiʻi Cesspool Prioritization Tool (HCPT), accessible through http://hawaiicesspooltool.org. The 2021 version of the HCPT weighted each of the fifteen risk factors equally in its prioritization calculation.

In 2022, the DOH directed a team from the University of Hawaiʻi (UH) Sea Grant College Program (Hawaiʻi Sea Grant), UH Water Resources Research Center, and One World One Water, LLC to refine the HCPT structure by developing and implementing an expert-driven methodology for weighting of the fifteen risk-factors. Specifically, the project team sought to answer these questions:

- Does weighting the fifteen risk-factors equally reflect the best available knowledge of subject matter experts relative to the risk of cesspool contamination?
- If not, which of the fifteen risk-factors are most critical to consider in the cesspool conversion prioritization process?
- How does an expert-informed weighting process change the priority rankings in each of the geographic areas outlined by the 2021 report (equal weights)?

2. Process and Methodology

a. Participants

The end goal of the updated weighting process was to synthesize contributions from a panel of experts into fifteen numeric weighting factors corresponding to each of the risk-factors used in the HCPT. The process was initiated by identifying subject matter areas related to the risk-factors used in the tool. Experts in each subject-matter area from Hawai‘i, the Pacific, and the continental United States were identified by the project team and the DOH through research and personal recommendations. Invitees were contacted either by email or phone and briefed on the project background and purpose, and invited to participate in the expert weighting exercise.

The participant areas of expertise included:

DOH Regulatory and Wastewater Engineering
Coral Reef Ecosystems
Wells, Groundwater, and Drinking Water
Society and Economics
Surface Water, Aquatic Resources, Wildlife
Wastewater Engineering and Soils
Tourism and Recreation
Oceanography and Microbiology
Coastal Geochemistry and Water Quality
Native Hawaiian Affairs and Water Law
Coastal Biology and Limu
Center for Water Resource Management
Water Quality and Sewage Pollution
Public Drinking Water
Coral Reefs and Coastal Processes
Law, Policy, and Planning
State Coastal Planning
UH Environmental Science Students

b. Workshops, Survey, and Analysis

Two virtual workshops were held on the Zoom virtual meeting platform, and participants were asked to independently complete a survey during the interval between the workshop events. The first workshop was held on Wednesday, March 2nd, 2022 and lasted for one hour. Workshop 1 focused on providing background and context to attendees, as well as explaining the survey, which was used to collect quantitative and qualitative information from participants. Following Workshop 1, the 2021 ‘Hawai‘i Cesspool Hazard Assessment & Prioritization Tool Report & Technical Appendices’ and the website for the online HCPT were shared with participants, along with the detailed instructions about the online survey which were shared orally during Workshop 1.

The survey consisted of thirty questions. For each of the fifteen risk-factors, the survey asked for users to assign a weight from 1-5 for each factor.

The Scoring Rubric was defined as:

Weight of (1) Baseline: Factor is important, but not exceptionally.

Weight of (2) Double weight: Factor is more important than baseline.

Weight of (3) Triple weight: Factor is very important.

Weight of (4) Quadruple weight: Factor is one of the most important factors of all.

Weight of (5) Extremely important: reserved for the single or few factors that are the primary drivers of impact.

Users were then asked to provide a brief explanation of why they weighed the factor as they did, and to share references and other relevant information that informed their decisions. Participants were also asked if they wished to share their name and affiliation within the addendum report. This choice was optional so participants could speak freely and openly.

Following the survey period (March 2nd-23rd, 2022) and preceding the second workshop, the project team processed the survey results in order to share them with the participants and to facilitate discussion and feedback during the second workshop.

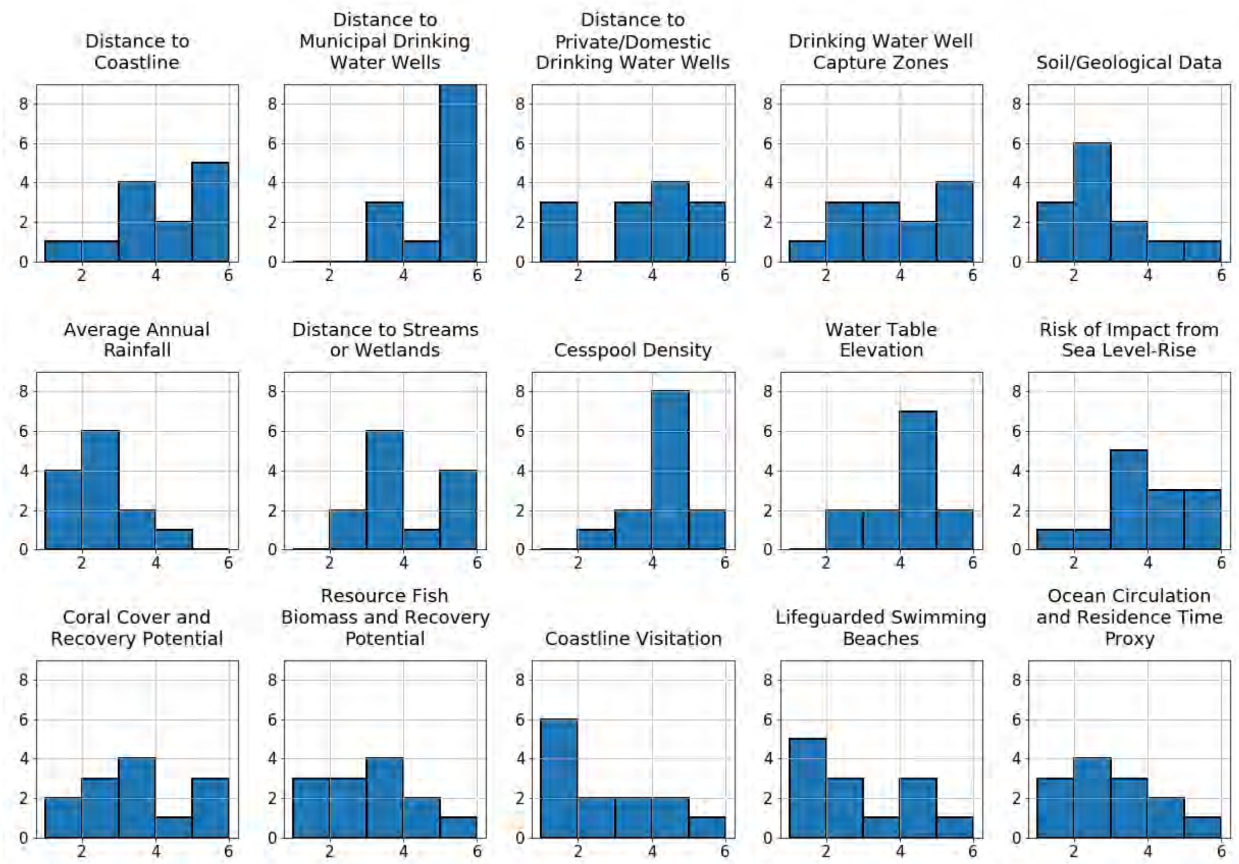
The second workshop was held on Wednesday, March 30th, 2022 and lasted two hours. The primary focus of Workshop 2 was communicating the results of the survey and analysis. The intent of the survey was to create a ‘multiplication factor’, or weight, for each of the fifteen risk-factors. Survey results were collected in a Google Form, which populated quantitative responses (weighted rankings) into a Google spreadsheet. Pandas, the Python analysis library, was used for the quantitative analysis of the results.

