Hawai‘i Water Plan

WATER RESOURCE PROTECTION PLAN

2019 UPDATE

State of Hawai‘i
Commission on Water Resource Management

Townscape, Inc.

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1 Introduction

Ola I ka wai a ka `ōpua
There is life in the water from the clouds

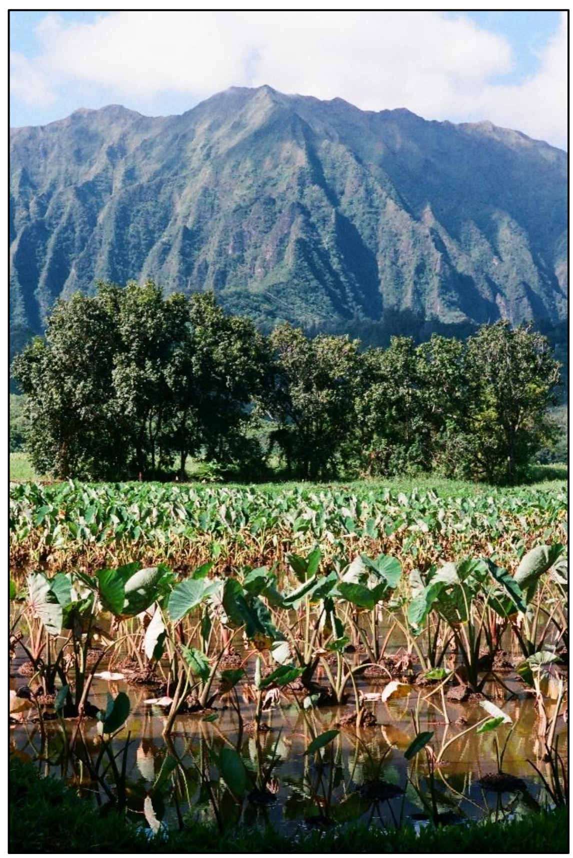
-ʻŌlelo Noʻeau: Hawaiian Proverbs and Poetical Sayings,
Mary Kawena Pukui

1.1 Importance of Water in Hawaiʻi

The Hawaiian Islands are some of the most isolated islands on earth, located approximately 2,500 miles from the nearest continent. Surrounded as they are by the ocean, the six major populated Hawaiian Islands – Kauaʻi, Oʻahu, Molokaʻi, Lānaʻi, Maui, and Hawaiʻi - are solely reliant on precipitation to meet drinking water and all other freshwater needs. Unlike the continental United States, Hawaiʻi does not have the ability to transport freshwater from one county to another, thus careful and wise management is critical to sustain this most precious life-giving resource.

Ancient Hawaiians understood the critical importance of fresh water. According to moʻolelo (stories) passed down from generation to generation, fresh water streams and springs were created throughout Hawaiʻi by the gods Kāne and Kanaloa. This established a spiritual connection between the indigenous inhabitants of the islands and the resource that is so vital to life. The importance of water in Hawaiʻi is also evidenced in the many place names that include "wai", as well as important words, such as those describing wealth (waiwai) and law (kānāwai). In accordance with their reverence and respect for water, land management units were organized around freshwater supplies in a traditional system known as the ahupua'a resource-management system. Water was viewed as such a critical resource to the health and well-being of the people of ancient Hawaiʻi, that the concept of private ownership did not exist. Today, our State Constitution and Water Code (**Hawaii Revised Statues Chapter 174C**) continue to reflect these traditional values by declaring that Hawaiʻi's water resources are part of the public trust.

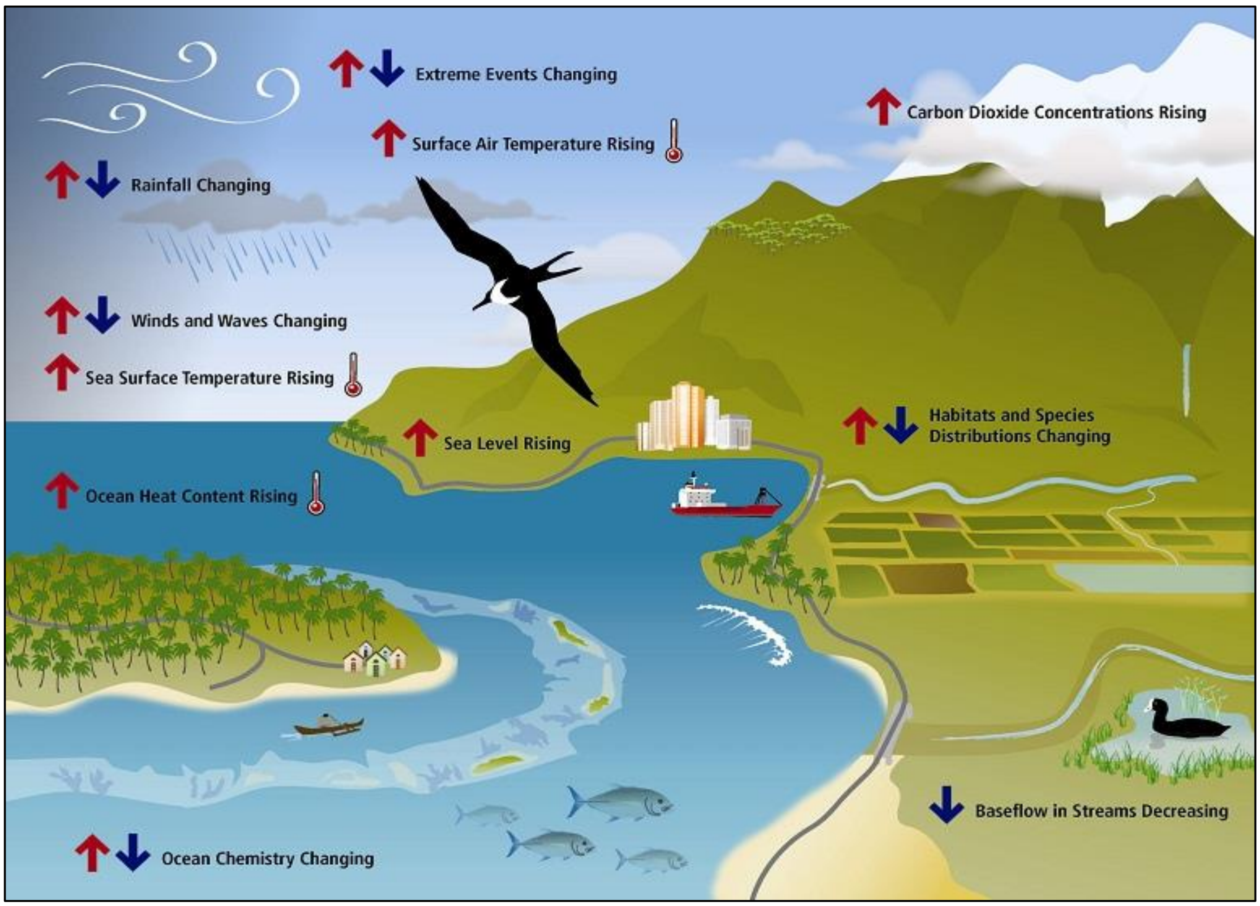
Photo credit:
https://douglaspooloatolentino.files.wordpress.com/2011/10/kanekanaloa.jpg,



1.2 The Need for Long-Range Water Planning

To ensure the long-term protection of the water resources trust, the State Water Code recognizes the need for a program of comprehensive water resources planning. The Hawaiʻi Water Plan, a multi-component, long-range plan, fulfills this need. Comprised of five component plans, each prepared by a different agency, the Hawaiʻi Water Plan seeks to protect, conserve, and enhance the quantity and quality of existing water resources, while providing for existing and future water demands within each county through an integrated water resource management approach.[1]

Figure 1-1 Indicators of Climate Change in the Pacific Islands Region



Source: Keener, V.W., Marra, J.J., Finucane M.L., Spooner, D., & Smith, M.H. (Eds.). (2012). Climate Change and Pacific Islands: Indicators and Impacts. Report for the 2012 Pacific Islands Regional Climate Assessment (PIRCA).Washington, D.C.: Island Press

[1] For more information about the Hawaiʻi Water Plan and its component plans, visit http://dlnr.hawaii.gov/cwrm/planning/hiwaterplan/

The need for water resources planning and sustainable management has never been greater. Hawaiʻi's population is projected to increase by about 20% from 2010 to 2040,[2] and with it, the demand for more drinking water. Balanced against that is the growing awareness of Hawaiian water rights and the recognition of environmental needs and the critical ecosystem services that are dependent on healthy watersheds and natural water flows. Hawaiʻi's land use is in flux. The cessation of sugarcane plantation agriculture is resulting in large swaths of productive agricultural lands becoming available for new land uses, creating opportunities to rebalance instream and offstream needs and fostering greater use of alternative water sources.

The future impact of climate change on water resources is still being studied but the best available information indicates that, for the most part, the impact will be negative. Scientists have already observed decreases in rainfall over the last 30 years, along with an associated decline in stream flows. This uncertainty requires both a precautionary and adaptive approach to water management to ensure the long-term protection of our water resources while providing flexibility for revisions of prior decisions in light of new and better information.

The Water Resource Protection Plan (WRPP) is the component of the Hawaiʻi Water Plan that seeks "to protect and sustain statewide ground and surface water resources, watersheds, and natural stream environments."[3] The WRPP is prepared by the State Commission on Water Resource Management (CWRM), which is established as the primary trustee of the water resources trust under the State Water Code. Among other things, the WRPP includes:

- General water resource management principles and policies;
- The nature and occurrence of water resources in the State;
- Hydrologic units for ground and surface waters and sustainable limits for water supply (i.e., ground water sustainable yields and surface water instream flow standards);
- Existing water uses and projected future demands;
- Programs for hydrologic data collection and analyses;
- Regulatory authorities and permitting systems; and
- Studies and programs to conserve and augment water resources.

Based on a comprehensive review of the current state of water resources and management, the WRPP identifies emerging threats, unresolved issues, management gaps, and recommended actions to further sustainable water management. Initially adopted in 1990, the WRPP was last updated in 2008.

[2] Research and Economic Analysis Division, Department of Business, Economic Development and Tourism. March 2012. *Population and Economic Projections for the State of Hawaii to 2040, DBEDT 2040 Series*.
[3] Statewide Framework for Updating the Hawaiʻi Water Plan, February 2000, p. 3-1

1.3 Vision, Mission, and Guiding Policies

Our Vision	*Flowing streams, sustainable aquifers, and functioning watersheds for the use, enjoyment, and benefit of all.*
Our Mission	*To protect and manage the waters of the State of Hawaiʻi for present and future generations.*

Guiding Policies

A policy is a statement that guides decision-making. As such, policies should be as clear and universally applicable as possible. CWRM's management actions and decisions are guided by policies, which are derived from statements in officially adopted documents, such as the State Constitution and State Water Code, and from CWRM and Supreme Court decisions on specific cases that laid the foundation for future decisions and actions. CWRM's guiding policies include:[4]

1. **The Public Trust Doctrine: The title to water resources is held in trust by the state for the benefit of its people.**
2. **The State recognizes four public trust purposes:**
   (a) maintenance of waters in their natural state;
   (b) domestic water use of the general public, particularly drinking water;
   (c) the exercise of Native Hawaiian traditional and customary rights; and
   (d) reservations of water for Hawaiian Home Lands.
3. **The Precautionary Principle: The State has a duty to take anticipatory action to prevent harm to public resources.**
4. **Apply adaptive management principles in the face of scientific uncertainty.**
5. **The State Water Code shall be liberally interpreted.**
6. **The State Water Code shall be applied in a manner that conforms to the intentions and land use plans of the counties.**
7. **Comprehensive water resources planning is needed for proper management and protection of the resource.**
8. **High standards of water quality shall be maintained.**
9. **Provide for public interest objectives while seeking to obtain maximum reasonable and beneficial use of waters of the state.**
10. **Quality of the water source should be matched to the quality of the water needed.**
11. **If there is a practical alternative water source available, that alternative source should be used in lieu of natural supplies.**
12. **Water use should be efficient, and waste of water is disallowed.**
13. **Appurtenant rights shall be assured.**

[4] For additional discussion on the following policies, please refer to **Appendix C Legal Authorities and Guidance**).

2 The Current State of Water Resources and Management Tools

Current and best-available information on water resources was gathered to identify technical water-related issues that need to be addressed. **Section 2.1** summarizes the water resource issues identified by the community and stakeholders during the CWRM public outreach process. **Section 2.2** describes the state of water resources in Hawai‘i and CWRM programs to manage and protect those resources. **Priority Recommendations** and the Action Plan describes the actions designed to address issues and program management gaps found in **Section 2.1** and **Section 2.2**.

2.1 Water Resource Issues

In order to find out how the public perceives and understands Hawai‘i ‘s water resources, CWRM held public meetings, and met with stakeholders and subject matter experts around the state. Ten key issues were distilled down from information gathered during these interactions. These issues are shown below in bold typeface and followed by a brief description of the issue.

Reliable, long-term data is needed to make sound water-management decisions.

To make sound decisions, water managers need reliable data. Longitudinal data provides the best information for identifying trends in water availability and use and can be helpful in predicting future scenarios to plan for. Monitoring of ground water and streams allows for an accounting of how much water there is, whether natural flows are sufficient for environmental and cultural needs, and how water is made available for human use. Despite current efforts, ground and surface water is not monitored as completely as it should be and the number of stream flow monitoring stations continues to decrease. This makes it difficult to understand long-term temporal and spatial changes in water resources and availability and the impacts of climate change on our water supplies.

In addition to monitoring of the resource itself, managers require an understanding of human water demand to be able to balance various water needs. Therefore, it is critical to have an accurate accounting of water use by various sectors, such as agriculture, domestic consumption, landscape irrigation, and industrial uses. Each owner or operator of a water source (i.e., wells or stream diversion works) is required to report their monthly water use; however, not all owners/operators are compliant. **Table 2-1** below shows the compliance rate for ground water use reporting.

Table 2-1 Water Use Reporting by Island 2016

Island	Total # of Production Wells[1]	# Wells Reporting Water Use	Compliance Rate
Kauaʻi	288	139	48.3%
Oʻahu	818	491	60.0%
Molokaʻi	89	40	44.9%
Lānaʻi	10	10	100.0%
Maui	567	240	42.3%
Hawaiʻi	927	331	35.7%
TOTAL	2,699	1,251	46.4%

1. Production Wells are defined as all wells that are not abandoned, observation, or unused wells.

Analysis of data provides critical guides for water management, such as the sustainable yield of ground water aquifers and instream flow standards for streams; whether existing regulatory controls are working; or whether additional regulation is needed. Water demand projections help to predict the amount of water needed in the future, allowing for early planning at the county level to identify the adequacy of existing resources and infrastructure, plan for the development of alternative sources, determine the need and opportunities for increased conservation and potential reallocation of water, and inform future land use plans and policies.

Water resource management needs to consider all the above considerations of demand, supply, and future water scenarios with decisions only made better with improved and long-term data and analysis. Strategic and coordinated resource monitoring, such as a network of deep monitor wells, stream flow gages, and climate stations would allow for the verification of sustainable yields, contribute to the monitoring of recharge trends in critical ground water aquifers, and provide valuable data for the understanding of ground water/surface water interactions, and the calculation of instream flow standards and surface water allocations. Such monitoring can also be used to study trends attributable to climate change and predict future needs and resources.

Improved water use reporting is another critical component to understanding water needs and availability. Reporting systems should be made as user-friendly as possible and outreach should be conducted to encourage compliance with reporting requirements. Enforcement should also be used to ensure that reporting requirements are met.

There is increasing competition for water resources in certain areas.

Human consumption of water resources continues to increase as Hawaiʻi's population grows and demand for domestic, commercial, industrial, and landscape and agricultural irrigation increases. Societal needs must be balanced against the need to maintain waters in their natural state for environmental uses and ecological health. Additionally, there has been a resurgence in traditional uses of water resources, which often rely on surface water sources and coastal springs for traditional and customary practices and subsistence activities. Such diverse uses of water may result in total demand in some areas exceeding ground water supplies, surface water supplies, or both.

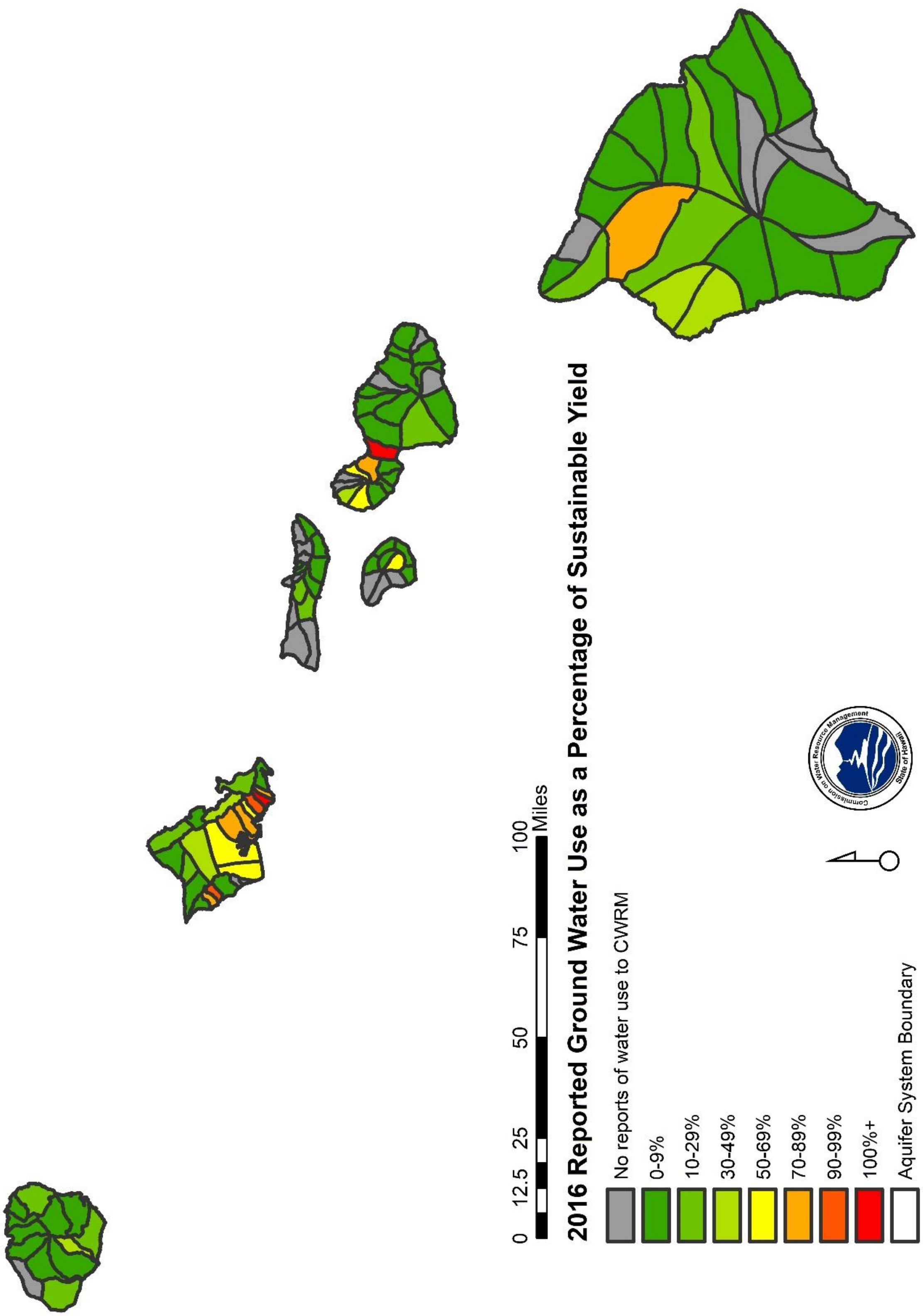
Demand for water resources continues to increase as more and more users compete for both ground and surface water. The State Constitution states that "All public natural resources are held in trust by the State for the benefit of the people."[5] It is CWRM's duty to protect water resources in accordance with its public trust responsibilities. Hawaiʻi has recently experienced a multi-year drought and climate change is expected to increase the occurrence of drought in some areas of the state.[6] Proactive planning at the State, County, and individual user level, as well as coordination among all, is needed to minimize negative impacts to the resource, communities, and the economy.

Competition for water resources brings increased urgency for aggressive conservation measures that ensure that water is not wasted or lost. Additionally, alternative water sources, such as recycled water and storm water, offer lower quality water that can be used for non-potable needs, reserving high quality water for potable uses, such as drinking and food preparation. Desalinated could also provide high quality water to supplement potable water supplies. As emerging technologies, potential alternative water users and the public need to be educated on the benefits and actual impacts of using such sources and alternative water providers need guidance from regulators and scientists to ensure that public health and the environment are protected

[5] Constitution of the State of Hawaiʻi, article XI, §1.

[6] Keener, V.W., Marra, J.J., Finucane M.L., Spooner, D., & Smith, M.H. (Eds.). (2012). Climate Change and Pacific Islands: Indicators and Impacts. Report for the 2012 Pacific Islands Regional Climate Assessment (PIRCA).Washington, D.C.: Island Press

Figure 2-1 2016 Reported Ground Water Use as a Percentage of Sustainable Yield



The availability of, and access to, water must be protected for public trust purposes.

The Hawai'i State Constitution recognizes that water resources are part of the public trust. The Hawai'i Supreme Court further established the following four public trust purposes: (1) maintenance of waters in their natural state; (2) domestic water use of the public, particularly drinking water; (3) the exercise of Native Hawaiian and traditional and customary rights, including appurtenant rights; and (4) reservations of water for Hawaiian Home Land allotments.[7]

It has been especially difficult to plan for traditional and customary rights, as practices are site specific, there are no databases of practices from which to plan for, and many practices are not shared publicly. Nonetheless, the State has an obligation to protect traditional and customary practices and should account for them in any natural resource planning effort. To do so, there needs to be a better understanding of the public trust purposes, guidance on how to incorporate public trust needs into decision-making, and education and outreach to water users and managers to understand those needs and management considerations.