Raw Data from Survey:

Respondent Number	Distance to Coastline	Distance to Municipal Drinking Water Wells	Distance to Private/ Domestic Drinking Water Wells	Drinking Water Well Capture Zones	Soil/ Geological Data	Average Annual Rainfall	Distance to Streams or Wetlands	Cesspool Density	Water Table Elevation	Risk of Impact from Sea Level-Rise	Coral Cover and Recovery Potential	Resource Fish Biomass and Recovery Potential	Coastline Visitation	Lifeguarded Swimming Beaches	Ocean Circulation and Residence Time Proxy
0	5	5	3	3	4	4	5	4	4	3	3	3	4	4	3
1	1	5	4	4	5	2	3	4	4	3	3	3	3	3	2
2	4	5	5	5	2	1	3	4	4	3	1	1	1	1	1
3	2	5	4	5	2	3	2	4	2	3	3	3	3	2	4
4	5	5	3	5	3	3	5	5	4	5	3	3	1	2	3
5	3	3	3	2	2	2	3	4	3	4	2	1	1	1	2
6	3	5	1	4	1	2	5	3	5	5	5	5	5	5	4
7	5	5	5	3	2	2	3	4	3	4	4	4	4	4	2
8	3	5	5	2	3	2	3	4	4	1	2	2	2	2	1
9	4	5	4	5	2	2	5	3	4	3	5	4	2	4	5
10	3	3	4	3	1	1	2	5	4	2	2	2	1	1	3
11	5	3	1	2	2	1	3	2	2	4	5	2	1	1	2
12	5	4	1	1	1	1	4	4	5	5	1	1	1	1	1

Histograms were used and presented in the workshop to display the spectrum of weights assigned by the group to each of the fifteen risk factors. Histograms are useful in this context because they not only show which factors scored the 'highest' (higher weights being equivalent to a greater level of importance in prioritization considerations), but also indicate the spread of participants' rankings, which is quantified as the standard deviation of each risk-factor's results. This spread indicated the level of consensus among respondents, with a higher standard deviation equating to a greater difference of opinion among respondents and a lower standard deviation indicating better consensus.

Histograms:



It was necessary to combine each of the participants' responses into a single weight for each factor. However, there are many mathematical ways to achieve this result and each has unique advantages and disadvantages. Therefore, a number of aggregation techniques were explored. These included basic statistical metrics, specifically the mean and median of each distribution, as well as a non-parametric calculation that counted the number of individual scores given to each factor (i.e. 4, '1's', 3 '2's', etc.), and used a separate weighting factor for each of the sums of scores. These "weighted weights" were then normalized into a single number (see https://github.com/cshuler/Act132_Cesspool_Prioritization for details). The different aggregation methods were presented to the participants of the second workshop and due to the similarity in the results of each, and the desire to communicate simply and effectively, it was agreed upon that the median value of each of the raw weights was the preferred method for calculating a single weight for each factor.

Quantitative analysis:

Factor	Mean	Median	Standard Deviation	Rank: 1	Rank: 2	Rank: 3	Rank: 4	Rank: 5	Weighted Weights
Distance to Municipal Drinking Water Wells	4.5	5	0.9	0	0	3	1	9	6.4
Distance to Coastline	3.7	4	1.3	1	1	4	2	5	4.6
Drinking Water Well Capture Zones	3.4	3	1.4	1	3	3	2	4	3.8
Distance to Streams or Wetlands	3.5	3	1.1	0	2	6	1	4	4
Distance to Private/Domestic Drinking Water Wells	3.3	4	1.5	3	0	3	4	3	4
Risk of Impact from Sea Level-Rise	3.5	3	1.2	1	1	5	3	3	4
Coral Cover and Recovery Potential	3	3	1.4	2	3	4	1	3	3
Cesspool Density	3.8	4	0.8	0	1	2	8	2	4.8
Water Table Elevation	3.7	4	0.9	0	2	2	7	2	4.4
Soil/Geological Data	2.3	2	1.2	3	6	2	1	1	1.4
Resource Fish Biomass and Recovery Potential	2.6	3	1.3	3	3	4	2	1	2.2
Coastline Visitation	2.2	2	1.4	6	2	2	2	1	1.8
Lifeguarded Swimming Beaches	2.4	2	1.4	5	3	1	3	1	2
Ocean Circulation	2.5	2	1.3	3	4	3	2	1	2
Average Annual Rainfall	2	2	0.9	4	6	2	1	0	0.8

c. Survey Outcomes

The weighting activity for each of the fifteen risk-factors resulted in fairly normal distributions for most parameters. Only *Distance to Municipal Drinking Water Wells* had a median score of '5'. This was the highest weighted ranking, indicating that the factor is 'Extremely important: reserved for the single or few factors that are the primary drivers of impact' and also had the second lowest standard deviation of all factors, which denotes concurrence among the survey respondents. Four factors scored as '4: *Quadruple weight: Factor is one of the most important factors of all'*. These factors included *Distance to Coastline*, *Distance to Private/Domestic Drinking Water Wells*, *Cesspool Density*, and *Water Table Elevation*. Four factors scored as '3: Triple weight: Factor is very important'. These factors included *Drinking Water Well Capture Zones*, *Distance to Streams or Wetlands*, *Risk of Impact from Sea Level Rise*, *Coral Cover and Recovery Potential*, and *Resource Fish Biomass and Recovery Potential*. Five factors scored as '2: Double weight: Factor is more important than baseline'. These factors included, *Soil/Ecological Data*, *Coastline Visitation*, *Lifeguarded Swimming Beaches*, *Ocean Circulation*, and *Average Annual Rainfall*. No factors scored as '1: Baseline: Factor is important, but not exceptionally'. The factors with the highest levels of concurrence (lowest standard deviation) were *Cesspool Density*, which ranked as a '4' and *Distance to Municipal Drinking Wells*, which ranked as a '5'.

Factor	Weight
Distance to Municipal Drinking Water Wells	5
Distance to Coastline	4
Distance to Private/Domestic Drinking Water Wells	4
Cesspool Density	4
Water Table Elevation	4
Drinking Water Well Capture Zone	3
Distance to Streams or Wetlands.	3
Risk of Impact from Sea Level Rise.	3
Coral Cover and Recovery Potential	3
Resource Fish Biomass and Recovery Potential	3
Soil/Ecological Data	2
Coastline Visitation	2
Lifeguarded Swimming Beaches	2
Ocean Circulation and Residence Time Proxy	2
Average Annual Rainfall	2

3. Limitations and Notable Feedback

The methods of gathering expert feedback included some limitations which should be noted to improve future iterations of this or similar processes, which are further elaborated in the following subsections.

a. Attendance

The workshops were held virtually to encourage the highest level of attendance possible during the COVID-19 pandemic and as recommended by local and national guidelines. Not all attendees of the first workshop elected to participate in the subsequent survey, nor did all initial attendees attend the second workshop. However, the number of participants and their representative spectrum of expertise was considered acceptable to continue with the weighting exercise. The survey results were processed and analyzed with the potential for future exercises to build upon the results if deemed appropriate. An alternative meeting structure could have requested participants to attend a full day ‘seminar’ during which the content of both workshops and the survey would have occurred during a single, though substantially longer, meeting. This approach would have capitalized on the ‘captive audience’ to ensure a high level of participation in the survey. However, due to the time commitment of such an event, which likely would have lasted 4-5 hours, it is unknown whether attendance would have actually increased with this format compared to the chosen format of multiple workshops held several weeks apart with the survey taken in between.

b. Areas of Expertise and the Survey Scoring Rubric

Attendees were invited to participate in the workshops so that they could provide their subject-matter knowledge and enhance the weighting process. In the 2021 iteration of the prioritization exercise all factors were considered equal. The 2022 workshops were intended to interrogate this approach and create a more rigorous methodology for weighting the factors based on a broader spectrum of expertise. However, no one can be an expert in all subject areas. In order to account for the fact that respondents may have ranked certain factors with a low weight because they felt less informed about those subject areas, a ‘weighted weight’ which ignored low ranks was added to the statistical analysis. Ultimately, it was determined that the three analysis options (mean, median, and ‘weighted weights’) produced comparable results.

c. Feedback on Data Sets

<u>i. Regional Variability</u>
Relating to the risk-factors ‘Soils and Average Annual Rainfall’:

The prioritization tool was designed for management decisions at the state level, and the fifteen data sets used as risk-factors were selected based on their statewide coverage. However, Hawaiʻi has certain regions with distinct characteristics. For instance, the hydrogeology of the Kona region of Hawaiʻi Island is markedly different from most other areas of the state in that water dissipates quickly from the surface into the subterranean environment. In this region, coastal water quality is greatly influenced by land-based contaminants. Similarly, preliminary research shared by the participants indicates great differences in wastewater as well as other indicators in Kona vs. Hilo, substantiating the potential role of rainwater in dilution of contaminants prior to entering coastal waters. In certain circumstances, 'outlier' areas of the state, in this case one of the driest and one of the wettest regions, may merit further consideration and scenario planning when developing prioritization and conversion timelines. It was also noted that peak rainfall, which can cause cesspool overflow, may be more descriptive in areas prone to intense precipitation, compared to average annual rainfall which is less likely to capture such events. Rather than a one-size-fits-all analysis, this tool can be considered as a foundational layer for statewide management and decision-making.

ii. Policy Gaps

Relating to the risk-factor 'Cesspool Density':
Since 2000, the United States Environmental Protection Agency (EPA) has banned large-capacity cesspools, which are generally defined as serving over twenty individuals. However, participants noted that not only are some large-capacity cesspools still in operation in Hawaiʻi, but certain high-density residential areas with active cesspools are contributing contaminants to the environment in a similar way to those of 'large capacity'. Yet, these cesspools are subject to the same state-level regulations as any other cesspool. This comment was made to highlight the enforcement gap between banned large-capacity cesspools and high-density operational cesspools, and to reinforce the participant's ranking of 'Cesspool Density' as a highly important factor for conversion consideration.

iii. Complications Along the Coast

Relating to the risk-factors 'Distance to Coastline' and 'Sea Level Rise Exposure':
Participants discussed the fact that many oceanfront homes are already experiencing visible tidal fluctuations in their cesspools. Though 'Distance to Coastline' is a straightforward indicator of the potential for land-sea connectivity, Hawaiʻi does have some coastal real estate located on bluffs, high above sea level. For this reason, 'Sea Level Rise Exposure' is likely to be a more appropriate indicator of cesspools located at or near current sea level, with both present-day or future potential for groundwater inundation and cesspool failure. Participants also noted the quandary of residential homes with cesspools and the most imminent risk of coastal erosion (i.e., the North Shore of Oahu) for whom cesspool replacement is threatened by large winter storms and swells. These homeowners may elect to wait 'until the last minute' (closer to 2050) to replace their

systems given the variability in erosion on a multi-decadal timescale, though those homes may be high-risk to human and environmental health given their extreme proximity to the ocean and high likelihood of total cesspool failure (i.e. system collapse).

<u>iv. Redundancy</u>

Relating to the risk-factors 'Beach user-days', 'Proximity to lifeguarded beach', 'Distance to Coastline', and 'Sea Level Rise Exposure':

Because the two factors 'Distance to Coastline' and 'Sea Level Rise Exposure' already have the potential to highlight those cesspools with the most direct impact on coastal areas, participants pointed out that the risk-factors 'Beach user-days' and 'Proximity to lifeguarded beach' may be duplicative. It can be noted that from a human health perspective, the risk-factors 'Beach user-days' and 'Proximity to lifeguarded beach' more readily highlight concentrations of human activity than 'Distance to Coastline', and 'Sea Level Rise Exposure'. In particular, areas like Kula, Maui which are regarded as "up country" have a direct and hazardous impact on Kihei, Maui beaches, despite their distance from the coastline.

d. Feedback on Methodology

<u>i. Socio-Economic Considerations</u>

This prioritization exercise focuses primarily on the cesspool risk-factors impacting human and environmental health. This provides a foundation to build upon, and can be further enhanced through the use of socio-economic data. When U.S. Census tracts are overlain on the HCPT tool, attributes like median household income can provide further insight and decision-making information. For instance, the state could compare Priority 1 areas of the greatest potential for contamination to areas of the lowest median household income. The intersection of these two layers would illustrate possible recipient areas for grant funding to facilitate the conversion of active cesspools into more advanced forms of wastewater treatment.

<u>ii. Survey Design</u>

The survey asked participants to consider each of the fifteen risk-factors according to a scoring rubric, by assigning a weight from 1-5 for each factor. For the weights of 5 (Extremely important: reserved for the single or few factors that are the primary drivers of impact) and 4 (Quadruple weight: Factor is one of the most important factors of all), the scoring rubric suggested that survey taker limit the number of high weights that were assigned (i.e. 'reserved for the single or few factors…). These instructions may have been interpreted differently by each participant. An alternative would have been to overtly limit the number of each ranking that could be assigned (i.e. allocating a single '5', up to three '4's, etc.).

To view the complete survey responses and feedback, please navigate to:
https://github.com/cshuler/Act132_Cesspool_Prioritization/blob/main/Workshop2_analysis/Workshop%202%20Data%20Analysis.ipynb

4. Prioritization Results

The HCPT prioritization method places each geographic area into three Prioritization Categories that include:

1. **Priority Level 1:** Greatest contamination hazard (map color of red).
2. **Priority Level 2:** Significant contamination hazard (map color of orange).
3. **Priority Level 3:** Pronounced contamination hazard (map color of yellow).

Under the 2021 equal weighting scenario, the total number of cesspools in the state categorized as Priority Level 1 was 13,885, with 13,482 and 54,058 as Priority Level 2 and Priority Level 3, respectively. Approximately 35%, 7%, 21%, and 37% of cesspools in the Priority Level 1 group are located on Oʻahu, Maui, Kauaʻi, and Hawaiʻi Island, respectively.

Under the 2022 expert-informed weighting scenario, the total number of cesspools in the state categorized as Priority Level 1 was 13,821, with 12,367 and 55,237 as Priority Level 2 and Priority Level 3, respectively. Approximately 35%, 7%, 21%, and 37% of cesspools in the Priority Level 1 group are located on Oʻahu, Maui, Kauaʻi, and Hawaiʻi Island, respectively.