Aging and inefficient water infrastructure could potentially waste and impact the quality of the resource.

Much of Hawai'i's water infrastructure was constructed decades ago. There are many ground water wells that are no longer in use and have not been properly sealed, providing potential conduits for contamination of ground water aquifers. Some older wells also do not have flow control devices that manage pumpage volumes and measure flow, making it difficult to monitor usage and minimize waste. Similarly, some stream diversions and large-scale agricultural irrigation systems are no longer used for their original purpose, are leaking and inefficient, and do not have flow control devices.

Water use reporting may be used to identify unused water infrastructure and prioritize wells and diversions for sealing and removal. Large agricultural irrigation systems are inventoried by the State Agricultural Water Use and Development Plan, which provides information on the current rehabilitation and maintenance needs for each system. This agricultural water needs assessment should include in their analyses important agricultural lands and the volumes of water needed, as well as the parties responsible for maintenance of these legacy irrigation systems.

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[7] The Supreme Court decision No. 21309 *In the Matter of the Water Use Permit Applications, Petitions for Interim Instream Flow Standard Amendments, and Petitions for Water Reservations for the Waiāhole Ditch Combined Contested Case Hearing* ("Waiāhole I"), *Section III. Discussion, B. The Public Trust Doctrine, 3. The State Water Resources Trust, b. Substance of the Trust, i. Purposes of the Trust* (2000) established the first three public trust purposes. The Supreme Court decision No. *22250 In the Matter of the Contested Case Hearing on Water Use, Well Construction, and Pump Installation Permit Applications, Filed By WAI'OLA O MOLOKA'I, INC. and MOLOKA'I RANCH, LIMITED, Section III. Discussion, A. The Commission's Decision Violated DHHL's Reservation Rights As Guaranteed by the HHCA, The Hawai'i Constitution, The Code, And The Public Trust Doctrine, 3. Reservations of water constitute a public trust purpose, which the commission has a duty to protect in balancing the competing interests for a water use permit application* (2004) established the fourth public trust purpose.

Climate change is anticipated to increase water demand and decrease water availability.

Climate change is expected to result in many water resource changes, including intensified flooding and drought, reduced recharge to ground water aquifers in leeward areas, elevation of basal aquifers due to sea level rise, and higher water use. In general, researchers expect wet areas in Hawaiʻi to get wetter and dry areas to get drier. However, there is considerable uncertainty in future predictions of climate. This will change water demands and supplies in some areas and require adaptation in demand management, water infrastructure, and distribution.

Proactive planning is needed for such climate change scenarios, including projected water demands and expected water availability in localized areas. Continued research is needed to refine climate change predictions for Hawaiʻi as new information is made available and our understanding of this phenomenon is improved.

Man-made pollution threatens fresh water supplies.

The availability of water for human use and consumption is affected not only by the amount of water that is in our ground water aquifers and in our streams; the quality of our water resources also impacts what is available for use. In general, Hawaiʻi's water quality is very good, with ground water requiring little treatment before being distributed for consumption. However, over the years, land uses have intensified and encroached over aquifers, increasing the potential for ground water contamination. Similarly, some land uses may increase the potential for erosion and surface runoff that transports sediment and other pollutants into streams and nearshore waters.

The State Department of Health oversees programs that protect the quality of surface and drinking water, County water departments are responsible for the quality of the drinking water they provide their customers, County environmental services departments manage polluted runoff control, and County planning departments have jurisdiction over land uses. Coordination among these entities and CWRM will ensure clean, healthy waters for drinking and public and environmental health.

Land uses changes are reducing the replenishment of fresh water sources.

To manage our water resources and ensure supplies for cultural needs, human consumption, and ecological sustainability, we need to understand the dynamics of hydrology, ecosystem function, and the impacts of land use and human water use on the resource. Some land uses impact water resources not only in their demands for water, but also in how water supplies are replenished. For example, urban development increases the impervious surfaces (hard surfaces that water cannot seep through). In these areas, less water can soak into the ground replenishing ground water aquifers, and more water runs off into streams. Some land uses also divert or hold back surface water, making it unavailable for uses downstream.

Continued understanding of hydrologic patterns and functions can inform strategies for source water replenishment. Long-range planning that seeks to minimize impacts on the natural flow of water should be used as a tool to protect critical water sources. Low impact development has also been identified as one way to restore some pre-development hydrologic functions by allowing storm water to infiltrate into the ground, rather than run off into drainages.

Communities feel uninformed and underrepresented in water resource management and decision-making.

Water resource management has often been left to government, scientific researchers, and other "experts." As communities become more informed about water resources, they are calling for more information on sources, uses, and water resource health and for the ability to participate in managing their water resources.

As beneficiaries of the public trust and direct users of water resources, the public can and should have a significant role in understanding water resources and its management. But for this to occur, there must be opportunities for information exchange and participation in the decision-making process. Opportunities must exist for government to share water resource and user data and to receive information on uses, users, needs, and observations from those who are affected by management decisions. At the same time, the public also needs to be receptive to the decision-making process, to the multiple demands that must be weighed, the tradeoffs that must be made, and to legal obligations and judicial precedent.

The priorities and processes for enforcement of State Water Code violations need to be clear, proactive, and relevant.

Effective management of any resource requires clear, thoughtful guidance and timely and fair penalties for violations. Many violations go unchecked due to the sheer number of water sources and permits in existence throughout the state and the limited number of staff, none of which are dedicated solely to investigating and correcting violations. Additionally, penalties have been criticized as arbitrary and not fitting of the severity of the violation. Compliance with water management permits and policies, such as reporting of water use or constructing a well or diversion, could benefit from developing enforcement priorities and processes. Updates and refinements to the regulatory process, enforcement policy, and penalty system could also address these concerns.

Water resource issues are complex and require expertise and management by a diverse group of individuals and entities.

Water is a complex resource that touches many facets of daily life and each person in unique ways. While we continue to learn more about the science of water, we have even more to learn about the ecology and cultural and spiritual links of people to water. With water's importance to everyone and with so much to understand, it is necessary that many sources of knowledge and perspectives are accounted for. All levels of government need to partner with private entities, scholars, and communities to monitor the resource, bring forth information and perspectives, and to plan for the future.

Water does not exist in isolation. It cannot be managed in a vacuum, separate from what is going on around it. Therefore, water must be planned for in a holistic way, considering ecological needs and land uses, as well as human needs.

2.2 Current Knowledge of Water Resources and Available Management Tools

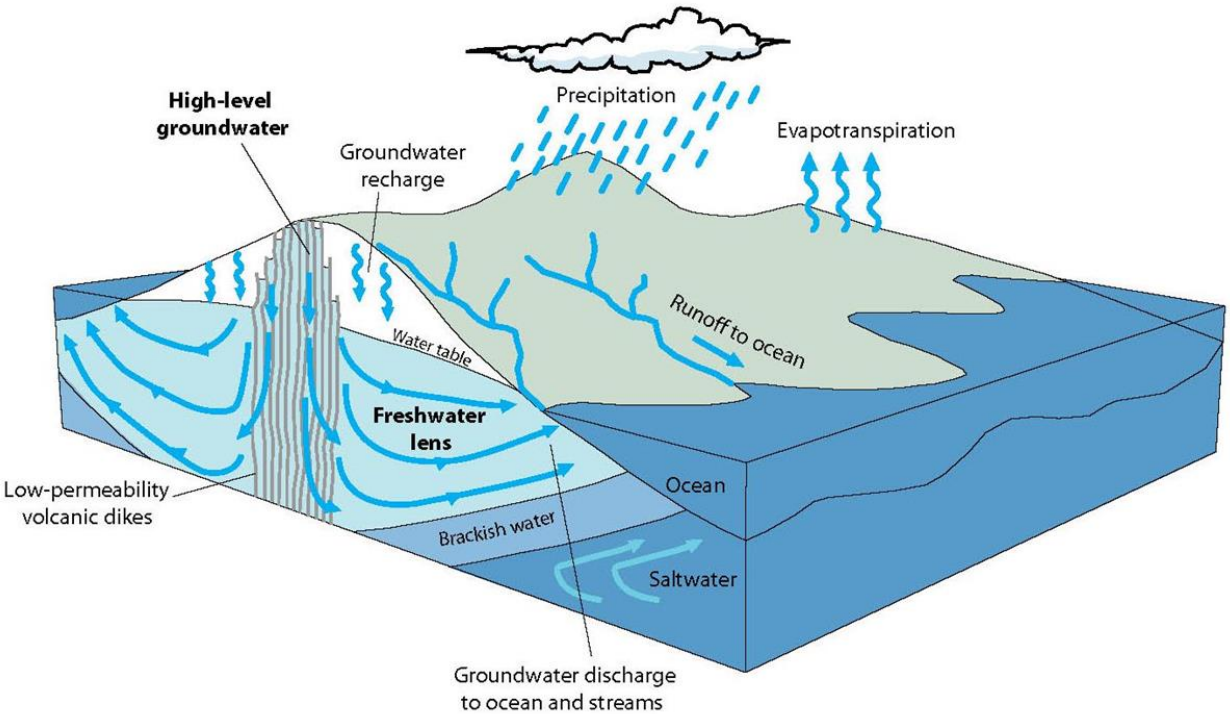
Water resources is a very complex subject in Hawaiʻi. This section summarizes major water resource management topics and related issues to provide readers a fundamental understanding of how CWRM assesses and analyzes data and information – and how these analyses inform the development of tools and implementation of programs to manage water resources across the State of Hawaiʻi. As part of this discussion, any program gaps, deficiencies, or issues are identified along with recommendations to address them.

The following sub-sections follow the order of the topical information contained in the appendices of the WRPP Update

2.2.1 The Hydrologic Cycle

The hydrologic cycle refers to the constant movement of water between the ocean, the atmosphere, and the Earth, and includes precipitation, infiltration and recharge, runoff, and evapotranspiration (**Figure 2-2**). **Evapotranspiration** is the loss of water from soils, canopy, and open water bodies through evaporation and the transfer of water from plants to the air through transpiration. Moisture in the air is carried by trade winds up mountain sides, where it cools and condenses, and finally falls to the land surface as **precipitation** (i.e., rain or fog drip). Plants immediately absorb and use some of the rain and fog drip, but the remaining volume of water **infiltrates** through the ground surface, **runs off** to the ocean or streams, **evaporates** into the atmosphere, or ends up **recharging** the ground water aquifers. Additional explanation of the hydrologic cycle may be found in **Appendix F**.

Figure 2-2 Hydrology of Ocean Islands



Source: USGS Pacific Islands Water Science Center (http://hi.water.usgs.gov/studies/GWRP/islhydro.html)

As rainwater wets the land surface, shallow infiltration saturates the uppermost soil layer and replaces soil moisture used by plants. Thereafter, excess water percolates slowly downward to recharge ground water bodies and support stream flow in perennial sections. However, human activities can alter infiltration and runoff patterns by changing the permeability of ground surfaces, thus encouraging or inhibiting infiltration of water into ground water aquifers.

Program Issues: To quantify and make accurate estimates of water availability, it is important to collect data and observations of individual hydrologic cycle processes over a long period of time. This includes observations of precipitation (rainfall), evapotranspiration, runoff (stream flows) and the ground water column.

Recommended Projects: Project 1.1, Project 1.2, and Project 1.4

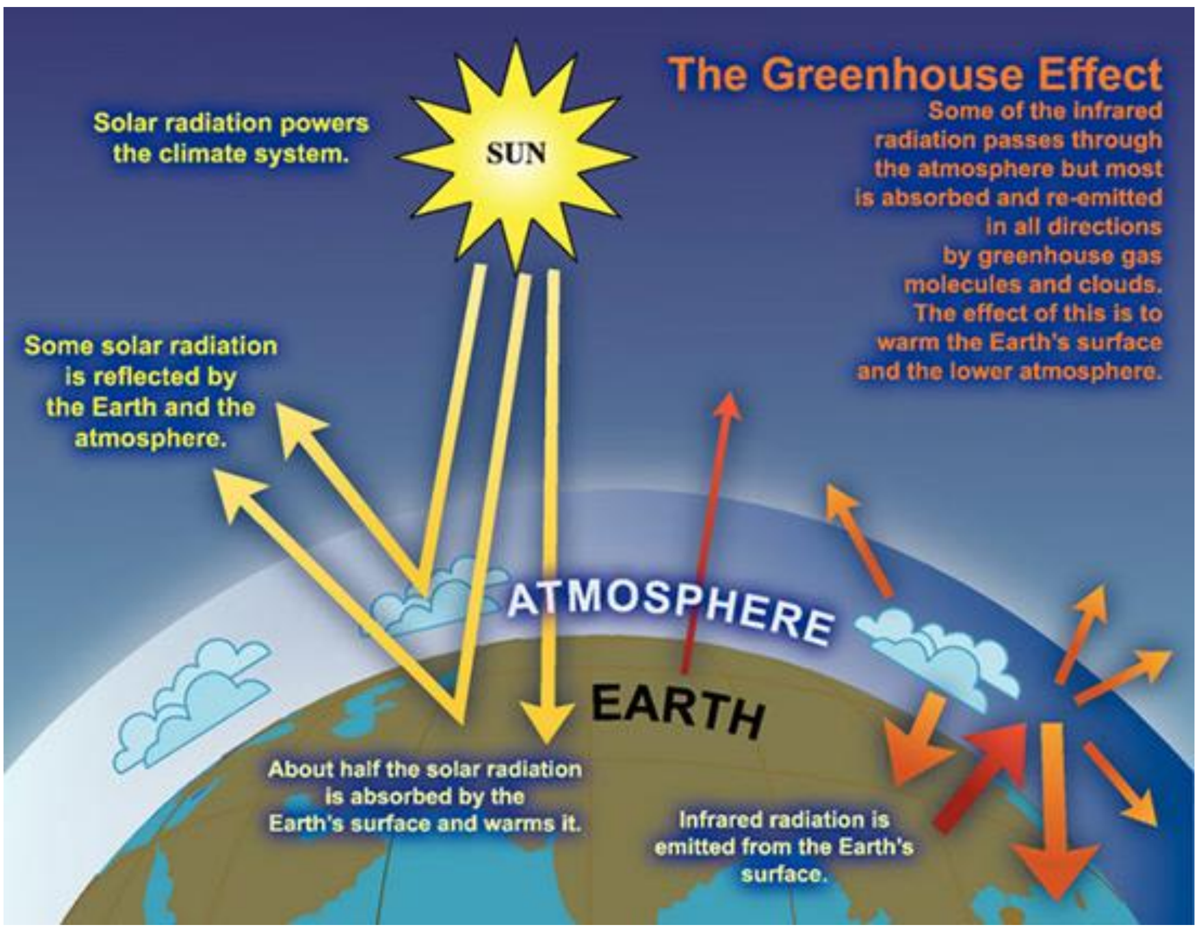
2.2.2 Climate Change

Climate change is "a change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity."

-United Nations Intergovernmental Panel on Climate Change (IPCC, 2007)

Greenhouse gases such as carbon dioxide (CO_2) absorb heat, or infrared radiation, from the Earth's surface, trapping heat in the atmosphere that would otherwise escape into space. While these gases occur naturally, the industrial age resulted in an increase in the burning of fossil fuels and deforestation, which increased their concentrations in the atmosphere. Results of greenhouse gas increases are warming of the Earth's oceans and air, changing precipitation patterns, melting snow cover and ice sheets, ocean acidification, and rising sea levels, which in turn lead to further impacts on natural processes.

Figure 2-3 An Idealized Model of the Natural Greenhouse Effect



Source: [Intergovernmental Panel on Climate Change, 2007, IPCC Fourth Assessment Report: Climate Change 2007. Ch.1]

Locally, Hawai'i has experienced changes in measured precipitation and stream flows[8] and is expected to also experience the following water-resource-related impacts from climate change:

- **Decrease/increase in potable water supplies across the region, changing frequency and intensity of climatic extremes.** Drought has been more frequent and prolonged, and there have been fewer tropical cyclones. Over the past century rainfall has decreased across the region. Average surface air temperatures are rising, especially at high altitudes. Ground water discharge to streams has significantly decreased over the past 100 years. This trend indicates a decrease in ground water storage[9]. However windward sides will become wetter during the wet season and leeward sides are expected to become drier in the dry season;[10]

- **Increase in potable and non-potable water demand** for municipal and agricultural uses may result from increases in air temperatures,[11] increases in evapotranspiration and longer and more frequent droughts;

- **Decrease in ground water discharge to streams** due to decreases in rainfall and decreases in fair weather flows from springs and seeps from high level aquifers;[12]

- **Impacts on water supply infrastructure** due to sea level rise and associated inland and coastal flooding, increasing corrosion of metallic pipelines resulting in more main breaks and higher repair and replacement costs;

- **Large increases in the costs of water supply infrastructure and flood mitigation measures** due to this complex array of climate change impacts on the water systems of Hawai'i.

Program Issues: It is important to establish and maintain long-term climate monitoring stations to track changes in Hawai'i's climate elements over time.

Recommended Projects: Project 1.1, Project 1.5

[8] University of Hawai'i at Mānoa Sea Grant College Program. June 2014 Climate Change Impacts in Hawai'i - A summary of climate change and its impacts to Hawai'i's ecosystems and communities
[9] Keener, et.al. (2012)
[10] USGS Open File Report 2016-1102
[11] Keener, et.al. (2012)
[12] Ibid

2.2.3 Inventory and Assessment of Resources

To meaningfully plan for and manage water resources, it is important to understand the inventory of water resources statewide; the human impact on those resources; and the issues, challenges, and opportunities for improving management and protection practices. Concerns related to water supply, water quality, and degradation of aquatic environments are frequently at the forefront of water management issues.

> *"Effective policies and management practices must be built on a foundation that recognizes that surface water and ground water are simply two manifestations of a single integrated resource."*
>
> - USGS Circular 1139: Ground Water and Surface Water: A Single Resource

A major issue with water resource management is balancing existing water needs with the availability of water for future generations and environmental needs. Over and above actual water withdrawals, other issues include environmental and safety concerns with the siting and maintenance of water infrastructure, such as reservoirs for storage.

The cumulative effects of land use changes, other human activities, and short- and long-term climate change can shift the natural balance of the hydrologic cycle, having profound social, environmental, and economic impacts within our island communities. CWRM has developed goals to guide sustainable water planning and management activities that seek to continually improve the understanding of water resources, collaborate with stakeholders and other water resource professionals, and apply updated information and best practices toward the management of water resources. Further description of CWRM's goals may be found in **Appendix C**.

Additionally, the interaction of ground water and surface water has been, and continues to be, a significant area of focus and deliberation. Most potable water is drawn from ground water aquifers, potentially having impacts on surface water and coastal leakage, the ecosystems dependent upon them, and associated traditional and customary rights. The interaction between ground and surface water also means that there is the potential for each to impact the water quality of the other. Despite this, typical management of water resources separates ground and surface water resources and the limited understanding of their localized interactions make it difficult to characterize actual processes. However, where interaction exists, monitoring and appropriate ground and surface water management programs are integrated and implemented. Further description of these issues may be found in **Appendix F: Inventory and Assessment of Water Resources**.

2.2.3.1 Nature and Occurrence of Ground Water

Ground water in Hawai‘i is stored in several different types of aquifers: basal, dike impounded, perched, caprock, brackish, deep confined freshwater. Descriptions of each type of aquifer may be found in **Appendix F: Inventory and Assessment of Resources**. Basal aquifers are the primary source for municipal water in Hawai‘i. There is a brackish transition zone where the freshwater basal lens meets seawater, with salinity gradually increasing with depth. The upward movement of this transition zone presents a constant potential danger of saline contamination to the freshwater aquifer. Interestingly, previous conceptual ground water models are being modified in response to recent discoveries of freshwater aquifers beneath the salt water underlying basal aquifers on Hawai‘i Island.

> "Aquifer - *a geologic formation(s) that is water bearing…Use of the term is usually restricted to those water-bearing formations capable of yielding water in sufficient quantity to constitute a usable supply for people's uses."*
>
> \- USGS Water Science Glossary of Terms
> http://ga.water.usgs.gov/edu/dictionary.html

CWRM established ground water hydrologic units, or aquifers, and assigned each one a unique code to provide a standard method by which to reference and describe ground water resources, facilitate consistent collection and sharing of information amongst diverse governmental and non-governmental entities, optimize ground water development, and implement resource protection measures. Aquifer boundary lines should be recognized as management lines and not strict hydrologic boundaries where ground water flow does not cross. There are 114 aquifers delineated across the islands of Kaua‘i, O‘ahu, Moloka‘i, Lāna‘i, Maui, and Hawai‘i. Tables of all units by island and accompanying maps of ground water hydrologic unit boundaries may be found in **Appendix F**.

The availability of ground water resources is dependent upon recharge, or the replenishment of fresh ground water, and ground and surface water interactions. However, ground water flow can be difficult to understand and predict because scientists must infer and interpolate its status and characteristics from limited data and modeling tools. CWRM, researchers, and others are constantly working to improve the understanding of ground water flow and the ability to assess the availability of ground water for human consumption.

The amount of ground water that can be developed in any aquifer is limited by the amount of natural recharge and aquifer outflow that must be maintained to prevent seawater intrusion, to maintain perennial streamflow, and to sustain the ecosystems dependent upon ground water discharge. CWRM first adopted **sustainable yield** estimates in the WRPP in 1990 and has revised them based on management approaches, new information and modeling techniques, and the identification of errors in previous models or studies. Explanations of how sustainable yields are estimated, as well as maps of hydrologic units and associated sustainable yields, may be found in **Appendix F**.