Census tracts that changed as a result of the expert-informed weighting process included:

Island, Census Tract Number (Tract #), and Cesspool Count	Original Rank	New Workshop Rank
Kauai		
Kauai: Puhi-Hanama'ulu: Tract#284: Cesspool Count =362	3 (Low)	2 (Medium)
Oahu		
Oahu: Nanakuli: Tract#13: Cesspool Count =96	1 (High)	2 (Medium)
Oahu: Kapiolani Park: Tract#227: Cesspool Count =32	2 (Medium)	1 (High)
Maui		
Maui: Honokowai: Tract#293: Cesspool Count =62	2 (Medium)	3 (Low)
Maui: Waihee-Waikapu: Tract#322: Cesspool Count =590	3 (Low)	2 (Medium)
Maui: Kula: Tract#325: Cesspool Count =2268	2 (Medium)	3 (Low)
Hawaiʻi Island		
BI: Hilo: University-Houselots: Tract#141: Cesspool Count =549	3 (Low)	2 (Medium)
BI: Hilo: Puʻuʻeo-Downtown: Tract#143: Cesspool Count =350	2 (Medium)	3 (Low)

Overall, there were minimal differences between the HCPT's 2021 equal weighting scenario and the 2022 expert-informed version of the tool. Statewide, eight census tracts shifted in priority designation between the two methodological approaches. Of these eight census tracts, the shift in priority was limited to a single step; e.g. none of the census tracts went from high to low priority or low to high priority.

The relative similarity between the two versions of the tool serves to validate the overall robustness of the 2021 HCPT tool. In many locations, similarities can be attributed to the fact that the cesspools which ranked as the highest priority for conversion negatively impact multiple aspects of social and environmental health, and the weights of individual factors are less important than the sum of the many impacts on risk-factors in the high priority ranked areas. This outcome was also alluded to by a sensitivity test detailed in the 2021 report, where hypothetical weights were applied to each factor collectively within different weighting scenarios. The sensitivity test indicated the changes in prioritization under different weighting strategies were likely to show small differences. Nonetheless, despite the limited magnitude of change, the social-science based weighting exercise was extremely valuable for not only demonstrating the validity of the results, but also for improving the robustness of the tool's methodology, including expanding the dimensionality of the tool's input. This robustness is now demonstrated by way of incorporating the expert judgements of knowledgeable practitioners and scholars.

5. Next Steps

The results of this effort will be shared with the DOH Wastewater Branch to inform ongoing cesspool conversion prioritization efforts. This work and the HCPT is only one part of Hawaiʻi's cesspool conversion prioritization process, as numerous other datasets including social, financial, and water quality impacts will also be factored into the cesspool prioritization process.

6. Technical Contributors

Role	Name
DOH Regulatory/ Wastewater Engineer	Michael Cummings
Coral Reefs and Ecosystem	Jamison Gove
Drinking Water Wells and Groundwater	Robert Whittier
Society and Economics	Kirsten Oleson
Surface Water, Aquatic Resources, Wildlife	Wished to remain anonymous
Wastewater Engineering/Soils	Roger Babcock
Tourism and Recreation	N/A
Oceanography/Microbiology	Wished to remain anonymous
Coastal Geochemistry/Water Quality	Steven Colbert, Tracy Wiegner
Native Hawaiian Affairs/Water Law	Wished to remain anonymous
Coastal Biology/Limu	Wished to remain anonymous
Hawaii Commission on Water Resource Management	Wished to remain anonymous
Drinking Water Planning Program Manager	Wished to remain anonymous
Water Quality/Ocean Sewage Pollution	Chris Clapp
Public Drinking Water	Wished to remain anonymous
Coral/Coastal Processes	Wished to remain anonymous
Law, Policy, Planning	Rick Bennett
State Coastal Planning	Wished to remain anonymous
UH Student	Wished to remain anonymous
UH Student	Wished to remain anonymous

Appendix H. WAI Onsite Wastewater Policy Considerations

Policy Requests for DOH to Streamline IWS Regulations and Expedite Cesspool Conversions

Technical Memorandum

Purpose

The purpose of this memorandum is to request the State of Hawaii Department of Health (DOH) Wastewater Branch (WWB) to conduct a number of policy changes that can improve the Individual Wastewater System (IWS) permitting process for all parties involved.

Background

There are approximately 88,000 cesspools in the State of Hawaii [1] that need to be converted by 2050 to meet Act 125. Among the biggest challenges for homeowners wanting to upgrade their cesspools are the high cost of conversion, the relatively large footprint of the new system, and the difficulty of maneuvering the permitting process. This memorandum is the product of local IWS designers and installers coming together to share their experiences with the cesspool conversion process and their suggestions on how the process can be improved to address the challenges that homeowners face. The proposed policy changes are in descending order of priority as ranked by the authors of this memorandum.

Proposed Policy Changes

1. Absorption Bed Size Reduction for Higher Quality Effluent

Current Regulations

The rules for designing an absorption bed as part of an IWS require the same disposal area size whether a septic tank or a treatment system capable of producing higher quality effluent is used [2].

Requests

It is proposed that the required absorption bed disposal area is reduced by one-third if a treatment system is used that complies with the "Standard No. 40" for Class I units as set forth by the National Sanitation Foundation (NSF) [3].

Justification

It has been shown that soil uptakes higher quality effluent faster than lower quality effluent. Therefore, is it reasonable for the required minimum size of an absorption bed to be reduced if a treatment unit producing higher quality effluent is used [4]. Pennsylvania [5], Florida [6], and Washington State [7] allow reductions by one-third, 40%, and 50%, respectively. A smaller absorption bed helps reduce the challenges of the large footprint and the high cost of a cesspool conversion.

2. Blackwater System Reduction if Greywater System used

Current Regulations

The rules state that where separate greywater and blackwater systems are utilized, the size of the blackwater system cannot be reduced.

Requests

It is proposed that where separate, permitted greywater and blackwater systems are utilized, the size of the blackwater system shall be allowed to be reduced by a maximum of 25%.

Justification

Between 60% and 70% of household wastewater is greywater [8]. When this greywater is diverted away from the blackwater system toward a properly designed and permitted greywater system, the blackwater system receives less than half of the design flow that it would receive if there were no greywater system. Florida allows a blackwater system reduction of up to 25% if a greywater system is used [9].

3. Cesspool Conversion to Seepage Pit: Water Quality and Quantity

Current Regulations

The rules state that the conversion of an existing cesspool to a seepage pit is only allowed if the use of an absorption bed or trench is not feasible. Furthermore, the design capacity of the seepage pit is defined via its wall area and the percolation rate of the soil [2].

Requests

It is proposed that the conversion of existing cesspools to seepage pits is allowed for all cesspools, as long as the seepage pit meets the following conditions to be confirmed by the engineer on record:

A. It receives effluent from a treatment system that complies with the "Standard No. 40" for Class I units as set forth by the NSF [3]. If a 3-foot vertical setback between the bottom of the seepage pit and the groundwater table cannot be met, the treatment unit shall instead comply with the NSF "Standard No. 245" [3], and UV disinfection shall be provided.

B. It can reliably dispose of the design flow that the IWS is being permitted for as determined by a 24-hour flow test.
C. It is structurally sound.

Justification

It is logical that a cesspool that functions well when receiving untreated wastewater will function even better when receiving treated wastewater. The exact disposal capacity can be determined with a 24-hour flow test, similar to how injection wells are tested [10]. The construction of an absorption bed is cost-prohibitive for many cesspool owners. Allowing the conversion of the cesspool to a seepage pit and the installation of a treatment unit upstream will result in a lower total cost and a smaller total footprint compared to a conventional IWS. The higher level of treatment is another positive outcome of this proposal.

4. IWS Size Reduction if Incineration Toilet Used

Current Regulations

The rules do not allow that if exclusively incineration toilets are used, the design flow for an IWS can be reduced [2].

Requests

It is proposed that if exclusively incineration toilets are used, the design flow for an IWS shall be reduced by 25%.

Justification

Toilet wastewater makes up between 25% and 30% of household wastewater flow [11]. When exclusively incineration toilets are used, this wastewater is diverted from the stream going toward the IWS. Vermont [12] and Florida [13] each allow a reduction of 25%.

5. Outhouse Incineration Toilet Permitting Simplification

Current Regulations

The rules state that incineration toilets in outhouses require IWS permits, and that they have to abide by the treatment unit setbacks [2].

Requests

It is proposed that the IWS permitting process be waived for NSF-certified incineration toilets, and that a separate permitting process be set up that does not include required setbacks.

Justification

The only output from an incineration toilet is a small amount of pathogen- and nutrient-free ash [14], therefore, the likelihood of a spill is infinitesimal. Furthermore, portable toilets, which pose a much higher spill risk, do not require an IWS permit.

6. Evapotranspiration Basis-of-Design Expansion

Current Regulations

The rules state that the October 1980 edition of the EPA Design Manual on Onsite Wastewater Treatment and Disposal Systems shall be used when designing evapotranspiration (ET) systems [2]. This manual states that pan evaporation shall be used as the basis of design [15].

Requests

It is proposed that the use of the Grass Reference Surface Potential ET as provided by University of Hawaii at Manoa Geography Department [16] shall also be allowed as the basis of design.

Justification

Using pan evaporation as the basis of design does not take into account the transpiration component provided by the plants, and only accounts for the evaporation component. The Grass Reference Surface Potential ET is based on the Penman-Monteith formula and uses “a hypothetical grass reference crop with an assumed crop height of 0.12 m, a fixed surface resistance of 70 s/m and an albedo of 0.23. The reference surface closely resembles an extensive surface of green, well-watered grass of uniform height, actively growing and completely shading the ground. The fixed surface resistance of 70 s/m implies a moderately dry soil surface resulting from about a weekly irrigation frequency” [17]. These assumptions reflect a typical ET installation, and will avoid costly overdesign of disposal area, which can render ET not feasible. The 1980 EPA manual states that the “Penman formula has been shown to give results comparable to measured winter values” [15], and the Penman-Monteith formula is an advanced version of the Penman formula.

7. Variance Process Streamlining

Current Regulations

The current IWS variance process requires a newspaper publication which costs approximately $800, and a one (1)-month public comment period after publication. The total process from application to granting of variance usually takes approximately two (2) months, and the variance has to be renewed at least every five (5) years.

Requests

It is proposed that the public comment period is shortened to 15 days, and that the IWS variance renewal period is extended to 10 years. Furthermore, it is proposed that the DOH adopts a public notice model like “The Environmental Notice” used by the Office of Environmental Quality Control (OEQC) [18] to replace the mandatory newspaper publishing.

Justification

Most IWS variance applications never receive any public comments during their 30-day public comment period. Therefore, a reduction of the public comment period to 15 days will not have any negative impact, while allowing the often time-sensitive IWS permitting process to move quicker. A typical IWS does not undergo significant changes during its decade-long lifespan. Therefore, an increase of the variance renewal period from five (5) to ten (10) years will not have any negative impact, while reducing administrative work for both the homeowner and the DOH. The adoption of a public notice model similar to that used by the OEQC will reduce the cost of newspaper publishing for the homeowner, while providing a central location for anyone looking for variance information.

8. No Pass Zone: Permitted Systems

Current Regulations

The rules specify that, in the No Pass Zone, systems that threaten water resources may be prohibited [19]. Upon request, the DOH WWB is interpreting this rule as the following for the No Pass Zone:

A. “Each cesspool can be converted into a septic system. If the property does not have the required amount of land area per IWS, each IWS can only be sized to handle the existing amount of bedrooms. If there is enough land area, then each IWS can be sized for the five (5) bedroom max.”
B. “If a property is in the No Pass Zone and has no cesspools, then only aerobic treatment units (ATUs) with ET as disposal will be allowed.”

Requests

It is proposed that, in addition to allowing the combination of ATU and ET, DOH also allows a treatment unit complying with the NSF "Standard No. 245" [3], and UV disinfection, combined with an absorption bed as disposal to be used in the No Pass Zone.

Justification

In cases outside of the No Pass Zone where a three (3)-foot vertical setback between the bottom of a absorption bed and the groundwater table cannot be met, the DOH currently allows the use of a treatment unit complying with the NSF "Standard No. 245" [3], and UV disinfection, combined with a absorption bed as disposal. If this level of treatment is deemed good enough to prevent groundwater contamination, it should be good enough for the No Pass Zone. Evapotranspiration disposal fields are much larger than absorption beds, and are usually much more expensive to install, if they are not too large to fit in the property in the first place.

9. Soil Replacement Simplification

Current Regulations

The current rules specify that “soil replacement systems shall be used for sites with the following soils layers in the upper soil horizons:

A. Soils with percolation rates less than one minute per inch;
B. Soils with percolation rates greater than sixty minutes per inch that occur within the upper five feet of the soil and underlain by more permeable soils [...]; or
C. Fractured lava” [2].

Upon request, the DOH WWB defines suitable soil replacement material as “silty clays, loam, beach sand or sandy soil mixtures or masonry sand (ASTM Size C-144, 1/8 inch to fines). Suitable soil descriptions such as 1" minus cinder, 3/8" cinder chips, crushed coral/cinder and #4 sand are no longer accepted.”

Requests

It is proposed that the DOH WWB revises the list of suitable soil replacement materials using industry-standard definitions such as sieve data, like they provide for the masonry sand. Furthermore, it is proposed that the DOH WWB conducts a study to provide information on products available at local quarries, complete with the respective percolation rates.

Justification

It is difficult for IWS engineers and installers to ensure that soil replacement materials produce the desired percolation rates. If a system is installed with the wrong soil replacement material, this can result in high costs to dig the system up and install again. A simplification of this process is in everyone’s interest.

10. Number of Bedrooms Definition

Current Regulations

The current rules specify that, for the purposes of calculating design flow, a bedroom is any room that

A. “Has a superficial floor area not less than seventy square feet and
B. Is provided with windows or skylights with an area of not less than one-tenth of the floor area or ten square feet, whichever is greater” [2].

Requests

It is proposed that, for the calculation of design flow, the DOH WWB uses the number of bedrooms specified on tax documents.

Justification

The current definition of what comprises a bedroom often leads to systems being overdesigned, and sometimes requires costly wastewater treatment works (WWTW) instead of a relatively affordable IWS. Florida statutes declare that the number of bedrooms “does not include a hallway, bathroom, kitchen, living room, family room, dining room, den, breakfast nook, pantry, laundry room, sunroom, recreation room, media/video room, or exercise room” [20].

Conclusion

The authors and contributors of this memorandum believe that the above requests can lead to an improvement of the IWS permitting process, and therefore, a higher number of cesspools converted. We would like to schedule a meeting to discuss these requests and answer any questions or concerns that you may have. Thank you very much.

Mahalo,
Joachim Schneider, Project Coordinator
WAI: Wastewater Alternatives & Innovations

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Appendix I. Memo from Dave Smith, former cesspool conversion working group member.