> *"'Sustainable yield' means the maximum rate at which water may be withdrawn from a water source without impairing the utility or quality of the water source as determined by the commission."*
>
> \- Hawai'i Revised Statutes §174C-3

2.2.3.2 Nature and Occurrence of Surface Water

Surface water generally occurs in areas that contribute to drainage systems that are confined by topographic divides and are referred to as **watersheds**, drainage basins, or catchments. Streams, springs, ditches and canals, and reservoirs are the most common surface water settings in Hawai'i. Descriptions of each type of surface water body may be found in **Appendix F: Inventory and Assessment of Resources**.

In 2005, CWRM adopted surface water hydrologic units to provide the same consistency and benefits provided by the establishment of ground water aquifers. There are 558 Surface Water Hydrologic Units statewide. Tables of all units by island and accompanying maps of surface water hydrologic units may be found in **Appendix F**.

> *"Instream flow standard means 'a quantity or flow of water or depth of water which is required to be present at a specific location in a stream system at certain specified times of the year to protect fishery, wildlife, recreational, aesthetic, scenic, and other beneficial instream uses.'"*
>
> \- Hawai'i Revised Statutes §174C-3

The State Water Code directs CWRM to "*establish instream flow standards on a stream-by-stream basis wherever necessary to protect the public interest in waters of the State*," and that "*in formulating the proposed standard, the commission shall weigh the importance of the present or potential uses of water from the stream for non-instream purposes, including the economic impact of restriction of such use*." CWRM developed a methodology for establishing measurable interim instream flow standards (interim IFS) based upon best available information, along with input from interested parties and agencies.

Interim instream flow standards are "*a temporary instream flow standard of immediate applicability, adopted by the Commission without the necessity of a public hearing, and terminating upon the establishment of an instream flow standard*." [13] Generally, the interim IFS for all streams in a given region were adopted by CWRM and defined as the "*amount of water flowing in each stream on the effective date of this standard, and as that flow may naturally vary throughout the year and from year to year without further amounts of water being diverted offstream through new or expanded diversions*."[14]

The interim IFS of certain individual streams have subsequently been amended as a direct result of petitions to amend the IFS, contested case hearings, other regulatory actions, and staff initiatives. Interim IFS may be amended by CWRM based on a petition and does not require a formal hearing process. On the other hand, an amendment to an Instream Flow Standard can only be initiated by CWRM. For a discussion of the regulatory process for setting instream flow standards, and references to specific actions amending the interim instream flow standard of specific streams, see **Appendix F**. An inventory of surface water resources, including surface water hydrologic unit codes, unit names, area, number of diversions, number of gages, number of active gages, and interim IFS may be found in **Table F-21 in Appendix F**.

Program Issues: Accurate and timely estimates of water availability require: (1) robust data sets; (2) careful analysis and study of the system; and (3) reports and results that are understandable and usable for resource managers and decision makers.

Recommended Projects: Project 1.2, Project 1.3, Project 1.4, Project 1.7, Project 1.8, Project 2.1

2.2.4 Monitoring of Water Resources

Continuous and consistent water data collection is critical to CWRM's ability to protect water resources. CWRM collects, analyzes, and verifies hydrologic data to provide an understanding of water within a particular area. Ground water data are used to observe empirical trends for changes in water levels, pumpage, salinity and the thickness of the transition zone, and to calibrate computer models that will refine conceptual models and sustainable yield estimates, and surface water data are used in the development of instream flow standards. Under the State Water Code, CWRM is primarily responsible for assessing the quantity issues of ground and surface water resources while the Department of Health (DOH) oversees ground and surface water quality issues with respect to public and environmental health. Please refer to **Appendix M: Water Quality** for more information about DOH programs and plans. CWRM's goals, policies, and objectives that guide and focus water resource monitoring programs and the use of resultant monitoring data may be found in **Appendix G: Monitoring of Water Resources**.

13 Hawaiʻi Revised Statutes §§ 174C-3.
14 Hawaiʻi Administrative Rules § 13-169-49.1

2.2.4.1 Monitoring of Ground Water Resources

Since ground water provides much of the municipal and drinking water supply statewide and demand for high-quality ground water continues to increase, long-term monitoring data is needed to identify emerging trends and problems, provide a basis for comparison, measure the impacts of water development, detect ground water threats, and determine the best management and corrective measures. On O‘ahu, CWRM, the USGS, and the Honolulu BWS have robust monitoring networks; however, monitoring networks in other counties are not as expansive and data is lacking in many areas.

Ground water monitoring activities in Hawai‘i include deep monitoring wells; water-level observation wells; spring discharge; conductivity; rainfall data; and data from well owners including pumpage, salinity (measured as chlorides or conductivity), water-level, and temperature data. Required, regular reporting by well owners is facilitated through the use of an online water use reporting database, the Water Resource Information Management System (WRIMS), which is able to provide reports on water use and other time-series data by aquifer system area, island, user, type of use (e.g., domestic, municipal, and agricultural), and other source information and documentation.

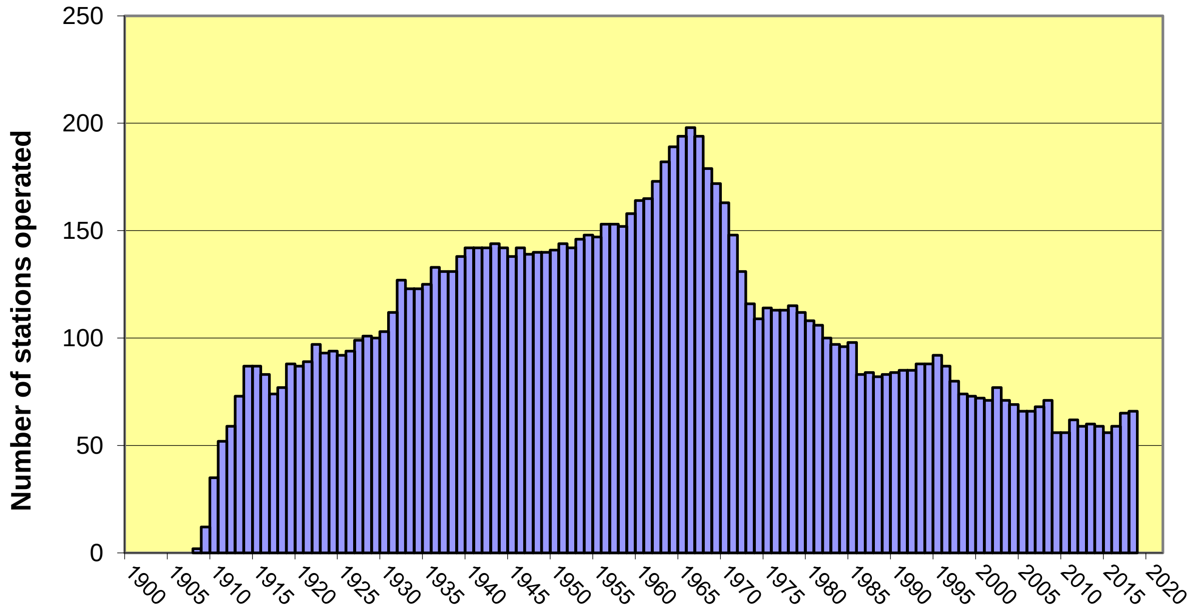
CWRM utilizes several tools to manage information on ground water including: a well index database, verifications of ground water well sources, a digital library of published Hawai‘i related hydrologic reports, and water use reports submitted by individual well owners or operators. These tools, as well as descriptions of monitoring programs, including a complete list of registered observation and deep monitor wells, and the identification of gaps in ground water monitoring activities and recommendations for improving the monitoring of ground water resources, are described in **Appendix G**.

2.2.4.2 Monitoring of Surface Water Resources

Similar to ground water resources, long-term monitoring information is critical to developing appropriate management strategies for surface water resources. Monitoring stream flow, along with appropriate climate and physical data, can provide valuable information on stream health and integrity. Important considerations for surface water monitoring include streamflow, rainfall, diversions, irrigation systems, end uses, biology, and water quality. Descriptions of each of these considerations are provided in **Appendix G**.

CWRM enters into cooperative agreements with the USGS to operate and maintain a statewide network of surface water gaging stations that gather stream, spring flow, water level, and rainfall data, which supports a wide range of statewide studies (e.g., flood analysis, water quality, ground/surface water interaction, biology, etc.). However, as plantation-supported gages were retired, the number of long-term gaging stations has decreased since its peak in 1966 when there were 197 continuous-record gages in the state. CWRM establishes surface water gaging stations in streams where IFS are established and where IFS establishment is anticipated.

Figure 2-4 History of USGS Continuous-Recording Stream Gage Operations



CWRM has a comprehensive information management system to track and maintain data for water use reports, stream channel alterations, and stream diversion works. This Surface Water Information Management (SWIM) System is integrated into CWRM's WRIMS and will facilitate the setting of IFS by helping CWRM to track and manage water use data, location and type of alterations to stream channels, and water use for various off-stream purposes, allowing CWRM to assess impacts upon instream uses and to develop appropriate management scenarios at the watershed level. Additionally, CWRM is working to verify and update diversion information and advance the water use reporting process. Descriptions of these management efforts, as well as an identification of gaps in surface water monitoring activities and recommendations for improving surface water monitoring, are described in **Appendix G**.

2.2.4.3 Rainfall Monitoring

Rainfall is the primary natural source of fresh water for streams, springs, and underground aquifers, and long-term rainfall data is important in analyzing the effects of climate changes; decadal and shorter-term atmospheric fluctuations, such as the Pacific Decadal Oscillation, El Niño, and La Niña events; and the effects of extreme weather events, such as floods and droughts, on water resources. Rainfall data has been collected in Hawaiʻi since the mid-1800s by sugar and pineapple plantations and ranches. There are currently several principal rainfall data collection networks in Hawaiʻi operated by the National Weather Service (NWS), USGS, University of Hawaiʻi, and private entities.

CWRM supported the Hawai‘i Rainfall Atlas project which enhances estimates of normal rainfall across the state. The locations of all the historic and active rain gages as of 2013, a description of the available rainfall data, gaps in rainfall data and analysis, and recommendations for rainfall monitoring may be found in **Appendix G**.

Rain gages provide much-needed monitoring of rainfall.

2.2.4.4 Cloud Water Interception and Fog Drip Monitoring Activities

Cloud water interception, or fog drip, is the direct interception of water, from clouds or fog, by vegetation. Some of this water makes its way into the ground. Fog drip is likely an important contribution to the hydrologic budget in Hawai‘i’s forested areas frequently enveloped in clouds, especially when there is little or no precipitation occurring. Although this subject has been studied to some degree in Hawai‘i and other locations around the world, there are still uncertainties as to what contributions cloud interception and fog drip make to the hydrologic cycle, and specifically to ground water recharge. Descriptions of fog drip monitoring programs, analyses, gaps, and recommendations for improvement may be found in **Appendix G**.

Cloud water monitoring.

2.2.4.5 Evaporation Data

Evaporation data was used extensively in Hawai‘i to assist in developing plantation irrigation practices. It is also an important tool in determining an area's hydrologic budget by contributing to estimates of **evapotranspiration** (the water evaporated from the soil and other surfaces combined with the transpiration from plants in a vegetated area). Very few pan evaporation stations remain now that the large plantations have shut down. Descriptions of evaporation monitoring programs, analyses, gaps, and recommendations for improvement may be found in **Appendix G**.

Program Issues: Hydrologic and climatic data collection networks must be sustained and expanded to maintain and improve water resource management in Hawai‘i.

Recommended Projects: Project 1.1, Project 1.2, Project 1.8

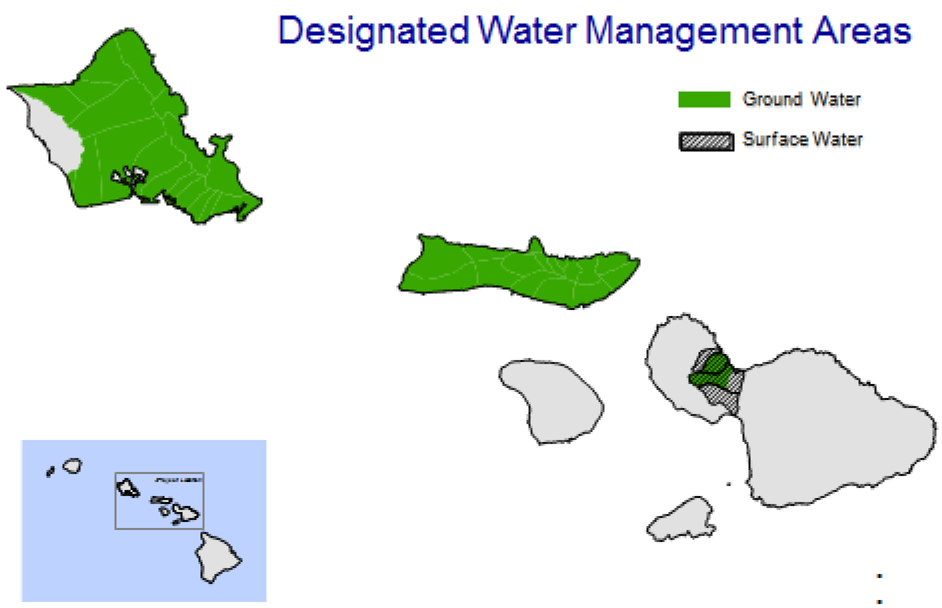
2.2.5 CWRM Regulatory Programs

CWRM uses regulatory controls to protect and conserve water resources, optimize water availability, protect public rights, and obtain maximum reasonable-beneficial uses. Permit systems are used to implement regulations concerning source development and water use. CWRM decisions on permit applications are guided by the Hawai‘i Water Plan, thus implementing the counties' long-range plans and policies regarding land and water use. The regulations also promote hydrologic data-gathering by requiring specific data to be collected and submitted to CWRM. In turn, this helps to assure informed decision-making in the future based on new and better information.

2.2.5.1 Designation of a Water Management Area

When the water resources of an area are determined to be threatened by existing or proposed withdrawals of water, CWRM shall designate the area as a water management area. This establishes greater administrative control over the withdrawals and diversions of ground and surface waters to ensure reasonable-beneficial use of the water resources in the public interest while protecting those resources. The State Water Code provides eight criteria for CWRM to consider in designating an area for regulation of ground water use (HRS §174C-44) and three criteria for surface water (HRS §174C-45) that are further discussed in **Appendix I**. **Figure 2-5** below shows the location of designated ground and surface water management areas.

Figure 2-5 Designated Water Management Areas



2.2.5.2 Regulatory Permits

There are five main types of permits regulated by CWRM: Water Use Permits, Well Construction Permits, Pump Installation Permits, Stream Channel Alteration Permits, and Stream Diversion Works Permits. These permits are described in **Table 2-2** below.

2.2.5.3 Penalties and Enforcement

CWRM has the authority to assess penalties for any violation of HRS Chapter 174C or HAR Title 13 for failure to comply with CWRM rules and orders, and for any violation of permit conditions.[15] To provide a logical and consistent means to assess penalties and guide the settlement of enforcement cases, CWRM adopted an Administrative and Civil Penalty Guideline with the objectives of deterring violations, removing the economic benefit of violations, providing fair treatment of the regulated community, and offering the violator a chance to undertake a beneficial alternative, under proper conditions, in a partial or total substitution of monetary fines (see **Appendix I**).

[15] HRS §174C-15 and HAR §13-167-10.

Table 2-2 Regulatory Permits

Regulatory Permit	Description
Water Use Permits (WUP)	Water Use Permits are required in designated ground and surface water management areas for both existing uses and prior to commencing any new water uses (HRS §174C-48). WUPs provide for the protection of public trust purposes and allow for maximum reasonable-beneficial use of water resources, while ensuring that the integrity of the resource is not threatened. CWRM is obligated to consider, protect, and advance public trust rights to the resource and make a presumption in their favor over other interests that seek water use permits.
Well Construction and Pump Installation Permits	Well Construction Permits are required statewide prior to the construction, modification, or decommissioning and sealing of any well that will explore for development, recharge (*injection wells are regulated by the State Department of Health's Underground Injection Control Program, environmental wells are regulated under the Department of Health's Underground Storage Tank and the Office of Hazard Evaluation and Emergency Response Programs, and geothermal wells are regulated by the Department of Land and Natural Resources' Engineering Division*), or permanently monitor ground water aquifers. Pump Installation Permits are required prior to the installation or replacement of well pumps (HRS §174C-84). Both permits are done in accordance with the Hawai'i Well Construction and Pump Installation Standards (HWCPIS).
Stream Channel Alteration Permits (SCAP)	Stream Channel Alteration Permits protect streams from alteration, whenever practicable, to provide for fishery, wildlife, recreational, aesthetic, scenic, and other beneficial instream uses. Generally, SCAPs are required for projects that are in the streambed itself or on the banks of the stream and are issued for all projects that alter a stream channel.
Stream Diversion Works Permit (SDWP)	Stream Diversion Works Permit are required for any structure placed within a stream for the purpose of diverting stream water. Any new stream diversion, or expansion of an existing stream diversion, may require a petition to amend the interim instream flow standard.

CWRM has prioritized enforcement of violations in water management areas and in response to complaints. CWRM staff plans to more rigorously enforce Water Code provisions and permit conditions, particularly the water use reporting requirement, with two newly-developed tools: (1) the online Water Resource Information Management System water use reporting system, and (2) DLNR's Civil Resource Violation System (CRVS),[16] which will be implemented to bring administrative enforcement actions for resource violations of a civil, rather than criminal, nature, especially minor, routine violation cases, such as failure to submit required monthly water use reports.

In addition to these enforcement tools, CWRM is also presently conducting outreach and education to facilitate voluntary compliance. One outreach effort focuses on agricultural irrigation system water use reporting to educate users in simple, yet reasonably accurate, methods for measuring diverted surface water flow, which will help to improve surface water use data collection and help agricultural operators to better manage their water use.

2.2.5.4 Complaints and Dispute Resolution

The State Water Code provides CWRM with the authority to process citizen complaints[17] and statewide jurisdiction to hear any dispute regarding water use, resource protection and management, water rights and competing uses, or other water issues, regardless of whether the area involved has been designated as a water management area.[18] Water quality complaints are referred to the DOH.[19] Complaints concerning flooding and flooding-related maintenance of stream banks are referred to the respective county authorities.[20] A person with standing may petition CWRM to establish a water management area or amend an interim instream flow standard.

2.2.5.5 Declaration of Water Shortage

The State Water Code (HRS §174C-62) mandates that CWRM formulate a plan to be implemented during periods of water shortage within a water management area. The water shortage plan must set forth provisions and guidelines for imposing use restrictions on different classes of permits as may be necessary to protect the resource. While CWRM has never moved toward the declaration of a water shortage in any part of the state, the Hawaiʻi Administrative Rules

> *"The commission, by rule, may declare a that a water shortage exists within all or part of an area when insufficient water is available to meet the requirements of the permit system or when conditions are such as to require a temporary reduction in total water use within the area to protect water resources from serious harm."*
>
> \- HRS §174C-62

16 HAR § 13-1, Subchapter 7
17 HRS §174C-13
18 HRS §174C-10
19 HAR §13-167-82
20 HRS §46-11.5

include provisions for emergency rulemaking that can be invoked if CWRM "finds that an imminent peril to public health, safety, or morals requires adoption, amendment, or repeal of a rule upon less than twenty days' notice of hearing."[21]

2.2.5.6 Declaration of Water Emergency

The State Water Code provides CWRM with emergency powers that can be exercised statewide during periods of water emergency, including non-water management areas and despite permitted water use allocations. Thus far, CWRM has never issued a water emergency declaration. CWRM has broad powers to order the "apportioning, rotating, limiting, or prohibiting the use of water resources" in any area if it declares an emergency condition.

Program Issues: Regulatory programs allow CWRM to manage the extent of water resource use and protection through permits and other means. These programs should be refined as needed to meet CWRM objectives as management priorities change. This could involve new or modified statutes, administrative rules, or regulatory programs.

Recommended Projects: Project 1.2, Project 2.3, Project 2.4, Project 2.7, Project 2.8

2.2.6 CWRM Water Use Reporting Program

CWRM collects information on existing water use and projected future water demand through the Water Use Reporting Program and the Water Use and Development Plan process in order to plan for and manage water resources. In particular, water use and demand data are used to foster comprehensive and sustainable resource planning for the development, use, protection, and conservation of water; facilitate integrated water and land use planning and policies; provide a regulatory and internal framework for efficient ground and surface water management; and promote coordination and collaboration among agencies, private entities, and communities.

> *"Any person making use of water from a well or stream diversion works… shall file a declaration of the person's use with the commission…and shall contain information including, but not limited to, the location of the water sources and all usage-related facts, or information within his knowledge or possession…the manner, purposes, and time in which the water source is being used and operated, the rate and volume of water being withdrawn or diverted therefrom, and the method or means of measuring and controlling the water taken or used."*
>
> - Hawaiʻi Administrative Rules, §13-168-5

[21] HAR §13-167-45.

2.2.6.1 CWRM Water Use Reporting Requirements

Operators of wells and stream diversion works are required to measure their water use and submit regular monthly reports of their use to CWRM, but salt water wells are exempt from the monthly reporting requirement and may instead report annually. Under the Hawaiʻi Well Construction and Pump Installation Standards (HWCPIS 2004), all well owners are required to install flowmeters to measure ground water withdrawals. To facilitate surface water use reporting, CWRM produced a handbook with guidelines for appropriate devices and means of measuring water use that would not be unduly burdensome on water users.[22] Additionally, in 2012, CWRM's Water Resource Management Information System went live, allowing water users to file their reports on-line and monitor their historical use from each source via the internet. This new tool was developed to facilitate reporting by water users and to enable CWRM staff to more efficiently enforce compliance with the reporting requirement. See **Appendix G** for a more detailed discussion of WRIMS and the online reporting features.