Memorandum

Subject: Recommendations to Accelerate Progress in Hawaii Cesspool Conversions

To: Cesspool Working Group

From: David Smith
Assistant Director
U.S. Environmental Protection Agency, Region 9

Date: December 28, 2021

Introduction

This memo recommends several actions and strategies for consideration by the Cesspool Working Group as it prepares to make policy and program development recommendations to the Hawaii Legislature in 2022. These actions and strategies are intended to assist the State in developing the organizational capability, appropriate policy incentives and regulatory drivers, and technical capacity needed to accelerate progress in transitioning to quicker and more widespread cesspool conversions. These recommendations are based on my observations of Working Group actions and work products to date and discussions with organizations around the country that have faced similar challenges in planning and executing strategies to replace septic tanks and similar distributed infrastructure. These views are my own and do not necessarily represent the policies or views of USEPA.

It has been my privilege to work with the Working Group and I believe we have made substantial progress in better understanding the challenges large-scale cesspool conversions will encounter and potential options for prioritizing conversions and creating the financial, organizational, and regulatory/legal structures necessary to enable those conversions. As the Group moves toward developing its recommendations to the Legislature, it will be important to remember that the Legislature is the principal customer for these recommendations. While Department of Health is clearly a key player in determining the best strategies to build conversion capability in HI, theirs is one voice in the Working Group. At times it has felt like the Group views DOH as the primary customer for these efforts, a perspective that I think constrains the kind of creative thinking that will be necessary to be successful in the long run. Each representative on the Working Group brings a valuable perspective, and it is important to both understand existing organizational capabilities and constraints in considering implementation possibilities and actively consider what can be done to surmount those constraints in order to enable the implementing organizations to be successful.

In the following sections, I provide some observations and recommendations addressing:
- the need for more coordinated master planning
- organizational options for conversion services
- policy changes to accelerate conversions
- policy/regulatory changes to increase regulatory flexibilities
- policy/regulatory changes to increase funding flexibilities

- broadening funding and financing options
- technology development and certification
- workforce development
- geographical targeting and priority setting.

Hopefully, this memo will assist the Workgroup in planning its work going forward.

Aligning Cesspool Conversion Planning with Evaluation of Centralized Wastewater System Needs

Cesspool conversion will entail a mix of smaller-scale actions taken by individuals/groups of cesspool users to replace existing cesspools and larger-scale actions by county/city level wastewater collection and treatment system operators to connect buildings or neighborhoodss previously serviced by cesspools to centralized wastewater systems. Determining the optimal mix of decentralized cesspool replacement, connection of cesspools to existing centralized treatment systems, and potentially creation of new small scale centralized collection and treatment systems will require careful master planning by county public works departments working with local stakeholders. This master planning will require consideration not only of cesspool conversion needs and options, but also evaluation of broader wastewater system operational, replacement, and upgrade needs. These additional wastewater system needs include but may not be limited to replacement of failing treatment or collection system infrastructure, potential changes in wastewater injection practices associated with NPDES regulatory requirements pursuant to the *Maui* Supreme Court decision, relocation or strengthening of system assets to address climate related risks like sea-level rise, and opportunities to enable increased recycling of treated wastewater to meet water supply needs. At present, the counties vary substantially in the degree to which they have current, comprehensive wastewater management plans that account for cesspool conversion needs.

To provide a robust framework for master planning and to enable better system planning and maintenance in the future, each County should develop, maintain, and use robust asset management systems that assist system operations, maintenance, and planning and help reduce system failures. DOH and the counties should consider securing consulting services to support master planning and developing asset management system capability similar to that recently developed for Hawaii County, with funding support from DOH. Developing and maintaining comprehensive wastewater master plans without asset management capability is much less likely to succeed in guiding the right mix of new project and system maintenance/upgrade projects at the County level.

I recommend that the Department of Health and EPA work with each County to ensure that careful master planning of area-wide wastewater treatment needs and options is completed within the next 5 years. This can be accomplished by offering funding (likely through targeted CWA Section 604(b) grants, SRF planning grants, and potentially through USDA Rural Development and other agencies) for county/island scale master planning, bolstering requirements in NPDES permits to develop and maintain robust asset management systems and otherwise ensure the long-term operational viability of these systems, and utilizing available compliance assistance tools.

The area-wide wastewater planning provisions under CWA Section 208 provide a useful guide for developing and maintaining comprehensive wastewater master plans. These plans will be critical to supporting decision making on the right mixes of decentralized and centralized system improvements needed to efficiently address cesspool conversion and other priority wastewater system challenges. Moreover, these plans will support development of comprehensive capital improvement plans and help make the "business cases" to funders and ratepayers about the systems' long-term needs for funding and potentially higher sewer rates. Without more comprehensive wastewater master plans at the county/island scales, HI risks enabling uncoordinated investments in dispersed cesspool conversions and centralized system connections and missing out on the efficiencies more coordinated, planned conversion strategies can yield.

<u>Organizational Needs and Recommendations</u>

The Working Group's consideration of financing, technology, and priority setting needs and issues has been pretty robust (aided in large part by the excellent reports developed by Carollo and inputs from Group members and other contributors). However, I think we've largely skirted the key challenge of identifying and testing a wide range of potentially viable organizational frameworks for leading and servicing cesspool conversions. It will likely be necessary to create more than one type of organization to provide the many types of services that will be necessary to carry out tens of thousands of conversions. As discussed below, there are many potential structural options, and the capacities of different types of providers to provide the wide range of needed services will vary substantially.

Based on reviews of experiences in other states, I recommend the Working Group report specifically discuss 3 types of organizational mechanisms for supporting cesspool conversions (not necessarily in order of preference):

<u>Public Agencies</u>
- *New program at HDOH.* This is based on the observation that it is simply infeasible for DOH to take on the workload associated with overseeing, permitting, and potentially financing conversions within its existing organizational structures. Adding more staff would not be enough to fix this capacity limitation at DOH.
- *New conversion programs at County public works or environmental departments*. There is promising interest in setting up pilot scale programs in 2 counties, but to be effective overall each County would likely need to establish such programs.
- *New public or quasi-public agency.* The scope of the cesspool conversion challenge is so large that it may be appropriate to create an entirely new state program, perhaps similar to Solar Banks and septic system conversion programs created in some states. This new agency or program could also modeled on state infrastructure banks, that serve as financing brokers capable of receiving large amounts of funding and then servicing project funding and implementation at the smaller household or neighborhood scales.

<u>Non-Profit Entities</u>
- *Existing HI Non-Governmental Organization like WAI.* Nonprofit NGOs have proven effective in supporting the types of services needed for cesspool conversions at the "retail" level and, in particular, addressing the needs of disadvantaged customers. Wastewater Alternatives &

Innovations (WAI) has demonstrated its commitment to lead and support cesspool conversions, including evaluation of emerging advanced treatment technologies, development of worker training proposals, and assessment of regulatory revisions needed to advance conversions. WAI is likely the most "shovel ready" NGO to take on more substantial duties to service cesspool conversions. That said, it will be important to be fair in offering opportunities for nonprofits/NGOs to assume organizational responsibility for cesspool conversion so that other potentially interested organizations can have a chance to participate. Other types of organizations that could be interested in assisting in cesspool conversion work might include HI Rural Water Association and Rural Community Assistance Corporation.

- *New NGO(s) to support cesspool conversion.* There are existing models in other states where NGOs have major responsibilities for supporting implementation of septic system conversions and similar distributed infrastructure projects. Groups like CRAFT3 in the Pacific Northwest have a proven track record of providing these types of services at scale, and CRAFT3 has specifically expressed interest in supporting development of similar capabilities in HI by other organizations.
- *Community Development Financial Institution (CDFI).* CDFIs provide financing assistance to support community development, often in low-income communities that have difficulty accessing traditional sources of capital. Supported by the federal CDFI Fund (Dept. of Treasury), CDFIs may provide a viable model for providing the funding/financing organizational capability that HI will need to transfer funds to large numbers of dispersed recipients. For example, the RCAC is a CDFI that provides technical and financing assistance for water infrastructure projects in western states including HI.

<u>Private and Public-Private Partnership Entities</u>

The future volume of needed cesspool conversions is so large in HI that servicing this "market" could be of interest to private companies or public-private partnership entities that could provide planning, design, financing, and operations support. These types of organizations could utilize larger scale funding/financing from federal or state sources, and/or private capital sources, to provide cesspool conversion sources and process repayment of loans or payment for cesspool conversion services. As several stakeholders in HI have expressed concern about whether homeowners have adequate technical capacity to properly operate and maintain more advanced IWSs, it is worth considering creating organizational capability to provide help not just with design and installation, but also ongoing operation and maintenance services. This could be a strength of private and P3-type organizations. In similar cases across the country, private or public/private entities have proven capable of providing efficient services while still realizing a reasonable profit. I encourage the Working Group to fully consider the potential for private sector involvement in creating and operating the organizational structures that will be necessary for cesspool conversions.

<u>Assessing the Organizational Options</u>

The Workgroup is not yet ready to identify one or more preferred organizational structures to support cesspool conversions in the state because as yet there has been no robust assessment and comparison of these organizational options. It would be useful for the group to compare potential organizational structures and partners by considering their capacity and track-records in performing specific key services that will be necessary to fully support large-scale cesspool conversions in the State. Table 1 below illustrates that different organizational structures have different capabilities to provide different functional services.

Table 1: Capability of Different Providers to Support Key Cesspool Conversion Services
(Note- the evaluations here are illustrative only; additional stratification of provider options and analysis of relative strengths and weaknesses of different provider structures would be important)
H- High capability M- Medium capability L- Low capability

Service Type	Public Agency	Non-Profit	Private	Public-Private
Inform/educate cesspool owners about mandates and funding/implementation support opportunities	M	H	M	H
IWS design and installation services	L	H	H	H
IWS permitting and permit oversight	H	M	L	M
Inspections to ensure proper installation	M	M	L	M
Evaluate and certify acceptable treatment technologies	M	M	M	M
Coordinate onsite conversions with centralized system connections	H	M	L	M
Tracking conversions to ensure consistency with targeting priorities and compliance with regulatory requirements (requiring conversion at point-of-sale or when a building undergoes major remodelling)	M	M	L	L
IWS grant funding	H	H	L	M
IWS financing, including collection of repayments	M	M	M	M
Develop ability to pay/means testing policies and implementation procedures	M	M	L	L
Reporting to legislature and public on conversion progress, issues, and policy/program adjustment needs	H	M	M	M
Develop workforce skills and capabilities to increase number of qualified designers, installers, and service professionals.	L	H	M	M
Others?				

The Workgroup should do the best it can with available time and resources to more rigorously understand and compare these different provider options. It will likely be necessary to request additional funding now or later to secure contractor support in characterizing and assessing these organization options, identifying a viable mix of organizational options to provide all required services, and developing organizational development strategy to launch different organizational structures in the short and longer terms.

Urgent Need to Accelerate and Broaden Pilot Projects To Test Different Provider Models
I recommend the Workgroup specifically endorse and support funding of several pilot projects to implement and evaluate different conversion service provider models over the next 5 years. The ongoing efforts by DOH and interested counties to initiate SRF-funded conversion programs at the county level are promising and should be pursued with each county. DOH should also provide funding to launch one or more pilot cesspool conversion projects by non-profit/NGO organizations. The key point is that greater urgency is needed within the Workgroup and in DOH to support implementing and testing a wider range of service provider models now, and to not await additional legislative action.

Organizational Recommendations to Legislature

The Workgroup should provide an honest assessment of public agency, non-profit organization, and private/P3 capabilities to provide these services and what levels of funding and authorities would be needed to enable them to provide needed services. I suspect that additional financial support from the Legislature and/or DOH will be needed to secure expert assistance in evaluating such options. The Workgroup should specifically endorse the development of nonprofit/NGO based and private/public private service providers to complement what public service providers will be realistically capable of supporting in the near and longer terms. Relying solely on public entities to provide the broad range of needed services for the huge number of future clients is unlikely to be successful, even if additional resources are provided. HI should view the next 5 years as a period to be actively testing alternative organizational structures to support more actual conversions while prompting the broader scale wastewater master planning needed to integrate cesspool conversion planning and priority setting with centralized wastewater system planning and management.

Policy/Regulatory Changes To Accelerate Conversions

Carrots will help spur conversions, but I think some policy/legal sticks will also be needed to create the demand for conversion services that will be needed to sustain newly created organizational mechanisms/providers of these services. Several good ideas have been discussed that could create some stronger legal drivers to advance conversions. Requiring conversions at the point-of-sale could make a lot of sense as this approach has been used widely and successfully to support home/building infrastructure upgrades at a time when the financial impact looks less daunting than is the case outside of a property sale. For example, a recent requirement in Oakland, CA, where I live, to require inspection of sewer laterals and, if necessary, their replacement at the time of property sale has been very effective in reducing the frequency of sewage spills caused by failing pipes. Real estate professionals are accustomed to ensuring that such requirements are met through the property transfer process. Similarly, requiring cesspool conversion at the time a major property remodeling job is permitted (to be enforced through the local building permit oversight process) could also advance conversions at a time when a building is undergoing significant reconstruction. This provision could also encourage investment in onsite water recycling system technology, which if done properly greatly reduces the volume of site black water (sewage) requiring full scale treatment while also reducing demand on potable water sources for landscape irrigation.

Legislative action to require more robust analysis of wastewater management needs (including cesspool conversion needs) could help prompt county/island scale investments to develop master plans (discussed above) and tighter regulation of wastewater management at neighborhood scales in cases where cesspool serves multiple households and/or there is a need to improve wastewater services in a decentralized system. Complementing new legislation, DOH should consider enacting policies that condition access to SRF financing on development and maintenance of robust areawide wastewater master plans, capital improvement plans, and asset management systems.

Policy/Regulatory Changes to Increase Regulatory Flexibilities and Broaden Oversight

Several stakeholders have suggested policy or regulatory changes that would increase access to funding and financing or lower barriers to implementing innovative yet protective wastewater treatment technologies. I have reviewed and endorse each of the recommendations in WAI's recent memorandum entitled "Policy Requests for DOH to Streamline IWS Regulations and Expedite Cesspool Conversions" (attached). I urge DOH to act on these and other relatively modest policy changes that would increase the range of viable conversion options and streamline the design and approval process.

Currently, DOH is principally responsible for permitting cesspool conversions and approving IWS technologies for use in the State. Given DOH's severe staffing restrictions, the state should consider authorizing other parties to share in these responsibilities. It may prove more efficient for the State to enable DOH to delegate certain oversight functions (e.g., IWS permitting, inspections, reporting, and technology validation to other parties with demonstrated technical and organizational capacity to carry out these functions). This approach could be similar to wastewater pretreatment program structures, through which local wastewater programs often bear principal responsibility for regulating individual industries discharging to sanitary sewers, with general oversight by the State and/or EPA. Considering the magnitude of the challenge in regulating and overseeing thousands of cesspool conversion actions each year, alternative regulatory structures should be actively considered by the Workgroup.