2.2.6.2 Water Use Reporting for Ground Water Sources

Table 2-3 below summarizes reported total ground water use during the calendar year of 2016 by ground water use category. Based on reported water use, Oʻahu uses the most ground water, withdrawing over 177 MGD, primarily for municipal purposes. Municipal uses account for about 56% of total reported water use statewide. This is partly a reflection of the high reporting compliance rate of the municipalities, relative to other ground water users. Statewide, total reported ground water use exceeds 395 MGD.

Table 2-3 Summary of 2016 Reported Ground Water Use

	Use Category (MGD)						Island
Island	**Agriculture**	**Domestic**	**Industrial**	**Irrigation**	**Military**	**Municipal**	**Total**
Kauaʻi	9.17	0.02	0.18	0.30	0.25	13.13	23.06
Oʻahu	9.32	3.00	1.72	4.81	21.22	137.78	177.85
Molokaʻi	0.43	0.00	0.00	0.04	0.00	2.00	2.47
Lānaʻi	0.00	0.00	0.00	0.70	0.00	1.08	1.78
Maui	14.57	0.03	35.96	5.01	0.00	27.83	83.39
Hawaiʻi	0.68	0.06	49.18	16.08	0.00	41.42	107.41
Use Total	**34.16**	**3.11**	**87.03**	**26.94**	**21.48**	**223.23**	**395.96**

Notes: Includes all fresh ground water sources, excluding wells categorized as "other," saltwater, and caprock sources.

This analysis does not include DHHL ground water reservations

[22] Commission on Water Resource Management. (2009). Stream Diversion Measurement Methods. Honolulu, HI. Prepared by Element Environmental LLC.

2.2.6.3 Water Use Reporting for Surface Water Sources

The number of reporters of large irrigation systems continues to increase. CWRM staff are continuing to improve the accessibility and ease of water use reporting so that more surface water use data can be collected.
Table 2-4 summarizes reported surface water use as of December 2016, by island.

CWRM stores and manages surface water data in WRIMS. At the same time, CWRM is continuing to work with landowners and system operators statewide to get more surface water gaging and water use reporting data into its information management system.[23] To facilitate this, CWRM compiled a handbook to inform users of the various types of methods that are available. Additionally, CWRM contracted with the USGS to conduct on-site training workshops statewide for measuring water flow and reporting water use for large-scale stream diversion ditch systems to aid current ditch operators and owners in meeting the mandate for surface water use reporting. CWRM continues to work closely with diversion works owners both with reporting water use date and installing of gaging equipment.

Table 2-4 Summary of Reported Surface Water Use (2016)

Island	Total (MGD)[1]
Kauaʻi	186.907
Oʻahu	13.811
Molokaʻi	0.000
Lānaʻi	0.000
Maui[2]	117.508
Hawaiʻi	56.340

1 Total of computed 12-month moving average for January 1, 2016 to December 31, 2016.
2 Includes Wailuku Water Company and Launiupoko Water Company

Stream diversion works declared in the 1990 registration process were not completely field verified. CWRM continues to regularly work with stream diversion works owners, update its stream diversion records, and expand water use reporting.

Program Issues: CWRM must continue to improve its collection of water use reports through a combination of outreach, training, and enforcement actions.

Recommended Projects: Project 1.2, Project 1.4

[23] Commission on Water Resource Management. (2009). Stream Diversion Measurement Methods. Honolulu, HI. Prepared by Element Environmental LLC.

2.2.7 Assessing Existing Water Demands

Existing water demands are recorded and archived to varying degrees by several entities statewide. CWRM relies on reported water use data to quantify both ground water and surface water demands and uses a twelve-month moving average to assess water use.

2.2.7.1 CWRM Assessment of Existing Ground Water Demands

As discussed in **Appendix H: Existing and Future Demands**, when actual ground water withdrawals or authorized planned uses may cause the maximum rate of withdrawal to exceed 90% of the aquifer's sustainable yield, CWRM may designate the area as a water management area and regulate water use through the issuance of water use permits. Once an area has been designated, CWRM continues to monitor water use for compliance with allocation limits.

Table 2-5 indicates water availability by summarizing existing water demands in relation to the aquifer system area sustainable yields for each of six major Hawai‘i Islands. Water use is based on reported pumpage as of December 31, 2016 unless otherwise noted. Because caprock and salt water withdrawals do not count against aquifer sustainable yields, water withdrawn from caprock and salt water sources are excluded from the tables. For the islands of O‘ahu and Moloka‘i, where most or all of the aquifer system areas have been designated as ground water management areas, a comparison of total allocations to sustainable yields is also presented.

Table 2-5 Existing Demands and Water Allocations by Island Compared to Sustainable Yield, December 2016

Island	Sustainable Yield (SY) (MGD)	Existing Permit Allocation (MGD)	Unallocated SY (MGD)	Existing Water Use[5] (12 MAV, MGD)	SY minus pumpage (MGD)	Existing Water Use as a Percent of SY
Kaua‘i[1]	328	N/A	N/A	26.009	301.991	7.9%
O‘ahu	393.5	292.351	101.149	177.84	215.66	45.2%
Maui[2]	357	N/A	N/A	86.89	270.11	24.3%
Moloka‘i	79	7.130	71.87	2.46	76.54	3.1%
Lāna‘i[3]	6	N/A	N/A	1.847	4.153	30.8%
Hawai‘i [4]	2,393	N/A	N/A	114.71	2278.29	4.8%
STATE-WIDE	**3,556.5**	**N/A**	**N/A**	**409.75**	**3,146.75**	**11.5%**

1 Kaua‘i aquifers are not designated ground water management areas; therefore withdrawals do not require water use permits.

2 Only the ‘Īao ASYA is a designated ground water management area; therefore withdrawals from the remaining ASYAs do not require water use permits.

3 Lāna‘i aquifers are not designated ground water management areas; therefore withdrawals do not require water use permits.

4 Hawai‘i island aquifers are not designated ground water management areas; therefore withdrawals do not require water use permits.

5 Includes DHHL ground water reservations

Table 2-5 shows that at an island-wide scale, total reported pumpage on all islands is within the sustainable yield, although O‘ahu and Maui have a few aquifer system areas where pumpage has exceeded sustainable yield. For more detailed information on aquifer SY, WUP allocations, and existing water use, please see **Appendix H: Existing and Future Demands**.

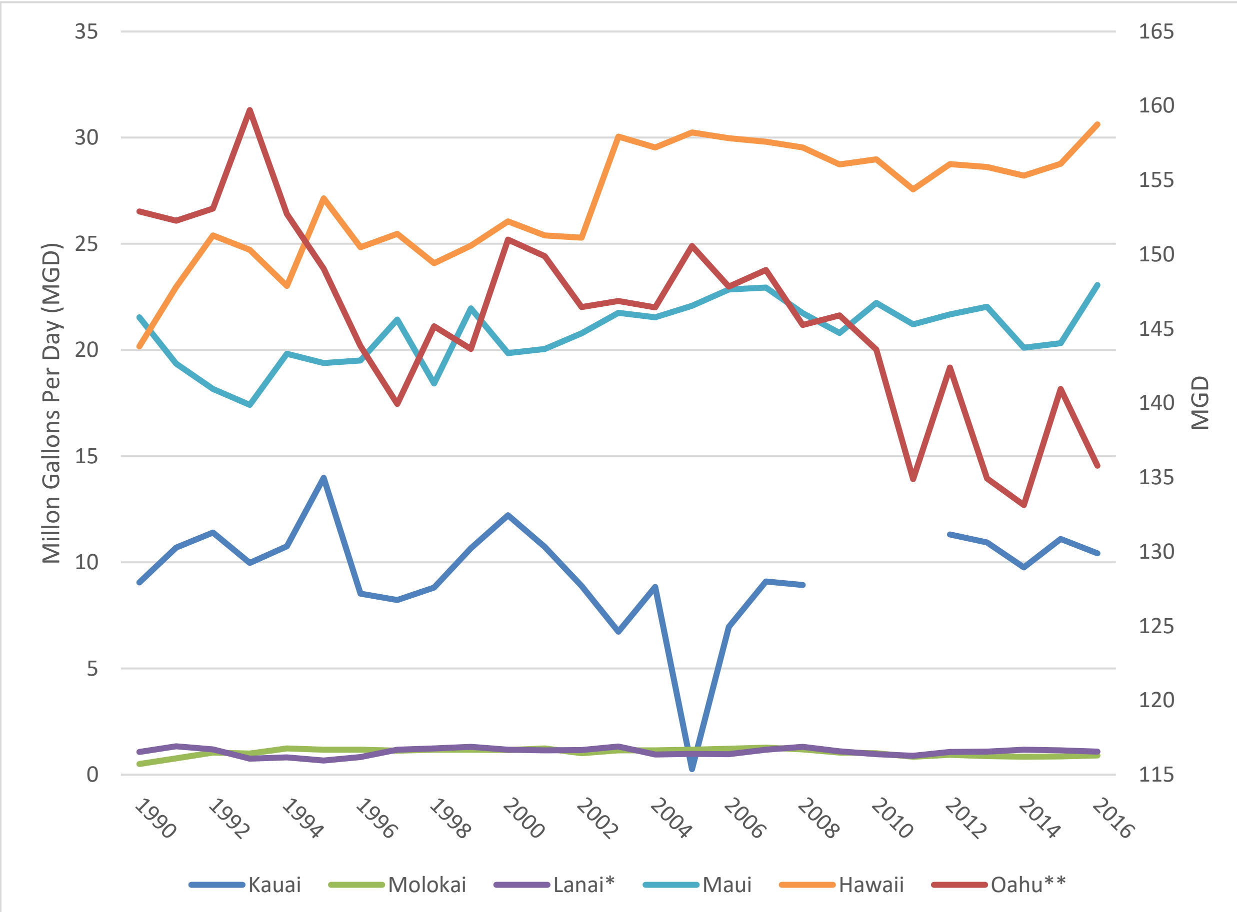
2.2.7.2 CWRM Assessment of Existing Surface Water Demands

CWRM staff is working to improve the understanding and collection of surface water use data with current resources. Efforts have been focused on the large legacy plantation irrigation systems. The current lack of understanding is due to past water use reporting exemptions, little information on stream diversions (field verification information), changes in water use by large-scale agricultural systems, and the difficulties associated with measuring diverted flow. A summary of the 1989 declared surface water use for each Surface Water Hydrologic Unit may be found in **Appendix N,** but it is mostly unverified. Thus, much of the information in **Appendix N** is only included in this document for reference purposes.

2.2.7.3 County Water Department Assessments of Existing Water Demands

With the exception of Lāna‘i, the county water departments provide the majority of the drinking water for each island. They also report their water use to CWRM in accordance with the requirements of the State Water Code. The table below summarizes their reported ground water use to CWRM from 1990 to 2016.

Figure 2-6 Reported County Municipal Water Use 1990-2016



* Data for Lāna‘i from Lāna‘i Water Company

**Data for O‘ahu is shown on right axis

The county water departments also provided municipal water use data to CWRM that characterizes existing water demands in terms of the agency's customer billing categories. This data in **Table 2-6** below represents existing water use only from county water systems and is intended to provide information on the relative distribution of demands across various use categories.

Table 2-6 2012 Water Use by County Water Departments (MGD)

County Water Department Customer Category	Kaua'i[1]	O'ahu[2]	Maui[3]	Hawai'i[4]
Agriculture	0.291	3.40	1.649	2.424
Domestic – Residential	7.326	73.41	21.055	15.206
Domestic – Non-Residential	2.818	34.33	8.14	6.598
Industrial	0.040	2.51	0.884	0.024
Irrigation	0.071	7.59	- - -	0.35
Military	0.020	2.87	- - -	- - -
Municipal	0.917	4.85	- - -	3.927
Other	- - -	0.03	- - -	- - -
Total	11.483	128.99	31.728	28.527

1 Consumption data for Fiscal Year 2011-2012. Source: Kaua'i Department of Water, November 22, 2013 Letter and January 9, 2104 Email.

2 Source: Honolulu Board of Water Supply, May 21, 2014 Email.

3 Source: Maui Department of Water Supply, November 26, 2013 Email.

4 Source: Hawai'i Department of Water Supply, December 13, 2013 Email.

In general, domestic residential water demand represents the highest use category for county municipal water systems, followed by domestic non-residential and agricultural and landscape irrigation. Municipal water demands also use a significant amount of water.

Program Issues: CWRM should continue to work with water use reporters, county water departments, and other large water users to improve water use reporting accuracy and to refine our understanding of water use and water availability.

Recommended Projects: Project 1.2 Project 1.4

2.2.8 Estimating Future Water Demands

The accuracy of future projections in water use over the long term is subject to many influences, including economic conditions, population growth, land use policies, and conservation practices. Several methods are used to derive water demand projections, including land use-based and population growth-based methods. These projections provide estimates over planning horizon increments of 5, 10, 15, or 20 years. Multiple growth scenarios are usually evaluated for each time increment to provide a range of projected demand. Demand projections can be refined using information contained in other State and county plans, information on federal and private water systems, and historical water use data.

2.2.8.1 Projected Future Department of Hawaiian Home Lands Water Demands

Department of Hawaiian Home Lands (DHHL) water needs are identified as a public trust purpose and are thus given high priority under the Hawaiʻi State Constitution and the Water Code. Please refer to **Appendix C: Legal Authorities and Guidance** for a discussion of DHHL's rights under the State Constitution, Water Code, and Section 221 of the Hawaiian Homes Commission Act.

As a State agency, the current and future water needs of DHHL are identified in the State Water Projects Plan (SWPP). In 2017, the SWPP was updated to reflect DHHL's potable and non-potable water needs, broken down by island, to 2031. These projected water demands may be found in **Appendix H: Existing and Future Water Demand**.

In order to ensure that DHHL's foreseeable future needs are provided for, CWRM has established water reservations by rule, pursuant to HRS §174C-49(d), in designated water management areas on Oʻahu and Molokaʻi, and by regular CWRM action in non-designated areas. These reservations are counted against available sustainable yields and may not be used by other parties. The existing water needs and future demands of DHHL protected through water reservations, as well as those identified in the SWPP, must be incorporated and recognized in the components of the Hawaiʻi Water Plan. Additional reservations for DHHL are planned based on the 2017 SWPP future demands.

Table 2-7 Current DHHL Water Reservations

Island	Hydrologic Unit	Quantity of Water Reserved (MGD)	Effective Date
O‘ahu	**Waipahu-Waiawa**	1.358[24]	February 18, 1994
O‘ahu	**Waimānalo**	0.124[25]	February 18, 1994
Moloka‘i	**Kualapu‘u**	2.905[26]	June 10, 1995
Hawai‘i	**Keauhou**	3.398	August 17, 2015
Kaua‘i	**Waimea River**	6.903	June 20, 2017
Kaua‘i	**Wailua**	0.708	September 18, 2018
Kaua‘i	**Anahola**	1.470	September 18, 2018
Kaua‘i	**Kekaha**	0.336	September 18, 2018
Kaua‘i	**Makaweli**	0.405	September 18, 2018
Lāna‘i	**Leeward**	0.067	September 18, 2018
Maui	**Honokōwai**	0.770	September 18, 2018
Maui	**Kama‘ole**	2.547	September 18, 2018
Maui	**Ke‘anae**	0.003	September 18, 2018
Maui	**Kawaipapa**	0.118	September 18, 2018
Maui	**Luala‘ilua**	0.063	September 18, 2018
Hawai‘i	**Hāwī**	0.148	September 18, 2018
Hawai‘i	**Māhukona**	3.014	September 18, 2018
Hawai‘i	**Honoka‘a**	0.396	September 18, 2018
Hawai‘i	**Hakalau**	0.083	September 18, 2018
Hawai‘i	**Onomea**	0.250	September 18, 2018
Hawai‘i	**Hilo**	0.492	September 18, 2018
Hawai‘i	**Kea‘au**	1.336	September 18, 2018
Hawai‘i	**‘Ōla‘a**	0.025	September 18, 2018
Hawai‘i	**Nā‘ālehu**	0.185	September 18, 2018
Hawai‘i	**Pāhoa**	0.660	September 18, 2018

2.2.8.2 Projected Future County Water Demands

According to county water agency projections, by the year 2035, water demands will approach 268 MGD statewide. This translates to an approximate 12% increase in demand from year 2020 to year 2035. Table 2-8 summarizes the water demands projected by the county water agencies through 2035. **Appendix H** also provides a breakdown by water demand categories or billing classes (as designated by the water departments), which is useful in comparing demands associated with potable and non-potable water uses. Demand forecasts were prepared independently by each county; therefore, assumptions and forecast methods vary.

[24] HAR 13-171-61 reserves 1.724 MGD, of which 0.366 MGD has been converted to water use permits.
[25] HAR 13-171-62
[26] HAR 13-171-63

Table 2-8 Projected Water Demand for All Counties, 2020 to 2035 (MGD)

County	2020	2025	2030	2035
Kaua'i[1]	17.795	18.744	19.696	20.526[6]
Honolulu[2]	144.8	144.3	147.2	150
Maui[3] **(DWS system – includes Maui & Moloka'i)** **Lāna'i (private system)** [4]	39.945	42.913	45.856	48.808[6]
Hawai'i[5]	36.941	40.786	45.031	49.718
Total	**239.481**	**246.743**	**257.783**	**268.852**

1 Source: Kaua'i Department of Water, November 22, 2013 Letter.
2 Source: Honolulu Board of Water Supply, June 20, 2018 Email.
3 Source: Maui Department of Water Supply, January 7, 2014 Email.
4 Lāna'i water demand information was not available at the time of this writing.
5 Source: Hawai'i Department of Water Supply, December 13, 2013 Email
6 Data interpolated from county demand projections from 2015 to 2030.

2.2.8.3 Water Planning at the County Level

The State Water Code requires each county to prepare and regularly update its County Water Use and Development Plan (WUDP) to address future water demands and to set forth the "allocation of water to land use in that county."[27] County WUDPs (1) assess existing and future land uses and associated municipal water demands; (2) incorporate agriculture, military, private, State, and other non-municipal water demand projections; and (3) evaluate the cost and adequacy of proposed development plans and identify preferred and alternative water development strategies to meet projected demands. It is adopted by CWRM and integrates all other Hawai'i Water Plan components, as emphasized through the adoption of the WUDP as County ordinances. Requirements, recommendations, and guidance for preparing the County WUDPs are found in the State Water Code and the Statewide Framework for Updating the Hawai'i Water Plan, and are summarized in **Appendix H.**

The status of each of the County updates are shown in **Table 2-9**. A summary of the findings of each WUDP, in terms of existing and future water demands, resource options and strategies, and the implications for natural supplies, may be found in **Appendix H**.

[27] HRS §174C-31

Table 2-9 Status of County Water Use and Development Plans

County, Island or District	Current WUDP Adoption Date	Status of WUDP Update	Strategies to Meet Future Water Needs
Kauaʻi	February 1990	In progress	
Oʻahu			
Central Oʻahu	March 1990	In progress	
East Honolulu	March 1990	In progress	
ʻEwa	March 1990	In progress	
Koʻolau Loa	March 2011	Current	• Ground water development • Water reuse expansion • Conservation
Koʻolau Poko	September 2012	Current	• Ground water development • Water reuse expansion • Surface water for kalo expansion • Conservation
North Shore	December 2016	Current	• Current supplies sufficient
Primary Urban Center	March 1990	In progress	
Waiʻanae	March 2011	Current	• Decrease ground water development • Increase import from Pearl Harbor ASYA • Conservation
Maui			
Maui	March 1990	In progress	
Molokaʻi	March 1990	Awaiting completion of Maui Island WUDP update	
Lānaʻi	August 2012	Current	• Ground water development • Water reuse expansion • Desalination • Conservation
Hawaiʻi	December 2011	Current	• Extend ground water system service areas • Water transfers • Alternative source development • Demand-side management
Keauhou		In progress	

Program Issues: CWRM should continue to work with the counties and others who prepare the Hawaiʻi Water Plan components to refine estimates of future water use. CWRM should also continue to encourage coordination between land-use and water planners.

Recommended Projects: Project 2.3, Project 3.1.

2.2.9 Resource Conservation and Augmentation

As an island state, Hawaiʻi has limited access to natural fresh water supplies. Competition for fresh water, increasing population and development pressures, the rising awareness of environmental and cultural water needs, and the impacts of global climate change require that Hawaiʻi become as efficient as possible in its uses of limited fresh water supplies, and plan for natural water resource alternatives. In fact, some areas of the State of Hawaiʻi are approaching the limits of water resource development: nearly all of Oʻahu and Molokaʻi, and part of Maui have been designated as ground water management areas, where ground water use and development is regulated by CWRM. Additionally, North Central Maui (Nā Wai ʻEhā) has been designated as a surface water management area, having similar regulations.

The State Water Code mandates that CWRM plan for and coordinate conservation and augmentation programs in cooperation with other federal, State, and county agencies, and private and public entities created for the utilization and conservation of water.[28] CWRM is moving forward in providing leadership and guidance for the establishment, development, and implementation of statewide water conservation and augmentation programs.

2.2.9.1 Water Conservation Programs

CWRM serves as a coordinator, funding source, and clearing house for information on water conservation. It also offers technical assistance and leads by example, but because CWRM is not a water purveyor, it cannot directly implement water efficiency programs. CWRM depends on water purveyors and users in Hawaiʻi to participate in and implement the measures outlined in its water conservation plans. State and county agencies and private businesses and organizations have incorporated varying degrees of water conservation within their operations. CWRM water conservation plans and programs are in **Table 2-10** below.