In developing recommendations to the Legislature, the Workgroup should carefully consider how these types of operational and regulatory changes can help accelerate conversions and, where necessary, urge the Legislature to authorize changes in regulatory frameworks to provide regulatory flexibility while ensuring the integrity of IWS systems.

Policy/Regulatory Changes to Increase Funding Flexibilities

The Workgroup should work closely with DOH to evaluate whether existing SRF funding and lending policies make maximum use of available programmatic flexibilities that could enable wider use of SRF funds to support cesspool conversions and enable broader participation by entities beyond the counties These other potential funding recipients include other governmental or quasi-governmental agencies, nonprofits, private companies, and public-private entities seeking funding to capitalize cesspool conversions. For example, some states have relaxed lending and granting restrictions to broaden the array of potential recipients or enable use of Drinking Water SRF funding to support projects that recycle wastewater and help offset demand on existing supplies. DOH should consider availing itself of existing opportunities to have outside consultants evaluate the State's granting and lending policies associated with several relevant funding sources that can help support cesspool conversion program development and delivery (including, but not limited to, Clean Water and Safe Drinking Water State Revolving Funds, CWA 604(b) planning grants, and CWA 319(h) nonpoint source management grants). EPA has offered the services of Northbridge, an experienced national consultant with experience in innovative finance program design, to help DOH evaluate such options.

Broadening Funding and Financing Options

No one funding sources will be sufficient to meet the funding challenges wholesale cesspool conversion will create. Multiple new strategies to optimize access to federal, private, and potentially other funding sources will be needed to meet this challenge.

The new Bipartisan Infrastructure Law will be providing a substantial increase in SRF funds available in HI that can be used to support cesspool conversion planning and funding. The Workgroup should work with DOH to identify strategies for broadening access to SRF funds by taking advantage of increased flexibilities in BIL-based funding (e.g. ability to increase the percentage of funds provided as grants and spent for planning purposes, and targeting increased CWA 604(b) planning grants to assist Counties in master planning and cesspool conversion program development). In addition, the State should engage with other federal funding agencies that offer grant and financing services that could be used to help fund cesspool conversions. In particular, the capabilities of the USDA-Rural Development, Economic Development Administration's Community Development Block Grants, and potentially Bureau of Reclamation grants for wastewater recycling should be discussed with these agencies and considered in broadening the range of potential federal funding sources under consideration. It may even prove feasible to utilize a portion of American Recovery and Reinvestment Act funds for these purposes.

The Workgroup should endorse the potential for nonprofit, for-profit, and public-private partnership organizations to harness public and private funding and financing sources to aid cesspool conversions. The Workgroup should also explore with philanthropic organizations potential interest in providing funding and organization support for cesspool conversions to complement financial support available from public and private sources. The Workgroup should evaluate, or recommend the evaluation of, existing legislative or regulatory barriers to participation in cesspool conversion service provision by nonprofit, private, public-private, and philanthropic organizations. Such evaluations would aid the Legislature in identifying potential legislative actions needed to authorize and empower different types of organizations to perform certain functions and services in the State.

Technology Development and Certification

Technological improvements in IWS systems are happening fast, and it will be in the State's interest to create an efficient, accessible process to evaluate and certify different technologies. The State's process for considering authorization of new technologies is limited and seems somewhat biased toward traditional wastewater treatment technologies. As mentioned above, it may be more efficient to complement the State's existing process for considering innovative technologies by empowering a separate organization to carry out technology testing and validation work. Based on similar technology validation processes currently in use (e.g. for new biosolids treatment technologies), it may be appropriate to develop a partnership between public regulatory agencies, private technology innovators, engineering researchers, and others to create a replicable framework for new technology testing and validation.

The State should be open to technologies that more efficiently treat wastewater at onsite or neighborhood scales, taking into account potential benefits from reducing energy costs and enabling wastewater separation to enable onsite reuse of grey water and reduction of blackwater requiring intensive treatment. In evaluating such new technologies (and perhaps

reconsidering existing approved technologies, it will be important to consider full life-cycle cost and benefit factors including:
- treatment effectiveness
- site feasibility (accounting for differences in site conditions and requirements)
- capacity of available installers to effectively use the technology
- operations and maintenance requirements
- energy use
- residuals generation and disposal needs
- capacity to support other needs (green infrastructure, water recycling, efficient building design, fit with land use priorities)
- direct and indirect costs.

The Workgroup should recommend creation of a certified technology program to provide a list of standard IWS designs already approved for use in cesspool conversions, linked with an efficient process for introducing, evaluating, and certifying new technologies to be added to the list over time. This program should identify the types of settings in which different certified technologies are approved for use. This will provide service providers a more predictable way to identify technology options and benefit from efficiency improvements new technologies may provide.

Workforce Development

Hawaii faces large challenges in developing a dedicated workforce capable of planning, designing, installing, and maintaining a huge increased number of cesspool conversions. The Workgroup should endorse recommend provision of state funding to advance the Work-4-Water initiative and potentially similar workforce development efforts to improve training and certification programs necessary to build workforce capability to support conversions across the State. These investments should include building workforce capacity to operate and maintain IWSs to support the needs of system owners who may not have the technical capacity to properly maintain them.

Geographical Targeting and Priority Setting

As we discussed at length in the last Cesspool Working Group meeting, there is substantial interest in recent efforts to set geographical priorities to guide the sequenced implementation of cesspool conversions to gain the greatest environmental benefit through the earliest conversion investments. I think the UH report on priority setting is very solid, and believe that it should be released along with brief description of the report purpose and likely uses. I am mindful that the authors' sensitivity analysis indicated that adjustment of criteria weights makes little difference in priority setting outcomes. However, it is also important to create policy making processes that are perceived as inclusive. Ideally, the Workgroup would be able to invest in a longer and more inclusive process of considering priority setting criteria and analysis as suggested by some stakeholders. I doubt that can be done within existing Working group resources and time constraints, but I could be wrong. I would be concerned about diverting excessive attention from the larger process of developing key recommendations to the Legislature in several areas along with the Report that will provide those recommendations.

It may be warranted for the Working Group to both issue the recent UH report with appropriate caveats and context in early 2022 and recommend investment in further evaluation of priority setting policy options through an inclusive process prior to making firm policy decisions about implementation priority locations and how funding and support would be tied to priority locations.

Conclusion

I hope these suggestions are helpful to the workgroup as you embark on what promises to be an intense journey in 2022. I believe you have created a good base for continued work but that greater urgency to characterizing and developing organizational options and stimulating near term pilot testing of different approaches to conversion service provision are warranted in the coming year. I understand the it would not be possible for the Workgroup to act on all these suggestions before completing the Report to the Legislature. However, it may also be appropriate to identify in those recommendations additional planning and program development work that is critical to building the right structures and capabilities to efficiently service conversion needs.

Please don't be shy in recommending bold actions. No one strategy will address the range of service needs and challenges, and it will require creativity and initiative to provide the Legislature and other stakeholders with the ideas and leadership needed surmount this huge challenge. If you have questions or would like to discuss, I can be reached after 12/31/21 . Best of luck to you all!

Department Note: Dave Smith's email address has been removed.