[28] HRS §174C-5(12) and §174C-31(d)(4)

Table 2-10 CWRM Water Conservation Plans and Programs

Program/Report	Purpose
Hawaiʻi Water Conservation Plan (CWRM, February 2013) http://files.Hawai'i .gov/dlnr/cwrm/planning/hwcp2013.pdf	Coordinate various state agencies' and muncipalities' individual water conservation programs and provide for collaboration toward a common goal.
Prototype Water Conservation Plan for the Department of Land and Natural Resources (CWRM, February 2005) http://files.Hawai'i .gov/dlnr/cwrm/planning/pwcp2005.pdf	Provide a framework for water conservation plans for all State agencies, and conservation program options and strategies for water purveyors throughout Hawaiʻi.
Conservation Manual for State of Hawaiʻi Facilities (CWRM, May 2007) http://files.Hawai'i .gov/dlnr/cwrm/planning/wcmshf2007.pdf	Facilitate State agency implementation of water conservation programs.
Water Loss Audit Program (2016)	Establishes a water loss audit program for public water systems, including technical assistance. Annual validated audits are required by affected systems.
Water Security Grant Program (2016)	Establishes a two-year pilot program to enable public-private partnerships that increase water security.

In general, the counties practice conservation by reducing system leaks and losses, adopting universal metering, customer water conservation programs, public education programs, adjusting water rates to influence demand, and as a last resort, rationing water use during severe shortages as provided by county rules and ordinances. Counties also practice conservation by protecting watershed areas to realize dependable yields. Each of the counties have independently undertaken water conservation programs and strategies, summarized in **Appendix J: Resource Conservation and Augmentation**.

2.2.9.2 Water-Energy Nexus

In modern society, water is used to produce energy and energy is used to develop and deliver drinking water and to treat wastewater. This water-energy connection is referred to as the water-energy nexus. While water in Hawaiʻi is relatively inexpensive, energy is not. The substantial amount of energy used by water and wastewater utilities and the volume of water used for energy production presents opportunities for utilities to find ways for conserving both water and energy by improving efficiencies in their production and delivery processes. High energy prices in Hawaiʻi provide powerful incentives to improve water efficiency. Water and wastewater utilities should conduct energy and water audits to inform their decision making.

CWRM's 2016 **Hawaiʻi Water Energy Nexus Report** found that utilities and agencies often pursue water conservation programs independently with dispersed results, and that greater collaboration between utilities and government agencies is necessary to develop effective and mutually beneficial conservation initiatives and programs, including partnerships and collaboration between energy and water utilities. There are very few programs targeting combined water-energy conservation in Hawaiʻi. For a short description of the known programs, please refer to **Appendix J**.

2.2.9.3 Developing a Resource Augmentation Program

Resource augmentation, including rainwater/stormwater capture, wastewater reclamation and reuse, and desalination of brackish water and seawater, should also be embraced as an important component of sustainable water resource management. In general, alternative water supplies should be renewable, drought resistant, environmentally sound, and socially responsible. Several county water and wastewater agencies employ reclamation techniques to process surface water and wastewater. However, there is no statewide water resource augmentation program.

It is the State's policy to encourage the development and maximum beneficial use of alternative water resources to augment the water development programs of each county. The State is providing leadership and guidance to counties and private water purveyors in the form of goals and priorities established through an integrated resource augmentation program that ensures that the pursuit and development of alternative-water sources is executed in an efficient and sensible manner, and encourages cooperation, development of implementation incentives, and innovative thinking among State, county, and private entities.

Existing CWRM programs that promote the use of alternative sources include water use regulation, instream flow standard assessment, and long-range planning. In designated water management areas, applicants for water use permits must show that no alternative water sources are available to meet their needs. If an alternative source is available, CWRM will deny requests for use of public trust resources in favor of the available alternative. In setting instream flow standards, the Water Code directs CWRM to consider alternative sources, and other physical solutions, to minimize the impacts of streamflow restoration on existing uses.[29] Finally, CWRM's Statewide Framework for Updating the Hawaiʻi Water Plan[30] advocates the use of an integrated resource planning (IRP) approach, a comprehensive form of planning that considers direct and indirect costs and benefits of demand-side and supply-side management, in addition to supply augmentation, for updating the County Water Use and Development Plan components of the Hawaiʻi Water Plan.

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[29] HRS §174C-71(1)(E)
[30] Commission on Water Resource Management. (2000). *Statewide Framework for Updating the Hawaiʻi Water Plan*

2.2.9.4 Water Supply Augmentation

Current and anticipated demands for fresh water are outpacing conventional source development and will likely surpass the volumes of naturally occurring ground and surface water at some point. State and county governments must actively pursue alternative water supplies to sustain Hawaiʻi's growing population, meet the needs of industry, and help ensure the long-term viability of our ground water aquifers and watershed areas. Common alternative water supplies may be found in **Table 2-11**.

Table 2-11 Alternative Water Supplies

Alternative Water Supply	Potential Uses/Benefits
Gray Water Reuse Definition: wastewater discharged from showers and bathtubs; hand-washing lavatories; wastewater that has not contacted toilet waste; 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).[31]	• Landscape irrigation • Toilet and urinal flushing • Freshwater conservation • Increased environmental flows • Reduced wastewater flows • Reduced energy consumption • Landscape enhancement • Nutrient reuse • Ground water recharge
Wastewater Reclamation Definition: The treatment of wastewater such that it may be used for beneficial purposes	• Constructed wetlands • Ground water recharge • Irrigation • Recreational uses • Construction-related uses • Recharge of natural wetlands • In-stream flow restoration • Composting • Toilet and urinal flushing • Industrial uses • Aesthetic uses • Freshwater conservation • Increased environmental flows • Landscape enhancement • Nutrient reuse • Pollution reduction and prevention • Drought-proof supply

[31] Hawaiʻi Department of Health, June 22, 2009, Guidelines for the Reuse of Gray Water.

Table 2-11 Alternative Water Supplies (continued)

Alternative Water Supply	Potential Uses/Benefits
Stormwater Reclamation (i.e., Rainwater Harvesting) Definition: Runoff water from the impervious surfaces in cities and developed areas, such as streets, sidewalks, roofs, parking lots, and other areas where water cannot percolate into the subsoil.	• Domestic uses (washing bathing, drinking, toilet and urinal flushing, etc) • Ground water recharge • Irrigation • Construction-related uses • Industrial uses • Aesthetic uses (ponds and water features) • Freshwater conservation • Ground water recharge • Landscape enhancement • Pollution reduction and prevention • Erosion reduction • Flood control and containment • Clean Water Act compliance
Desalination Definition: removal of dissolved minerals, including but not limited to salt, from seawater, brackish ground water, or treated wastewater.	• Domestic use • Industrial uses • Freshwater conservation • Drought-proof supply

Note: Water conservation, through the implementation of effective demand- or supply-side measures, may also be viewed as a strategy to meet future water needs.

Major challenges related to successful resource augmentation include reliability, quality, efficiency and economics, technology, and environmental impacts. Further discussion and descriptions of resource augmentation methods, issues, constraints, reports/studies, and programs may be found in **Appendix J: Resource Conservation and Augmentation**.

Program Issues: CWRM should continue to promote water delivery and use efficiency, alternative water supplies where appropriate, and to facilitate planning and discussions among stakeholders who are interested in implementing these practices. Other regulatory agencies should also review their policies and programs to reduce barriers to alternative water supplies

Recommended Projects: Project 2.5, Project 2.6, Project 3.1, Project 3.2

2.2.10 Drought Planning

Drought is a persistent and extended period of below normal precipitation that induces a variety of adverse effects. Direct and indirect impacts of drought manifest as changes in the environment, economy, public health, and long-term water supply and may be exacerbated by climate change. Drought can lead to difficult decisions regarding the allocation of water, stringent water use limitations, water quality problems, and inadequate water supplies for fire suppression. CWRM has assumed the role of lead agency in the development of the State's drought program, which is described in **Appendix K: Drought Planning.**

> **Drought Response vs. Mitigation**
>
> **Drought Response:**
> Emergency actions that are implemented directly in response to drought conditions.
>
> **Drought Mitigation**
> Short- and long-term actions and/or programs that may be implemented prior to, during, and after drought events to reduce the degree of risk to human life, property, and the economy.

According to the U.S. Drought Monitor, Hawai‘i has frequently experienced severe drought conditions somewhere in the state since June 2008.[32] The 2012 Pacific Islands Regional Climate Assessment (PIRCA) shows a statewide increase in average air temperature from 1916-2006, a downward trend in rainfall since the beginning of the 20th century, and an even steeper negative rainfall trend since 1980 (**Figure 2-7**). The data also show a decrease in stream base-flow across the state since the early 1900s, which indicate a decrease in ground water recharge and storage, coinciding with the trend of decreasing rainfall. Furthermore, research projections of future rainfall in the Hawaiian Islands suggest that Hawai‘i should be prepared for a future with a warmer climate, diminishing rainfall, and declining stream base flows.

In recent years, planning has shifted from responding to drought impacts to proactively reducing its impacts before they occur. Federal legislation and the resultant State and county actions that have contributed to the development of Hawai‘i's drought program are listed in **Table 2-12**. Further discussion and descriptions of drought resources, as well as recommendations for drought planning, may be found in **Appendix K**.

[32] National Drought Mitigation Center, U.S. Drought Monitor, accessed February 28, 2014, http://droughtmonitor.unl.edu/MapsAndData/DataTables.aspx

Figure 2-7 Interannual and Interdecadal Rainfall Variations in the Hawaiian Islands[33]

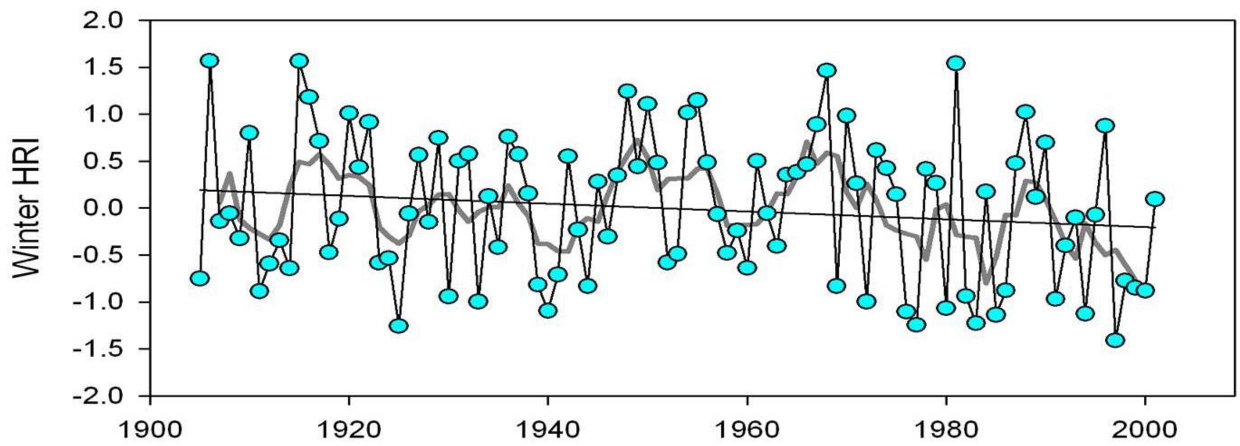

Table 2-12 Drought Planning-Related Federal Legislation and State and County Actions

Action	Need/Purpose
Federal Disaster Management Act of 2000 (FEMA)	Requires each state and territory to conduct hazard mitigation planning and to implement projects to reduce hazard impacts prior to a disaster occurrence
Hawai'i State Multi-Hazard Mitigation Plan (Hawai'i Emergency Management Agency, 2013)	Assesses risk and vulnerability to multiple hazards, reviews current mitigation actions and capabilities, and develops a mitigation strategy for each hazard including mitigation projects and actions. Required to receive public assistance subsequent to disasters, additional pre-disaster mitigation funds for state or local mitigation projects, and non-emergency assistance such as Public Assistance restoration of damaged facilities and Hazard Mitigation Grant Program funding.
County Hazard Mitigation Plans • Kaua'i (August 2015) • Honolulu (September 2017) • Hawai'i (October 2015) • Maui (October 2015)	Required for a county to be eligible for post-disaster federal funding. The counties prepare multi-hazard plans and have a five-year update cycle
Hawai'i Drought Plan (CWRM, 2017)	Develops coordinated emergency response mechanisms, while outlining steps toward mitigating the effects of future drought occurrences at a statewide level.

[33] Chu, P.-S., and Chen, H. 2005. Interannual and interdecadal rainfall variations in the Hawaiian Islands. Journal of Climate 18: 4796-4813.

Table 2-12 Drought Planning-Related Federal Legislation and State and County Actions (continued)

Action	Need/Purpose
Drought Risk and Vulnerability Assessment and Geographic Information System (GIS) Mapping Project (CWRM, 2003)	Illustrates the extent and severity of drought risk for different impact sectors throughout the islands and facilitates the development of drought response and mitigation strategies.
County Drought Mitigation Strategies	Coordinates government agency and stakeholder actions and identifies projects for integration within the *County Hazard Mitigation Plans*. Implementation of these projects is championed by County/Local Drought Committees.

Program Issues: CWRM should continue to coordinate drought mitigation and planning activities among impacted stakeholder sectors, conduct regular updates of the Hawai‘i Drought Plan and develop water shortage plans for priority water management areas.

Recommended Project: Project 2.8

2.2.11 Watershed Protection

The USGS simply defines a watershed as the divide separating one drainage basin from another.[34] However, healthy watersheds provide Hawai‘i communities with valuable water-related services such as flood mitigation, streamflow, healthy nearshore waters, and healthy ground water supplies. Watershed management seeks to maintain and restore the continuing functioning of these and other ecosystem services. CWRM's goals toward watershed protection encourage integrated efforts, good data, and collaboration across all levels of government, communities, and the private sector. Further discussion may be found in **Appendix L: Watershed Protection**.

"(DLNR) shall 'devise ways and means of protecting, extending, increasing, and utilizing the forests and forest reserves, more particularly for protecting and developing the springs, streams, and sources of water supply to increase and make that water supply available for use.'"

-Hawai‘i Revised Statutes § 183-31

[34] USGS Water Science Center http://water.usgs.gov/wsc/glossary.html#W

The State of Hawaiʻi has a long history of watershed protection and management programs, which were initiated to ensure a sustainable water supply. Additionally, many modern watershed protection and management programs have sprung from the requirements of the Clean Water Act of 1977, subsequent supporting legislation, a resurgence in Hawaiian culture, and a newfound appreciation for traditional land and water management principles. In the face of a changing climate, these programs and principles have become even more critical as a means to ensure the sustainability of clean and plentiful water resources for our island communities. Initiatives in Hawaiʻi that engage in and support watershed protection, include public/private Watershed Partnerships and the Hawaiʻi Association of Watershed Partnerships, various State DLNR Division of Forestry and Wildlife (DOFAW) watershed protection initiatives, Honolulu Board of Water Supply's watershed prioritization, the County of Maui Department of Water Supply's grant program, the Hawaiʻi Coastal Zone Management Program, the Department of Health water quality programs, and other State watershed protection programs. Additional information on each of these programs and initiatives may be found in **Appendix L: Watershed Protection**.

Although current watershed management efforts favor a comprehensive approach, watershed management in Hawaiʻi tends to have either a water quality (DOH, Environmental Protection Agency (EPA), and the Coastal Zone Management Program) or water quantity (Honolulu BWS, Maui DWS, the Watershed Partnerships, and DOFAW) improvement focus. The Natural Resources Conservation Service (NRCS) and the Soil and Water Conservation Districts address both water quality and quantity, and entities such as the State Office of Conservation and Coastal Lands (OCCL), the Land Use Commission (LUC), and U.S. Army Corps of Engineers (USACE) address water as part of a system, but do not have water resource protection as a main focus. Further discussion of watershed issues, programs, and recommendations may be found in **Appendix L**.

Fencing protects vegetation (left side of photo) from feral ungulates.

Program Issues: CWRM should continue to collaborate with watershed partnerships, county water departments, and large landowners to support watershed studies, protection and restoration.

Recommended Projects: Project 1.7, Project 3.2, Project 3.3

2.2.12 Water Quality

The State Water Code provides that the Department of Health shall have primary jurisdiction and responsibility for administration of the state's water quality control programs.[35] The *Hawaiʻi Administrative Rules, Title 11, Chapter 20, Rules Relating to Public Water Systems*, identifies the maximum contaminant levels for various chemicals, as well as other parameters for drinking water quality. Water quality standards for state waters are found under HAR §11-54. CWRM defers to DOH on most water quality related matters. DOH plans and strategies for ensuring water quality are listed below and described in **Appendix M: Water Quality**.

- **DOH Strategic Plan: The Five Foundations for Healthy Generations**

  Examines DOH's core environmental protection programs and discusses their history, organization, mission, goals, strategies, and performance measures, and sets forth targets to measure the effectiveness of programs in meeting community needs.

- **Environmental Health Management Report**

  Provides an overview of all of the activities of the Environmental Health Administration, not just those involved in water quality, and clarifies the environmental goals and objectives of the DOH.

- **Water Quality Plan (WQP)**

  The DOH is responsible for formulating and updating the State Water Quality Plan, a component of the Hawaiʻi Water Plan, for all existing and potential sources of drinking water.[36] The major objective of the WQP is to protect public health and ecological systems by preserving, protecting, restoring, and enhancing the quality of ground and surface waters throughout the State of Hawaiʻi.

The Safe Drinking Water, Clean Water and Wastewater programs provide input and guidance to the WQP. Major initiatives are listed below and described in **Appendix M**.

- Surface Water Quality Management Program
- Source Water Assessment and Protection Program
- Comprehensive State Groundwater Protection Program Strategy/Plan
- Underground Injection Control (UIC) Program
- Groundwater Contamination Maps
- Wastewater Recycling Program

Program Issues: CWRM should continue to work with DOH and other stakeholders to monitor, protect and improve water quality.

Recommended Projects: Project 2.2, Project 2.6, Project 2.7, Project 3.2

[35] HRS §174C-66
[36] HRS §174C-68 and HAR §13-170-50.

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3 Priority Recommendations and the Action Plan

3.1 Planning for the Future

CWRM underwent a multi-part process to identify issues and needs, projects and tasks to address those issues and needs, and priorities for near-term action. This section briefly describes that process.

3.1.1 Goals for the WRPP Update

From the information received through the stakeholder input process and the analysis of current water resource information and management tools, three broad goals were developed to focus the actions that would be put into a near-term Action Plan. Goals are ideal future end-states that reflect the values of a community or institution. The following goals will guide CWRM in its actions to further the protection and management of the water resources trust.

Goal 1: A solid and up-to-date foundation of data on Hawaiʻi water resources, water use, and water dynamics is used to make water resource management decisions.

Goal 2: Water resources, public trust uses, and water rights are protected and balanced against reasonable beneficial uses.

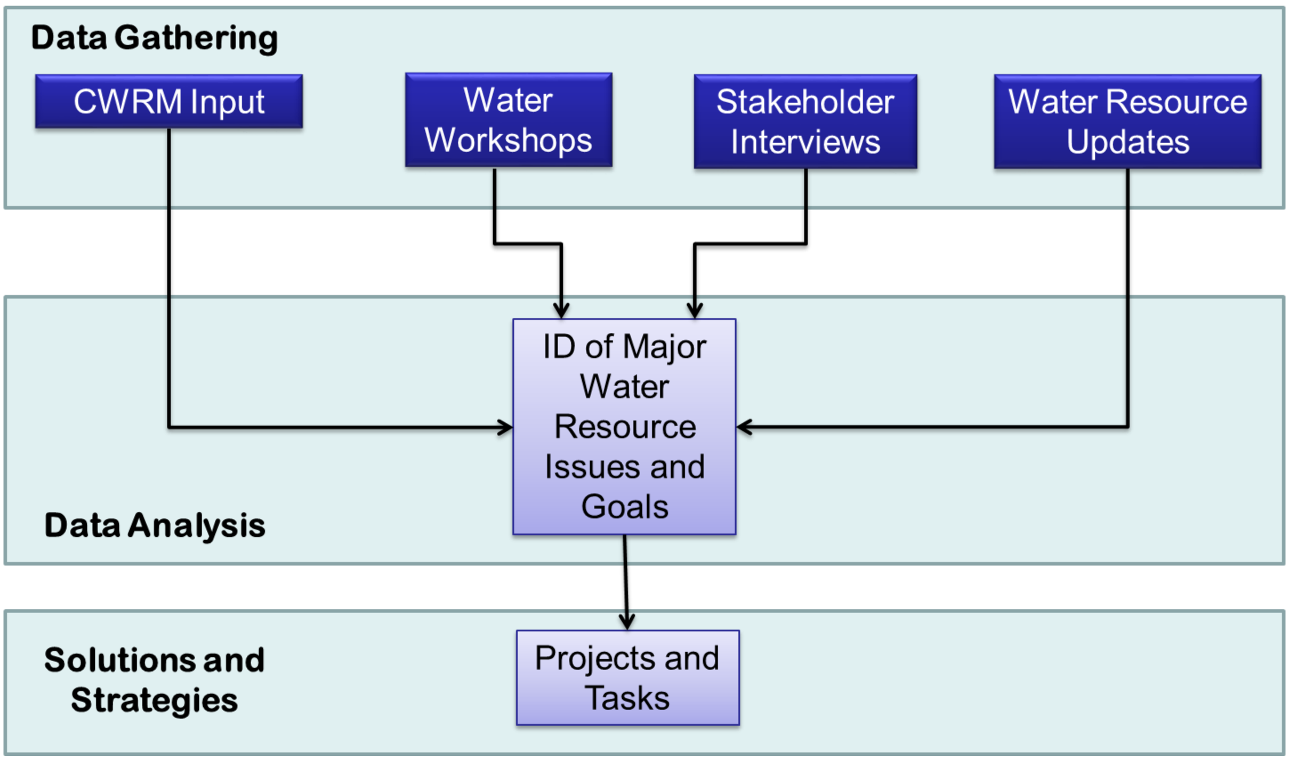
Goal 3: Partnerships, education, and awareness increase collaborative water resource management among government, private, and community entities and the citizens of Hawaiʻi.

3.1.2 Identification of Issues, Tasks, and Projects

This update of the WRPP began with a thorough evaluation of the implementation of the 2008 WRPP - what actions and programs were implemented, what issues or management needs remain outstanding, what new information was generated through monitoring or studies to better inform management going forward? The next step involved a series of meetings, interviews, and workshops to gather additional input. Initially, the input of CWRM staff was sought. This was followed by a series of interviews and small group meetings with stakeholders having a special interest in water resource management or use, such as federal, state, and county agencies; non-governmental organizations; cultural practitioners; large landowners; and professional hydrologists. CWRM then conducted a series of workshops statewide to gather input from the general public (see **Appendix E** for the stakeholder input process and summary). In addition, actions, directives and policies established by CWRM at its monthly meeting and decisions of the Supreme Court in its review of contested case hearing decisions were also compiled.

Through the update process, several hundred possible tasks were identified to address various issues. These tasks were then refined by CWRM and grouped into broader categories resulting in a total of 20 projects to achieve the three goals listed above. The following diagram outlines the planning process.

Figure 3-1 Process for Identifying WRPP Projects and Tasks



3.1.3 Prioritization of Projects and Tasks

Each of the 20 projects are included in an Action Plan, but tasks needed to be prioritized to provide guidance to CWRM on what to focus on in the near-term. In order to determine which tasks CWRM will actively seek to initiate and/or implement within the next five years, tasks were put through a two-tier prioritization process where they were scored against a set of seven prioritization criteria, listed below.

PRIORITIZATION CRITERIA

1. Task is a required service or product that, (a) is mandated by the State Water Code, Administrative Rule, or Court Decision; (b) impacts core foundational CWRM services or products; and/or (c) is depended on by other projects, programs, or services.
2. Task is in strategic alignment with CWRM's Vision, Mission, Goals, and Policies.
3. Task reduces or mitigates risk or negative impact on water resources and/or the public.
4. Task has value to the public.
5. Task addresses an existing or foreseeable conflict.
6. Task can be leveraged by other users or partners, adds value for external partners, increases positive collaborative efforts, or strengthens relationships with stakeholders.
7. Task costs can be shared among other government agencies, academic institutions, private individuals / entities, non-profit organizations, and / or community groups / individuals.

The 20 projects and respective priority tasks are the basis of this Action Plan. This ensures that all major issues identified during the research, update, and stakeholder outreach process were addressed in some fashion. Tasks that were not included in the near-term Action Plan are still considered important and are compiled in **Appendix O,** to be implemented as opportunities and funding sources arise.

3.2 Action Plan

Table 3-1 Table 3-1 lists those tasks that CWRM will seek to initiate or implement within the next five years as a part of its Action Plan. Included in the Action Plan table are the project title, lead CWRM Branch and partnering agency or entity, estimated cost range, and status to enable CWRM to track the progress and performance of its Action Plan. Tasks listed in the table are presented as they correspond to the three goals of CWRM and not necessarily how they ranked during the prioritization process. The cost ranges for each task are estimations of the cost for CWRM. Total project costs would be determined through detailed scoping and development of the activity.

The Action Plan Table shall be treated as a living document to allow CWRM to track the progress of meeting the goals identified in the Action Plan. The "Task Status" column will be populated with the information needed to determine the status, progress, and/or results for the corresponding task.

Table 3-1 Action Plan

	DESCRIPTION	LEAD CWRM BRANCH AND PARTNERS	COST RANGE	TASK STATUS**
GOAL 1:	**A solid and up-to-date foundation of data on Hawai‘i water resources, water use, and water dynamics is used to make water resource management decisions**			
Project 1.1	**Collect and analyze climatic data to determine trends in water resource health and anticipate future issues and problems.**			
Task 1.1.1	Identify the adequate level of hydrologic and climatic data collection needed statewide to enable effective decision-making about water security.	CWRM/ University of Hawai‘i (UH)/ USGS/ Counties	$155,000	In progress
Task 1.1.2	Develop implementation plan based on recommendations from Task 1.1.1	CWRM/ USGS/UH/ Counties	$100,000*	
Task 1.1.3	Coordinate climate data sharing by establishing a common data portal or shared public data resource.	Ike Wai CWRM/NWS/ USGS	Internal	In progress
Project 1.2	**Improve the reporting and analysis of ground and surface water use.**			
Task 1.2.1	Maintain and improve the ease of use and utility of CWRM's WRIMS database on a continuous basis.	CWRM	$375,000*	In progress
Task 1.2.2	Increase participation of stream diversion and well owners in online reporting through outreach, education, and ultimately, enforcement.	Ground Water/Stream Branches	$250,000/ Internal	In progress
Task 1.2.3	Develop standards for surface water use reporting to improve consistent reporting.	Stream Branch	Internal	In progress

*May require additional recurring costs for operation and maintenance

**This column will be populated as CWRM implements tasks listed with "in progress" or "completed"

Internal: CWRM staff will accomplish task with existing resources

Table 3-1 Action Plan (continued)

DESCRIPTION		LEAD CWRM BRANCH AND PARTNERS	COST RANGE	TASK STATUS**
Goal 1	**A solid and up-to-date foundation of data on Hawai‘i water resources, water use, and water dynamics is used to make water resource management decisions**			
Project 1.3	**Update estimates of aquifer sustainable yields with new and best information available using the 2008 precautionary approach.**			
Task 1.3.1	Improve recharge estimates to include the best available information on climate change impacts.	Ground Water Branch/USGS	$250,000	
Project 1.4	**Develop and implement a strategic surface water monitoring plan.**			
Task 1.4.1	Improve estimates of stream flow characteristics, particularly during low-flow conditions (USGS StreamStats).	Stream Branch	$1,500,000	In progress
Task 1.4.2	Verify diversion use and amounts for large/legacy irrigation systems	Stream Branch	Internal	In progress

*May require additional recurring costs for operation and maintenance

**This column will be populated as CWRM implements tasks listed with “in progress” or “completed”

Internal: CWRM staff will accomplish task with existing resources

Table 3-1 Action Plan (continued)

	DESCRIPTION	LEAD CWRM BRANCH AND PARTNERS	COST RANGE	TASK STATUS**
Goal 1	**A solid and up-to-date foundation of data on Hawai'i water resources, water use, and water dynamics is used to make water resource management decisions**			
Project 1.5	**Understand how climate change will impact water resources.**			
Task 1.5.1	Partner and coordinate with other entities who are researching the potential impacts of climate change.	Planning Branch	Internal	
Task 1.5.2	Integrate the best available information on the impacts of climate change on long-range water resources planning.	Planning Branch/Counties/DOA/DLNR/ DOH	Internal	
Task 1.5.3	Encourage long-range planning at the Federal/State/County levels to include climate change adaptation plans.	Planning Branch /Counties/ Federal	Internal	
Project 1.6	**Improve the understanding of appurtenant water rights.**			
Task 1.6.1	Develop an efficient process to determine and quantify appurtenant water rights to guide CWRM staff and the public.	CWRM	Internal	In progress
Task 1.6.2	Develop and implement a process to catalog and inventory appurtenant water rights. Incorporate known and anticipated appurtenant claims into instream flow standards and surface water permitting.	CWRM	$100,000	

*May require additional recurring costs for operation and maintenance

**This column will be populated as CWRM implements tasks listed with "in progress" or "completed"

Internal: CWRM staff will accomplish task with existing resources

Table 3-1 Action Plan (continued)

	DESCRIPTION	LEAD CWRM BRANCH AND PARTNERS	COST RANGE	TASK STATUS**
Goal 1	**A solid and up-to-date foundation of data on Hawai‘i water resources, water use, and water dynamics is used to make water resource management decisions**			
Project 1.7	**Understand the impacts of land use on hydrology, ecosystem function, and water resources needed for human consumption.**			
Task 1.7.1	Understand the impacts of native vs. nonnative plant species on water resources and watersheds by supporting research and long-term hydrologic monitoring programs.	CWRM/USGS/ UH/DLNR/ Counties	$100,000*	In progress
Task 1.7.2	Develop a pilot adaptive management plan for protecting ground water dependent ecosystems	CWRM/USGS/ UH/National Park Service (NPS)/ Cultural Practitioners	$175,000 *	In progress
Project 1.8	**Develop and implement a comprehensive statewide ground water monitoring plan.**			
Task 1.8.1	Construct new deep monitoring wells in critical aquifers to gather and utilize data to identify impacts from pumpage and climate and land use changes, verify fresh water sustainable yields, and monitor recharge trends.	Ground Water Branch	$5,000,000/ 1 Full-Time or Equivalent staff (FTE)	In progress
Task 1.8.2	Resurvey geodetic-control benchmarks in the State for deep monitor wells and water –level observation wells to ensure consistent and accurate water level measurements.	USGS	TBD	

*May require additional recurring costs for operation and maintenance

**This column will be populated as CWRM implements tasks listed with “in progress” or “completed”

Internal: CWRM staff will accomplish task with existing resources

Table 3-1 Action Plan (continued)

	DESCRIPTION	LEAD CWRM BRANCH AND PARTNERS	COST RANGE	TASK STATUS**
Goal 1	**A solid and up-to-date foundation of data on Hawai‘i water resources, water use, and water dynamics is used to make water resource management decisions**			
Project 1.9	**Establish Sustainable Funding sources.**			
Task 1.9.1	Increase permit fees to amounts sufficient to defray administrative costs of permit systems	CWRM	Internal	In progress
Task 1.9.2	Establish and implement water source registration fees for the purpose of supporting CWRM core activities and programs.	CWRM	1 FTE	
GOAL 2:	**Water resources, public trust uses, and water rights are protected and balanced against reasonable beneficial uses.**			
Project 2.1	**Manage instream and non-instream uses to provide for reasonable beneficial use while protecting public trust uses.**			
Task 2.1.1	Prioritize streams for developing measurable IFS.	Stream Branch	Internal	In progress
Task 2.1.2	Continue to develop measurable instream flow standards by reviewing instream needs and current non-instream uses.	Stream Branch	Internal	In progress
Task 2.1.3	Implement and enforce measurable instream flow standards.	Stream Branch	Internal	In progress

*May require additional recurring costs for operation and maintenance

**This column will be populated as CWRM implements tasks listed with “in progress” or “completed”

Internal: CWRM staff will accomplish task with existing resources

Table 3-1 Action Plan (continued)

DESCRIPTION		LEAD CWRM BRANCH AND PARTNERS	COST RANGE	TASK STATUS**
GOAL 2	**Water resources, public trust uses, and water rights are protected and balanced against reasonable beneficial uses.**			
Project 2.2	**Protect water quality from land use impacts.**			
Task 2.2.1	Implement source water protection programs.	DOH/Office of Planning/CZM/ Counties	TBD	
Task 2.2.2	Develop standards and guidelines for stormwater reclamation and reuse.	DOH/EPA	TBD	
Task 2.2.3	Address the impacts of leaking underground storage tanks on water quality.	DOH/EPA	TBD	
Task 2.2.4	Address impacts of byproducts of desalination process injected below the UIC line.	DOH/EPA	TBD	
Task 2.2.5	Develop guidelines and incentives for on-site water reclamation and reuse.	DOH/EPA/ Counties	TBD	

*May require additional recurring costs for operation and maintenance

**This column will be populated as CWRM implements tasks listed with “in progress” or “completed”

Internal: CWRM staff will accomplish task with existing resources

Table 3-1 Action Plan (continued)

	DESCRIPTION	LEAD CWRM BRANCH AND PARTNERS	COST RANGE	TASK STATUS**
GOAL 2	**Water resources, public trust uses, and water rights are protected and balanced against reasonable beneficial uses.**			
Project 2.3	**Provide clear guidance on criteria used to make water resource management decisions, including, but not limited to, the precautionary principle, the protection of public trust purposes, including traditional and customary practices, and economic considerations.**			
Task 2.3.1	Develop a process and policy for regulatory and planning purposes, for identifying the presence of traditional and customary practices in a particular area and the water needs associated with those practices.	CWRM/AMAC	Internal	In progress
Task 2.3.2	Continue to refine the application of the precautionary principle and public trust doctrine to water resource management.	CWRM	Internal	In progress
Task 2.3.3	Update model/methodology for estimating irrigation water demands to ensure the most efficient use of water.	Ground Water/ Stream Branches	$100,000	
Task 2.3.4	Establish additional water reservations for DHHL	Planning Branch	Internal	In progress

*May require additional recurring costs for operation and maintenance

**This column will be populated as CWRM implements tasks listed with “in progress” or “completed”

Internal: CWRM staff will accomplish task with existing resources

Table 3-1 Action Plan (continued)

	DESCRIPTION	LEAD CWRM BRANCH AND PARTNERS	COST RANGE	TASK STATUS**
GOAL 2	**Water resources, public trust uses, and water rights are protected and balanced against reasonable beneficial uses.**			
Project 2.4	**Update CWRM's policies on enforcement and penalties, and modernize and streamline the regulatory process.**			
Task 2.4.1	Develop formal enforcement policies.	Ground Water/ Stream Branches	Internal	
Task 2.4.2	Implement the Civil Resource Violation System already being utilized by other DLNR divisions.	Ground Water/ Stream Branches	Internal	
Task 2.4.3	Update CWRM's Administrative Rules to reflect updated penalties and streamline the regulatory process.	Ground Water /Stream Branches	Internal	In progress
Project 2.5	**Develop, update, and implement water conservation tools, techniques, and plans.**			
Task 2.5.1	Study how energy conservation can be used as an incentive for, and complement to, water conservation.	Planning Branch	$200,000	
Task 2.5.2	Conduct water audits of public water systems to verify use and aid water providers in identifying water losses.	Planning Branch/ DOH/EPA	$700,000 0.5 FTE	In progress
Task 2.5.3	Seek funding for a water conservation rebate program	Planning Branch	$500,000 0.5 FTE	
Project 2.6	**Plan for and provide guidance on the use of alternative water sources.**			
Task 2.6.1	Appraise opportunities for aquifer storage and recharge/recovery in Hawaiʻi.	Planning Branch/ DOH/Counties	$500,000	
Task 2.6.2	Inventory current and planned resource augmentation projects and efforts in the State.	Planning Branch/DOH	$300,000	
Task 2.6.3	Undertake a statewide stormwater recharge study	Planning Branch/ DOH/EPA/OP/ CZM/ Counties	$300,000	

Table 3-1 Action Plan (continued)

	DESCRIPTION	LEAD CWRM BRANCH AND PARTNERS	COST RANGE	TASK STATUS**
GOAL 2	**Water resources, public trust uses, and water rights are protected and balanced against reasonable beneficial uses.**			
Project 2.7	**Protect ground water sources by updating well standards and sealing abandoned wells.**			
Task 2.7.1	Develop an abandoned well sealing program in coordination with DOH and the Counties, including staff and funding resources, in order to eliminate potential conduits for ground water contamination.	Ground Water Branch/DOH/ Counties	2 FTE	
Task 2.7.2	Identify and prioritize abandoned and unused wells for sealing.	Ground Water Branch/DOH/ Counties	Internal	In progress
Task 2.7.3	Update the Hawai‘i well construction and pump installation standards to address free-flowing tunnels and artesian wells.	Ground Water Branch	Internal	
Project 2.8	**Prepare for water shortages and drought.**			
Task 2.8.1	Coordinate statewide drought planning efforts and resources through regular meetings of the County drought committees and Hawai‘i Drought Council.	Planning Branch	Internal	In progress
Task 2.8.2	Complete regular updates to the Hawai‘i Drought Plan. Evaluate and revise Plan recommendations and drought communication protocol as necessary and appropriate.	Planning Branch	$75,000	Completed
Task 2.8.3	Develop water shortage plans for priority water management areas.	Planning Branch	$200,000	

*May require additional recurring costs for operation and maintenance

**This column will be populated as CWRM implements tasks listed with “in progress” or “completed”

Internal: CWRM staff will accomplish task with existing resources

Table 3-1 Action Plan (continued)

	DESCRIPTION	LEAD CWRM BRANCH AND PARTNERS	COST RANGE	TASK STATUS**
GOAL 3:	**Partnerships, education, and awareness increase collaborative water resource management among government, private, and community entities and the citizens of Hawai‘i.**			
Project 3.1	**Update the Hawai‘i Water Plan.**			
Task 3.1.1	Update the Statewide Framework for Updating the Hawai‘i Water Plan to reflect new issues and data, improved methodologies, and current priorities.	Planning Branch/DOA/ DLNR/ Counties/DOH/ Stakeholders	$300,000	
Task 3.1.2	Ensure incorporation of recent issues and insights, e.g., climate change, reuse, DHHL needs, and traditional and customary practices, into Hawai‘i Water Plan components.	Planning Branch	Internal	In progress
Task 3.1.3	Promote coordination and collaboration among agencies, private entities, and water users when developing Hawai‘i Water Plan components	Planning Branch/ Counties/ DLNR/DOA/ DOH/ Stakeholders	Internal	In progress
Task 3.1.4	Conduct regular updates of the WRPP	Planning Branch	$300,000	
Project 3.2	**Support multi-sectoral based management of water resources.**			
Task 3.2.1	Collaborate with the State Department of Health to protect water resources by the further integration of water quality and water quantity programs.	Planning Branch/DOH	Internal	In progress
Task 3.2.2	Engage and collaborate with other agencies having an interest in water resources to address inter-agency issues and increase coordination.	CWRM/DOH/ CZM/LUC/ Counties/ Federal Partners	Internal	

*May require additional recurring costs for operation and maintenance

**This column will be populated as CWRM implements tasks listed with “in progress” or “completed”

Internal: CWRM staff will accomplish task with existing resources

Table 3-1 Action Plan (continued)

	DESCRIPTION	LEAD CWRM BRANCH AND PARTNERS	COST RANGE	TASK STATUS**
GOAL 3	**Partnerships, education, and awareness increase collaborative water resource management among government, private, and community entities and the citizens of Hawai‘i.**			
Project 3.3	**Increase CWRM community involvement, participation, outreach, and education.**			
Task 3.3.1	Hold regular CWRM meetings on the neighbor islands to allow CWRM members and staff to learn about and understand issues throughout the State and to increase opportunities for neighbor island communities to participate in CWRM processes.	CWRM	Internal	In progress
Task 3.3.2	Publish water use and monitoring data on CWRM's website.	Ground Water/Stream Branch	Internal	In progress
Task 3.3.3	Assess the development of a pilot community-based surface water data collection program.	Stream Branch	Internal	

*May require additional recurring costs for operation and maintenance

**This column will be populated as CWRM implements tasks listed with "in progress" or "completed"

Internal: CWRM staff will accomplish task with existing resources

3.3 Long-Term Projects

All of the projects, programs, and associated tasks that were identified as a result of this WRPP update process are considered important to managing the use and protection of water resources. Following the task prioritization process, those tasks that were found to be of lower priority are captured in this WRPP as tasks that should be revisited in future planning and updates to the WRPP or those that may be initiated should funds become available or should priorities change. As with any plan, the Water Resource Protection Plan should be regarded as a guide for future and immediate action and should not be so rigid as to not be adaptable to future conditions, new information, or opportunities. A complete list of the long-term tasks may be found in **Appendix O**.

3.4 Implementation and Next Steps

In the past five years during this plan update process, CWRM initiated and/or completed five of the fifty-six tasks in the Action Plan requiring funding. Many of the tasks that will be accomplished using existing staff resources have already been initiated and are ongoing. All tasks are retained in the Action Plan to show the full panoply of tasks that address the issues raised through the stakeholder outreach process.

To complete the remaining tasks in the next five years, it is estimated that an additional $5,000,000 and five full-time staff positions will be required. This $5,000,000 shortfall is equivalent to Capital Improvement Projects (CIP) funds needed for new deep monitor well construction (**Task 1.8.1**). CIP funds are not part of the Commission's operating expenses but will be requested as part of the Department's CIP request during the annual legislative budgeting process.

Should the CIP requests be denied or should a shortfall in the budget occur due to unanticipated executive, judicial, or legislative directives that supersede the priorities outlined in this WRPP, some of these tasks may need to proceed in phases, allowing the actual cost to be spread out beyond the five-year planning period. Phasing will be determined based on available funding at the time and subject to contract negotiations. While some tasks are a critical path and must be implemented before others, in general, any of the tasks in the Action Plan may be selected for implementation in any given year given the needs and grant and partnership opportunities available at that time. Where CWRM is identified as lead agency, it is CWRM's goal to initiate or implement each task in the Action Plan within the next five years.

Currently, CWRM's main source of funding is through annual legislative appropriations. CWRM seeks opportunities to leverage these funds with federal matching funds, other cost-sharing opportunities, and grants. Unfortunately, obtaining cost-share commitments in advance is difficult. The federal agencies that CWRM partners with are also subject to annual budgets, and so commitments for cost-sharing cannot be made in advance of the start of each federal fiscal year. Non-profit organizations occasionally express interest in investing in water resource management, but they often have their own specific interests that may not align with the priorities of CWRM. Finally, executive, judicial, and legislative mandates have in the past and will in the future require CWRM to deviate from its pre-determined priorities. Lack of inclusion in the current Action Plan should not preclude undertaking these new tasks, should the need and opportunity arise. Therefore, some flexibility is needed in plan implementation. CWRM staff will use the Action Plan as a guide for identifying priority tasks, and the Action Plan will be implemented through internal workplans developed by CWRM staff and annual budget requests.

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APPENDIX A

Acronyms and Abbreviations

Water Resource Protection Plan 2019 Update

A ACRONYMS AND ABBREVIATIONS

12-MAV	Twelve-month moving average
ADC	Agribusiness Development Corporation
AWM	Abandoned Well Management
AWUDP	Agricultural Water Use and Development Plan
BFI	Base Flow Index
BMP	Best Management Practice
BWS	Honolulu Board of Water Supply
CLDC	County/Local Drought Committee
CNPCP	Coastal Nonpoint Pollution Control Program
CO_2	Carbon Dioxide
CRVS	DLNR Civil Resource Violation System
CSTR	Completely Stirred Tank Reactor
CTAR	College of Tropical Agriculture and Human Resources
CTD	Conductivity, Temperature, Depth
CWRM	Commission on Water Resource Management
CZD	Capture Zone Delineation
CZM	Coastal Zone Management
DAGS	Department of Accounting and General Services
DBEDT	Department of Business, Economic Development, and Tourism
DHHL	Department of Hawaiian Home Lands
DLNR	Department of Land and Natural Resources
DOA	Department of Agriculture (State)
DOFAW	Division of Forestry and Wildlife (State DLNR)
DOH	Department of Health (State)
DOT	Department of Transportation (State)
DOW	Department of Water
DOWALD	DLNR Division of Water and Land Development
DIP	Drought Impact Reporter
DMW	Deep Monitor Well
DWS	Department of Water Supply
EDR	Electrodialysis reversal

EHA	DOH Environmental Health Administration
EPA	Environmental Protection Agency (Federal)
ESPC	Energy Savings Performance Contract
ET	Evapotranspiration
FEMA	Federal Emergency Management Agency
FTE	Full-Time or Equivalent staff
GAP	Gap Analysis Program
GDE	Ground Water Dependent Ecosystem
GIS	Geographic Information System
GPAD	Gallons Per Acre per Day
GPD	Gallons Per Day
gpd/ac	Gallons per day per acre
GPM	Gallons Per Minute
GPS	Global Positioning Satellite
GWDUI	Ground Water under the Direct Influence
GWPP	Groundwater Protection Program
HAR	Hawai‘i Administrative Rules
HECO	Hawaiian Electric Company
HDP	Hawai‘i Drought Plan
HI-EMA	Hawai‘i Emergency Management Agency
HRS	Hawai‘i Revised Statutes
HSA	Hawai‘i Stream Assessment
HWCPIS	Hawai‘i Well Construction and Pump Installation Standards
HWP	Hawai‘i Water Plan
IFS	Instream Flow Standard
IIFS	Interim Instream Flow Standard
in/yr	Inches per year
IPCC	Intergovernmental Panel on Climate Change
IRP	Integrated Resource Planning
IWREDSS	Irrigation Water Requirement Estimation Decision Support System
km	Kilometers
kWh	Kilowatt-hours
LEED	Leadership in Energy and Environmental Design
LICH	Landscape Industry Council of Hawaii
LUC	Land Use Commission
LUPAG	Land Use Pattern Allocation Guide

m^3/s	Cubic meters per second
mg/d	Million gallons per day
mg/L	Milligrams per liter
MGD	Million gallons per day
MPTZ	Midpoint of the transition zone
NCDC	National Climatic Data Center
NDMC	National Drought Mitigation Center
NGS	National Geodetic Survey
NIDIS	National Integrated Drought Information System
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWISWeb	National Water Information System Web Interface (USGS)
NWS	National Weather Service
OCCL	State Office of Conservation and Coastal Lands
OP	Office of Planning, State of Hawaiʻi
ORMP	Ocean Resources Management Plan
PIRCA	Pacific Islands Regional Climate Assessment
PPCP	Pharmaceuticals and Personal Care Products
PPM	Parts Per Million
PUC	Public Utilities Commission
RAM	Robust Analytical Model
RHFF	Red Hill Fuel Facility
R-O	Reverse osmosis
RFD	Request for Determination
SCAP	Stream Channel Alteration Permit
SDWP	Stream Diversion Works Permit
SGFCP	State General Flood Control Plan
SMURRF	Santa Monica Urban Runoff Recycling Facility
SPAM	Stream Protection and Management
SWAP	Source Water Assessment Program
SWIM	Surface Water Information Management System
SWPP	State Water Projects Plan
THIRA	Threat Hazard Identification and Risk Assessment
TTZ	Top of the Transition Zone
TWI	Trade Wind Inversion
UH	University of Hawaiʻi

UIC	Underground Injection Control
US	United States
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USDM	United States Drought Monitor
USGS	United States Geological Survey
USNPS	United States National Park Service
WAVE	Hawai'i Water Audit Validation Effort
WCFSP	Water Conservation Field Services Program
WMO	World Meteorological Organization
WMP	Watershed Management Plan
WQP	Water Quality Plan
WRF	Water Recycling Facility
WRPP	Water Resources Protection Plan
WRIMS	Water Resource Information Management System
WRRC	Water Resource Research Center
WSAG	Water Security Advisory Group
WUDP	Water Use and Development Plan
WWRF	Wastewater Reclamation Facility
WWTP	Wastewater Treatment Plant

APPENDIX B

Planning Context for the WRPP

Water Resource Protection Plan 2019 Update

B Planning Context for the WRPP

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Figures

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B Planning Context for the WRPP

Water resource issues in Hawai‘i are constantly evolving, as they are increasingly subject to socio-cultural, economic, and political developments. Water resource management and the planning process must, therefore, be flexible and adaptable to changing parameters. The purpose of this appendix is to provide the reader with an informed examination of the legislative requirements and administrative influences that have contributed to the planning context for the current update to the WRPP. The following sections are intended to provide a historical review of the development of current water planning infrastructure and to demonstrate how legislation and regulation have contributed to contemporary water planning.

Background information is presented in two parts:

- **Legislative Context**. This section provides a chronological account of the development and scope of major legislation related to water resource planning in Hawai‘i. Such legislation has constructed legal constraints and obligations for specific government agencies. The intent and objectives of legislative actions are discussed, as well as the atmosphere in which such legislation was conceived.
- **Administrative Context**. This section provides a summary of statewide water planning efforts that preceded the WRPP, and indicates how past planning efforts have ultimately impacted and encouraged the development of this document.

An understanding of related events and themes will give the reader a more comprehensive perspective on the WRPP. The sections below provide ancillary information to supplement chapters one and two of the WRPP.

B.1 Legislative Context: A Historical Perspective of Water Regulation in Hawai‘i

B.1.1 Territorial Legislation and Early State Water Laws

Historically, governmental regulation of water development and use throughout the state was largely confined to O’ahu, mainly the Honolulu area, due to the rapid urbanization and industrialization of the island, the expansion of sugar and pineapple cultivation, the establishment of military activities and facilities, and the emergence of Honolulu as a transportation hub in the Pacific. During the early years of the territorial government, uncontrolled development and use of ground water resources gave rise to public concern over the steadily declining flow from artesian wells in Honolulu. In 1925, the Territorial Legislature created the Honolulu Sewer and Water Commission. This commission’s responsibility included the investigation of water resources on O‘ahu.

Public outcry for better management and operation of water systems continued until 1929, when the legislature created the Honolulu BWS. The Honolulu BWS was provided with complete responsibility for management, operation, and regulation of water works and artesian water development in Honolulu. In 1959, the Honolulu Board of Supervisors transferred the Suburban Water System to the Board of Water Supply. With this transfer, all water functions for the island were finally vested in the semi-autonomous Honolulu BWS. Water resources management for the remainder of the Territory was the responsibility of the Territorial Division of Hydrography.

The Hawaiʻi Irrigation Authority was created by the Territorial Legislature in 1953 to construct and operate small irrigation systems throughout the islands. The Hawaiʻi Water Authority replaced the Hawaiʻi Irrigation Authority in 1959 and was made responsible for the collection and correlation of all water resource data in the Territory. Following statehood in 1959, water resource management became a function of the DLNR. The DLNR's Division of Water and Land Development, now the Engineering Division, became responsible for carrying out the Water Development Program. "Under this program, the division investigates and develops traditional and alternative water sources to meet increasing demands of urban development, agriculture and other uses. Finite water resources and limited funding effects a closer look at alternative water sources. This program also promotes partnerships and cost sharing in the development of water projects to meet the goals of otherwise competing entities."[1]

Under the leadership of the Honolulu BWS, water resource management on Oʻahu appeared to be under control. However, by the late 1970s, increasing public apprehension over the condition of the state's water resources prompted the State to review the situation on Oʻahu. At the time, Chapters 177 and 178 HRS 1975 governed ground water resources. Chapter 177 was the Groundwater Use Act, which provided for the regulation of ground water resources in designated areas. Chapter 178 was the Artesian Well Law, which provided for the control of waste, notification of intent to drill, and transfer of a flowing artesian well from an individual to the county. Chapter 176 was the Water Resources Act, which provided the responsibilities and duties of the board of land and natural resources with regard to the compilation, inventorying, studying, and publication of statewide water resource information. Chapter 176D HRS, entitled Protection of Instream Uses of Water, directed the board of land and natural resources to establish and administer an instream use protection program to protect and enhance, where practicable, beneficial instream uses of water.

[1] Report to the Governor 1992-93, DLNR, State of Hawaii.

In 1977, a State Water Commission was appointed by the Governor to assess the state's water resources following a prolonged drought, during which O‘ahu's ground water levels fell to record lows and hardship befell farmers and ranchers on other islands. In its report, submitted in early 1979, this commission made a number of recommendations, including the following:

1. Regulate the Pearl Harbor ground water resources through Chapter 177;
2. Establish a permit system for water development and use; and
3. Formulate a State Water Code.

In accordance with the Groundwater Use Act, the first designation of a water control area was made in 1979 when the Board of Land and Natural Resources designated the ‘Ewa-Pearl Harbor and Wahiawā Districts.

Meanwhile, the State was taking steps to address water resources through a comprehensive, statewide approach. In 1978, the State of Hawai‘i Constitutional Convention identified the State's "obligation to protect, control and regulate the use of Hawai‘i's water resources for the benefit of its people." Under Article XI, Section 7, of the State Constitution:

> *"The legislature shall provide for a water resources agency which, as provided by law, shall set overall water conservation, quality and use policies; define beneficial and reasonable uses; protect ground and surface water resources, watersheds and natural stream environments; establish criteria for water use priorities while assuring appurtenant rights and existing correlative and riparian uses and establish procedures for regulating all uses of Hawaii's water resources."*

Thus, the initiative for the Commission on Water Resource Management emerged from the Constitutional Convention of 1978. However, CWRM was not established until 1987, when the Legislature enacted the State Water Code, Chapter 174C HRS. HRS Chapters 177 and 178, Groundwater Use Act and the Artesian Well Law, respectively, were repealed and superseded by the State Water Code. HRS Chapter 176 Water Resources and Chapter 176D Protection of Instream Uses of Water were also repealed and replaced by the State Water Code.

B.1.2 CWRM Administration

The State Water Code provides the legal basis for the establishment of CWRM and delineates the agency's authority and responsibilities. CWRM's primary responsibility is to administer the State Water Code. CWRM's general mission is to protect and enhance the water resources of the State of Hawai‘i through wise and responsible management. As specified in the HRS §174C-2, the State Water Code "shall be liberally interpreted to obtain maximum beneficial use of the waters of the State for purposes declared to be in the public interest, such as domestic uses, aquaculture uses, irrigation and other agricultural uses, power development, and commercial and industrial uses." The State Water Code also specifies that, "adequate provision shall be made for the protection of traditional and customary Hawaiian rights, the protection and procreation of fish and wildlife, the maintenance of proper ecological balance and scenic beauty, and the preservation and enhancement of waters of the State for municipal uses, public recreation, public water supply, agriculture, and navigation."

In conjunction with the State Water Code, CWRM also needed to enact new administrative rules within a two-year time period, as required by HRS §174C-8. Accordingly, chapters 13-167 to 13-171 of the Hawai‘i Administrative Rules were adopted in 1988 to state and clarify definitions, rules, procedures, and provisions required by, but not specified in the State Water Code. CWRM operates under these rules through periodic updating and public participation based on the experience of implementing the State Water Code.

Several major amendments to the State Water Code occurred over the years as CWRM's experience broadened and more hydrologic information became available. Significant amendments to HRS §174C and the associated HAR are listed below:

Amendments to the State Water Code, HRS §174C:

- **Act 101 (AWUDP, 174C-31(e)):** The 1998 Legislature added the AWUDP as a fifth component to the HWP to ensure that the plantation irrigation systems affected by plantation closures would be rehabilitated and maintained for future agricultural use. The major objective of the AWUDP is to develop a long-range management plan that assesses state and private agricultural water use, supply and irrigation water systems.
- **Water resource management fund (174C-5.5):** This section was added to the State Water Code to provide a consistent source of funding to allow CWRM to implement monitoring, management, resource protection programs/activities, and enforcement necessary to sustain the State's resources. The funds would also allow the development and regular updating of the HWP using state-of-the art methods such as integrated resource planning.
- **Dual line systems (174C-51.5):** This measure was added to the State Water Code in 2000 to allow CWRM to require the use of dual line water supply systems in new industrial and commercial developments in designated water management areas. This new section helps to further CWRM's policy favoring the use of alternate water sources, such as reclaimed water, as a measure to conserve higher quality water for higher uses.
- **Administrative violation system (174C-15.5):** The 2004 Legislature added this section to allow CWRM to use the DLNR's civil natural resource violations system with the mutual consent of both CWRM and DLNR. Also in 2004, the Legislature increased the maximum fine under 174C-15(b) HRS from $1,000 to $5,000.

Amendments to the associated HAR:

- HAR Chapter 13-169 was amended in 1988 and 1989 to establish interim instream flow standards for perennial streams statewide.
- HAR Chapter 13-171 was amended in 1993 and 1994 to effectuate the following: (1) authorize CWRM to adopt specific water reservations in water management areas as necessary for purposes consistent with public interests, including current and foreseeable development and use of Hawaiian Home Lands; (2) delineate the procedure by which water reservations would be established; and (3) establish water reservations for Hawaiian Home Lands in Honolulu, Leeward and Windward Oʻahu, and in Kualapuʻu, Molokaʻi.
- HAR Chapter 13-168 was amended in 1997 and 2004 to establish and revise the State standards for well construction and pump installation.

The State Water Code and the administrative rules represent the culmination of intense efforts by the Legislature, State and county agencies, community and professional organizations, and various private interests. The State Water Code contains the collective input of many entities and attempts to address various competing interests.

In addition to the State Water Code, other laws may contribute to water resource management and related issues. The Legislature, during the 2007 session, passed Senate Bill 1853 toward the creation of an Aha Moku Council System. The Aha Moku Council System will enable another means for CWRM and other agencies to gain public input and feedback on water resource management issues.

Act 212, Session Laws of Hawaiʻi, enacted on July 1, 2007, created a framework for the establishment of an ʻAha Moku council. The purpose of Act 212 is “to initiate the process to create a system of best practices that is based upon the indigenous resource management practices of moku (regional) boundaries, which acknowledges the natural contours of land, the specific resources located within those areas, and the methodology necessary to sustain resources and the community. Pursuant to the Act, the ʻAha Kiole Advisory Committee members were appointed on November 1, 2007. According to the Report to the Twenty-Fourth Legislature, 2008 Regular Session, Interim Report, ʻAha Kiole Advisory Committee, dated December 28, 2007, the ʻAha Kiole Advisory Committee determined a schedule of meetings and events to be held in each moku during 2008. The purpose of these meetings is to engage in discussion with the community to develop consensus on establishing an ʻAha Moku Council System and ʻAha Moku Council Commission. It is anticipated that the future Aha Moku Councils will provide government agencies and other organizations with input on regional natural resource management methods and practices.

B.1.3 State Water Code Implementation and the Hawaiʻi Water Plan

CWRM implements and utilizes comprehensive water resource planning to regulate and manage the State's ground and surface water resources. The State Water Code sets forth the requirements for the development of the Hawaiʻi Water Plan (HWP) to guide CWRM in executing its general powers, duties, and responsibilities to assure economic development, good municipal water service, agricultural stability, and environmental protection. CWRM is responsible for assembling the eight-part HWP, which consists of the following components:

- WRPP, prepared by CWRM;
- WQP, prepared by the DOH;
- SWPP, prepared by the Department of Land and Natural Resources (DLNR);
- AWUDP, prepared by the Department of Agriculture (DOA), and the
- WUDPs, prepared by each county.

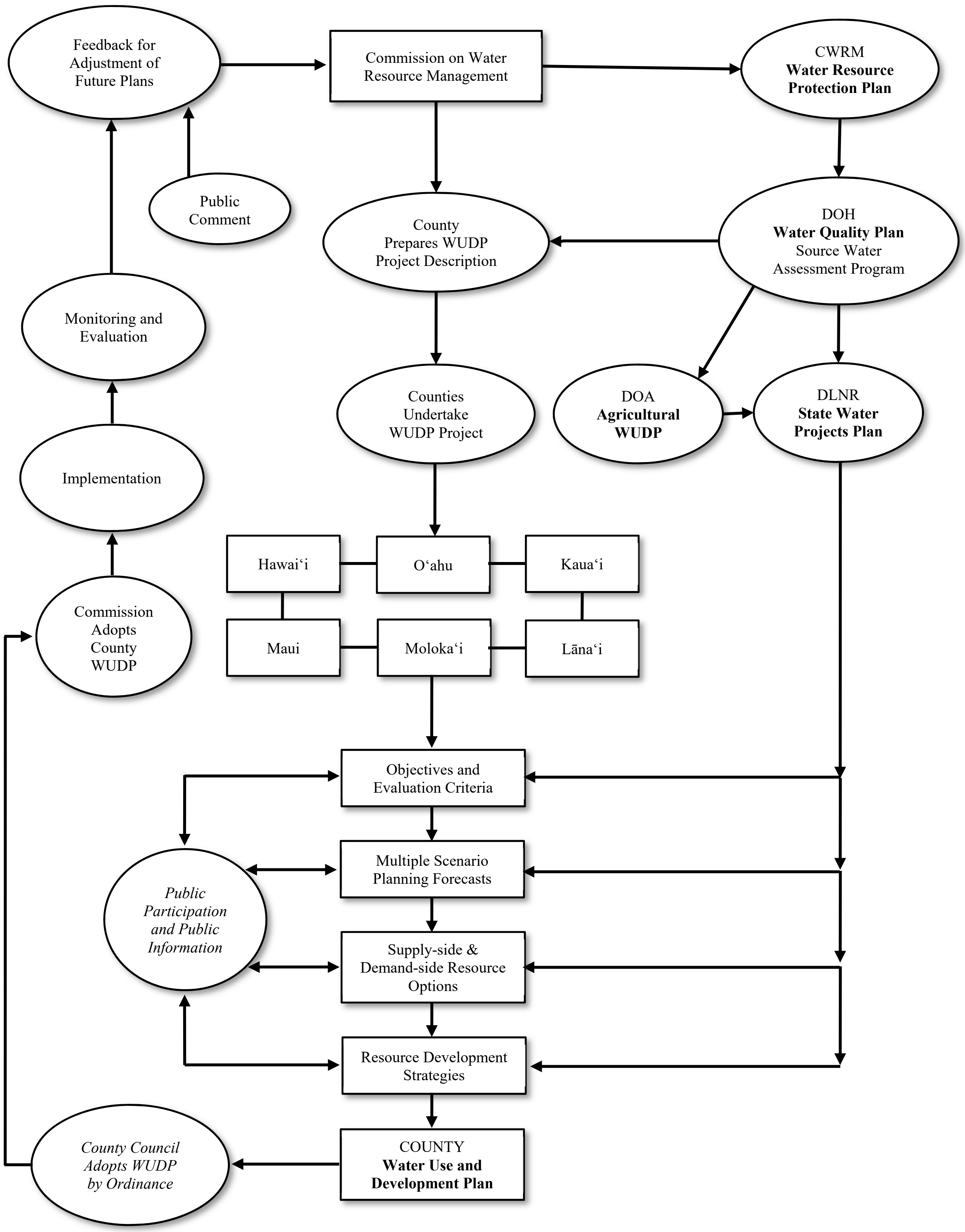
The State Water Code provides that each HWP plan component, with the exception of the WQP, must be *adopted* by CWRM. The DOH's Water Quality Plan is *accepted* and incorporated by CWRM into the HWP. CWRM will integrate the plan components from various agencies into a cohesive tool for managing, protecting, and studying water resources statewide.

The State Water Code imposed a December 31, 1989 deadline for adoption of the HWP. The responsible State and county agencies were able to publish the HWP components in 1990; however, the deadline did not allow for the construction of a truly comprehensive plan. As reflected in the recommendations of the 1990 plan components, more information and additional study would be required to achieve a document that addresses the full extent of the State Water Code requirements.

Specific plan recommendations that emanated from the 1990 HWP clearly identified the need for further studies, assessments and follow-up actions that should be undertaken by government agencies. In 1992, the State and each county prepared draft updates to their respective HWP components, but CWRM's adoption of the 1992 draft HWP update was deferred, pending refinement of the individual plan components and availability of additional information.

As agencies struggled to execute an earlier effort to update the HWP in 1992, a consensus arose among State and county agencies that a comprehensive water resource planning process was needed to address the problems of supply, demand, and conservation of water. Accordingly, CWRM developed a framework document to guide the updating process.

Figure B-1 Framework for the Hawai‘i Water Plan



B.1.4 Adoption of the Statewide Framework for Updating the Hawaiʻi Water Plan

CWRM adopted the Statewide Framework for Updating the Hawaiʻi Water Plan in 2000, under the authority of HRS 174C-31 which provides that CWRM may add to the HWP any other information, directions, or objectives it feels necessary or desirable for the guidance of the counties in the administration and enforcement of code provisions. As such, the Framework is intended to provide focus and additional "guidance" to each agency responsible for updating specific components of the plan. The Framework should be viewed as a long-term vision to preparation of a "living document" which over several plan iterations will result in a truly comprehensive water resource plan.

The Framework incorporates techniques to address current complexities associated with planning, regulation, and management of water resources. The integrated resource planning (IRP) approach described in the Framework was used to identify nexuses between HWP components and develop strategies to manage these relationships.

The objectives of the Framework are as follows:

- To achieve integration of land use and water planning efforts that are undertaken by federal, State, county, and private entities so that a consistent and coordinated plan for the protection, conservation and management of our water resources is achieved;
- To recommend guidelines for the HWP update so that the plan and its component parts are useful to CWRM, other State agencies, the counties, and the general public;
- To develop a dynamic planning process that results in a "living document" for each component of the HWP, which will provide county and State decision-makers with well-formulated options and strategies for addressing future water resource management and development issues;
- To better define roles and responsibilities of all State and county agencies with respect to the development and updating of the HWP components;
- To describe and outline the techniques and methodologies of integrated resource planning as the basic approach that should be utilized in developing and updating the County WUDPs;
- To facilitate permitting and to identify potential critical resource areas where increased monitoring or baseline data gathering should proceed;
- To establish an overall schedule for phased updating of the HWP; and
- To outline an implementation plan for near-term and long-term actions.

The framework document is organized into four sections. Section I briefly outlines the objectives of establishing a statewide framework for updating the HWP and its various component plans. Section II discusses the overall framework for the HWP, including the IRP approach, elements of the IRP process, relationships between HWP components, and the importance of implementing management strategies at the county level. Section III describes the roles and responsibilities of those agencies charged with preparing/updating the various components of the HWP. This section also identifies the minimum requirements of each component plan and the recommended elements that should be included within an IRP approach. Lastly, Section IV outlines a schedule and preliminary implementation plan for the phased updating of the HWP components.

B.2 Administrative Context: A Historical Perspective of Water Resource Planning in Hawaiʻi

It should be emphasized that the State Water Code is a relatively young chapter of the HRS that seeks to address an ambitious spectrum of water management issues and resource protection goals. Of the HWP components, the WQP and the WRPP are critical to balancing use and resource protection. The development of the WRPP is itself an evolving process. Despite the ways popular issues can shift from year to year, and public perception can be persuaded by politics and other influences, the challenge remains to sustain flexibility in the document and encourage a planning process that acknowledges and embraces issues, as they arise without compromising the intent of the State Water Code. This section describes the previous efforts toward statewide water resource planning that have contributed to the overall planning context surrounding the current WRPP update.

B.2.1 The 1979 Hawaiʻi Water Resources Plan

The Hawaiʻi Water Resources Plan, published in 1979, was the product of regional water planning efforts that began in the mid-1960s. During a period in U.S. history when nationwide public awareness of environmental degradation rapidly escalated, the Water Resources Planning Act of 1965 created a national policy to encourage the conservation, development, and utilization of water and related land resources on all levels of government and by private entities. The act established the groundwork for comprehensive studies designed to facilitate water resources planning and created a coordinating agency called the U.S. Water Resources Council. In 1968, the Council designated the State of Hawaiʻi Department of Land and Natural Resources as chair to an ad hoc committee of government agencies charged with the preparation of a preliminary plan of study for a regional plan of Hawaiʻi water resources.

The Hawaiʻi Water Resources Plan is conceptually broad and represents the first coordinated multi-agency water planning effort. The plan is noteworthy and timely considering the multiplicity of plans and planning agencies that sprouted nationwide during the 1960s and 1970s in reaction to increasing environmental pollution. “The need to coordinate water planning, management, protection, and use at all levels of government has become increasingly apparent,” notes the plan’s introduction.

In 1973, the *ad hoc* Hawaiʻi Water Resources Coordinating Committee's study was funded with $580,000 appropriated by the Hawaiʻi State Legislature and $200,000 authorized by Congress. The Hawaiʻi Water Resources Regional Study was supported by a total budget of $1.78 million over a period of three and one-half years. A review draft of the Hawaiʻi Water Resources Plan was published in 1977, followed by publication of the final document in 1979.

Nearly 50 agencies from all levels of government, numerous private entities, and the interested public participated in the planning process, which, according to the plan's executive summary, contributed to a "comprehensive plan of action to achieve the balanced conservation, development, and use of Hawaiʻi's water resources and related land resources." The planning period encompassed the decade from 1990 to 2000, and the study was designed to suggest solutions to long-range problems and needs on a coordinated basis by federal, State and county governments and the private sector.

The overall goal of the Hawaiʻi Water Resources Regional Study was to promote and enhance the quality of life, despite a growing population within a limited land area with limited resources. The study sought to address these issues by:

- Identifying the water and related land resource problems and needs;
- Reflecting public attitudes and preferences in the measures or alternatives proposed to satisfy those problems and needs; and
- Suggesting a schedule to implement recommended actions.

The study was organized to cover 15 subjects, or elements, and a study team was assigned to each planning subject. The planning process and results are captured in 19- study element reports and supplements that were prepared for use by the plan-formulation team, the general public, and participating agencies. Preliminary drafts of the Hawaiʻi Water Resources Plan allowed participants to identify major planning concerns and formulate specific water resource planning objectives. Management alternatives were identified with respect to planning objectives, and these alternatives were subsequently assembled into three plans: the economic development plan; the environmental quality plan; and the balanced plan, which included compatible actions that contributed significantly to both economic and environmental objectives. The relative social, economic, environmental, and regional development impacts were evaluated, and conflicts were resolved to the extent practicable to arrive at a comprehensive list of recommendations and specific actions.

The plan concludes with an implementation schedule, cost estimates, and a suggested institutional arrangement for implementing, revising, and updating the plan. Priority recommendations are highlighted, as well as cost-sharing opportunities.

Many of the Hawaiʻi Water Resources Plan's priority recommendations and specific actions regarding water management legislation have been gradually implemented through the emergence of the initiative for the Water Commission through the Hawaiʻi Constitutional

Convention of 1978, and through the enactment of the State Water Code and the formal establishment of the Water Commission in 1987. The intents of other plan recommendations are captured within the HWP Framework and amendments to the Water Code and Hawaiʻi Administrative Rules. Still, other recommendations retain their validity and contribute to the objectives of the WRPP.

B.2.2 The 1990 Hawaiʻi Water Plan and Water Resource Protection Plan

The objectives of the HWP and CWRM's responsibilities in preparing the HWP and the WRPP, as set forth in the State Water Code, are listed below.

Objectives of the HWP:

The Hawaii water plan shall be directed toward the achievement of the following objectives:

(1) *The attainment of maximum reasonable-beneficial use of water for such purposes as those referred to in subsection (a);*

(2) *The proper conservation and development of the waters of the State;*

(3) *The control of the waters of the State for such public purposes as navigation, drainage, sanitation, and flood control;*

(4) *The attainment of adequate water quality as expressed in the water resource protection and water quality plans; and*

(5) *The implementation of the water resources policies expressed in section 174C-2. (§174C-31(g))*

CWRM Responsibilities in the Preparation of the HWP:

The Hawaii water plan shall divide each county into sections which shall each conform as nearly as practicable to a hydrologic unit. The commission shall describe and inventory:

(1) *All water resources and systems in each hydrologic unit;*

(2) *All presently exercised uses;*

(3) *The quantity of water not presently used within that hydrologic unit; and*

(4) *Potential threats to water resources, both current and future. (§174C-31(h))*

Within each hydrologic unit the commission shall establish the following:

(1) *An instream use and protection program for the surface watercourses in the area; and*

(2) *Sustainable yield. The sustainable yield shall be determined by the commission using the best information available and shall be reviewed periodically. Where appropriate the sustainable yield may be determined to reflect seasonal variation. (§174C-31(i))*

The commission may add to the Hawaii water plan any other information, directions, or objectives it feels necessary or desirable for the guidance of the counties in the administration and enforcement of this chapter. (§174C-31(n))

In formulating or revising the plans, each county and the commission shall consult with and carefully evaluate the recommendations of concerned federal, state, and county agencies. (§174C-31(o))

The commission shall not adopt, approve, or modify any portion of the Hawaii water plan which affects a county or any portion thereof without first holding a public hearing on the matter on the island on which the water resources are located. At least 90 days in advance of such hearing, the commission shall notify the affected county and shall give notice of such hearing by publication within the affected region and statewide. (§174C-31(p))

In formulating or revising each county's water use and development plan, the state water projects plan, the water resource protection plan and the water quality plan, each county and the commission shall incorporate the current and foreseeable development and use needs of the department of Hawaiian home lands for water as provided in section 221 of the Hawaii Homes Commission Act. (§174C-31(q))

Respective portions of the water resource protection and water quality plans, and the water use and development plans of each county, shall be developed together to achieve maximum coordination. (§174C-32)

The development of the Hawaii water plan or any portion thereof shall proceed in coordination with and with attention to the Hawaii state plan described in chapter 226. (§174C-32)

The Hawaii water plan and its constituent parts, except for the water quality plan, shall be adopted by the commission not later than three years from July 1, 1987. The commission shall receive the water quality plan from the department of health and incorporate this part in the Hawaii water plan. (§174C-32)

The initial HWP, including the WRPP, was prepared by various State and county agencies and formally adopted by CWRM in 1990. The preparation of the 1990 WRPP was an enormous undertaking, since the plan sought to address all ground water and surface water resource issues in the State.

In order to complete the HWP by the December 31, 1989 deadline imposed by the State Water Code, CWRM had to rely on incomplete information and estimates. The Legislature likely realized the uncertainty of the data, as evidenced by the discussion of the crucial item of sustainable yields; the law provides that the “sustainable yield shall be determined by the Water Commission using the best information available and shall be reviewed periodically.” The Legislature wisely provided the means for CWRM to further develop, review, adjust, and fine-tune sustainable yields based on experience and availability of additional information and findings.

CWRM adoption of the 1992 update to the WRPP was deferred pending further refinement of plan components. While it may be argued that the current WRPP and other HWP components fall short of their intended objectives, sufficient provisions established in the 1990 plan, together with policies subsequently adopted by CWRM, provide for appreciable guidance to the CWRM in carrying out its duties and responsibilities. However, this is not to say that the current plan should not be updated or that specific elements do not require further revision and/or modification.

Specific plan recommendations that emanated from the initial preparation of the HWP clearly identified the need for further studies, assessments, and follow-on actions that should be undertaken by each responsible agency. This inherent need to improve upon the existing plans formed the basis for the HWP Framework, adopted by CWRM in 2000. In the interim, the existing HWP and WRPP comprised the first steps toward “comprehensive water resource planning.” More importantly, the 1990 WRPP remains a valid planning and resource-management tool until more recent updates can be adopted.

B.2.3 Integration of the Water Resource Protection Plan with other Hawai‘i Water Plan Components

Because different State and county agencies prepare the separate components of the HWP, it is critical that the components are interrelated in order for the overall result to be cohesive. The relationships between the various component plans are described below.

The WQP and the WRPP are the two plan components that are critical to determining both water usage and water development strategies. These two plans outline the regulations, standards, and resource management policies that define the availability of ground and surface water resources and the quality to be maintained in these resources. In addition, the quantity of ground and surface water resources that can be withdrawn on a sustainable basis is determined as part of the WRPP. The WQP and WRPP therefore provide critical inputs to the SWPP, the

AWUDP, and the County WUDPs developed by the four counties. The SWPP, AWUDP, and County WUDPs must be consistent with the 1990 WRPP and WQP until subsequent updates are developed.

The relationships between the plans prepared by the State and the WUDPs prepared by the four counties are best understood by noting that the County WUDP must, by statute, encompass *all* water usage and planned water development plans projected throughout the county. Since the various state agencies ultimately build their projects within one of the four counties, their water use demands and their proposals for developing various resources to meet those demands must be factored into the overall water demands and development strategies of each of the counties. This relationship is depicted in **Figure B-1 Framework for the Hawaiʻi Water Plan** as input from the state level to the county level. In practice, the relationship should be more in the nature of a cooperative dialogue and joint planning effort, if a cohesive HWP is to be achieved.

The Framework principally guides the updating of the various County WUDPs. As part of each county's WUDP update, a county-specific project description shall be prepared by each county and submitted to CWRM. The County WUDP project description should present specific issues, planning activities, a schedule, and objectives to be met by the county in its update of the plan. Integration of the State-level planning effort will be achieved by bringing the results of the State planning into the county planning process.

In addition to the coordination of Hawaiʻi Water Plan Components described in the Framework, inter-agency collaboration on water-related planning is promoted through other agency programs. The Department of Land and Natural Resources participates in the policy and working groups established in the CZM's Ocean Resource Management Plan (ORMP). The ORMP is an integrated, place-based approach to management of ocean resources based on land-sea links, the role of human activities, and improved collaboration in governance. Since the ORMP is a living document to be updated every five years, there is great flexibility to coordinate appropriate aspects of the Water Resource Protection Plan and other Hawaiʻi Water Plan components.

B.3 Current Update of the Water Resource Protection Plan

CWRM is responsible for the preparation, implementation, and updating of the WRPP, the key component of the Hawaiʻi Water Plan. The scope of the WRPP, as provided by the State Water Code in HRS §174C-31, is as follows:

(1) *Study and inventory the existing water resources of the State and the means and methods of conserving and augmenting such water resources;*

(2) *Review existing and contemplated needs and uses of water including State and County land use plans and policies and study their effect on the environment, procreation of fish and wildlife, and water quality;*

(3) *Study the quantity and quality of water needed for existing and contemplated uses, including irrigation, power development, geothermal power, and municipal uses;*

(4) *Identify rivers or streams, or a portion of a river or stream, which appropriately may be placed within a wild and scenic rivers system, to be preserved and protected as part of the public trust. For the purposes of this paragraph, the term "wild and scenic rivers" means rivers or streams, or a portion of a river or stream of high natural quality or that possess significant scenic value, including but not limited to, rivers or streams which are within the natural area reserves system. The commission shall report its findings to the legislature twenty days prior to the convening of each regular legislative session; and*

(5) *Study such other related matters as drainage, reclamation, flood hazards, flood plan zoning, dam safety, and selection of reservoir sites, as they relate to the protection, conservation, quantity and quality of water.*

§174C-31, HRS further provides that:

The Water Resource Protection Plan shall include, but not be limited to:

(1) *Nature and occurrence of water resources in the State;*

(2) *Hydrologic units and their characteristics, including the quantity and quality of available resource, requirements for beneficial instream uses and environmental protection, desirable uses worthy of preservation by permit, and undesirable uses for which permits may be denied;*

(3) *Existing and contemplated uses of water, as identified in the water use and development plans of the State and the counties, their impact on the resources, and their consistency with objectives and policies established in the water resource protection quality plan;*

(4) *Programs to conserve, augment, and protect the water resource; and*

(5) *Other elements necessary or desirable for inclusion in the plan.*

Thereafter, the commission, in coordination with the counties and the department of health, shall formulate an integrated, coordinated program for the protection, conservation and management of the waters in each county based on the above studies. This program, with such amendments, supplements, and additions as may be necessary, shall be known as the water resource protection and quality plan.

The initial WRPP was completed and adopted by CWRM in 1990. As new and better information becomes available (e.g., hydrologic information and land use changes), CWRM must periodically update the WRPP. The 1990 WRPP provided the means by which to address many issues, including but not limited to estimates of sustainable ground water yields by island, description of aquifer sectors and aquifer systems, and an initial evaluation of current and projected water needs for the State and the counties.

This current update to the WRPP includes policies, program directives, resource inventories, and recommendations across a broad spectrum of resource management issues. Efforts supporting this update focused on the following tasks:

- Declaration of CWRM policies, goals, and objectives;
- Update of ground water hydrologic units and sustainable yields;
- Establishment of surface water hydrologic units and a stream coding system, and the development of a surface water diversion database;
- Explanation and description of CWRM's surface water management program and implementation plan;
- Development of statewide ground and surface water monitoring program priorities;
- Examination of water conservation and augmentation alternatives, drought preparedness and mitigation actions, and watershed protection programs; and
- Development of recommendations for future actions and funding requirements.

This update of the WRPP is intended to provide for more successful coordination and integration of State and county efforts related to sustainable water resource development and to enable CWRM to more effectively implement the statutory objectives of the State Water Code. Regularly updating this and other components of the HWP will facilitate the counties' integration of updated information into their respective WUDPs. Preparation and revision of HWP components through a "living document" approach provides county and State decision makers with well-formulated options and strategies for addressing future water resource management and development issues.

B.4 Conclusion

The collective effect of the legislative and administrative history described above is the emergence of a dynamic planning context for water resource management—one that the current update to the WRPP acknowledges and strives to address to the fullest extent possible.

APPENDIX C

Legal Authorities and Guidance

Water Resource Protection Plan 2019 Update

C Legal Authorities and Guidance

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C Legal Authorities and Guidance

This Appendix summarizes the legal authorities and guidance for water management set forth in the State Constitution, the State Water Code, and the Hawai‘i Administrative Rules. The CWRM applies these legal authorities and guidance when implementing the State Water Code. Also presented are CWRM's goals and objectives for executing the agency's mandated responsibilities.

Following the summary of policies in **Sections C.1 and C.2**, **Section C.3** presents CWRM's goals and objectives for executing the agency's mandated responsibilities

C.1 Legal Authorities Pertaining to Water Resource Management in Hawai‘i

This section discusses general water resource policies in the State Constitution, Hawai‘i Revised Statutes, and Hawai‘i Administrative Rules.

C.1.1 The Hawai‘i State Constitution

The **Hawai‘i State Constitution** is the document that defines the principles and authorities of the government of the State of Hawai‘i. Created by a Constitutional Convention in 1949, it was adopted by the people on November 7, 1950, was confirmed by the U.S. Congress in March 1959, and went into effect on August 21, 1959 when a presidential proclamation was issued admitting the state of Hawai‘i into the Union. It has been amended several times either through proposals adopted by the legislature or by constitutional convention and ratified by the people.

Article XI, Section 1 mandates that the State "conserve and protect Hawaii's natural beauty and all natural resources…and shall promote the development and utilization of these resources in a manner consistent with their conservation and in furtherance of the self-sufficiency of the State." Additionally, under Article XI, Section 7, "The State has an obligation to protect, control, and regulate the use of Hawaii's water resources for the benefit of its people." With this statement, the Public Trust Doctrine was written into the State Constitution.

The Public Trust Doctrine is a concept relating to the ownership, protection and use of natural resources, where common resources such as water are to be held in trust by the State for the use and enjoyment of the general public. In Hawaii, the application of the Public Trust Doctrine in resource management considers both the public's right to use and enjoy trust resources, and the private property rights that may exist in the use and possession of trust resources; however, any balancing between public and private interests begins with a presumption in favor of public use, access, and enjoyment. See **Section 0** for more on The Public Trust Doctrine.

C.1.2 The State Water Code (Hawai‘i Revised Statues Chapter 174C)

Statutes are the written laws created and passed by a State’s legislature. The **State Water Code**, enacted in 1987 as **Chapter 174C of the Hawai‘i Revised Statues** (HRS), provides the legal basis for and establishment of the Commission on Water Resource Management (CWRM) and defines its responsibilities and authorities.

The Hawaii State Legislature (Legislature) incorporated the Public Trust Doctrine into the State Water Code. This section presents broad declarations of water resource protection and management policy that are embedded in the State Water Code and are employed by CWRM in program administration.

The State Water Code Declaration of Policy is as follows:

- *It is recognized that the waters of the State are held for the benefit of the citizens of the State. It is declared that the people of the State are beneficiaries and have a right to have the waters protected for their use. (HRS §174C-2)*
- *There is a need for a program of comprehensive water resources planning to address the problems of supply and conservation of water. The Hawaii water plan, with such future amendments, supplements, and additions as may be necessary, is accepted as the guide for developing and implementing this policy. (HRS §174C-2)*
- *The state water code shall be liberally interpreted to obtain maximum beneficial use of the waters of the State for purposes such as domestic uses, aquaculture uses, irrigation and other agricultural uses, power development, and commercial and industrial uses. However, adequate provision shall be made for the protection of traditional and customary Hawaiian rights, the protection and procreation of fish and wildlife, the maintenance of proper ecological balance and scenic beauty, and the preservation and enhancement of waters of the State for municipal uses, public recreation, public water supply, agriculture, and navigation. Such objectives are declared to be in the public interest. (HRS §174C-2)*
- *The state water code shall be liberally interpreted to protect and improve the quality of waters of the State and to provide that no substance be discharged into such waters without first receiving the necessary treatment or other corrective action. The people of Hawaii have a substantial interest in the prevention, abatement, and control of both new and existing water pollution and in the maintenance of high standards of water quality. (HRS §174C-2)*
- *The state water code shall be liberally interpreted and applied in a manner which conforms with intentions and plans of the counties in terms of land use planning. (HRS §174C-2)*

C.1.3 The Hawai‘i Administrative Rules

The **Hawaii Administrative Rules (HAR), Title 13, Department of Land and Natural Resources, Subtitle 7, Water Resources** contains the rules and procedures adopted pursuant to the State Water Code for administering code provisions. The rules constitute procedural policies of CWRM that provide additional guidance for the implementation of the broad water management and use policies included in the State Water Code. The appropriate chapters from the HAR are briefly summarized below:

HAR Chapter 13-167: Rules of Practice and Procedure for the Commission on Water Resource Management

This chapter governs practice and procedure before CWRM under Chapter 91, HRS, the Constitution and water laws of the State, the Constitution and laws of the United States, and such other related acts as may now or hereinafter be administered by CWRM. The rules in this section are intended to secure the just, speedy, and inexpensive determination of every proceeding.

HAR Chapter 13-168: Water Use, Wells, and Stream Diversion Works

The primary purpose of this section is to carry out the intent of the State Water Code to assure maximum beneficial use of ground and surface waters of the State by establishing rules for reporting and gathering meaningful data on all water uses and sources. The rules in this section provide for the declaration and certification of all existing uses of surface and ground water; the registration of all existing wells and existing stream diversion works; the reporting of current uses of surface and ground water; the permitting of wells; the permitting of pump installations and repairs; and the permitting of stream diversion works. The *Hawaii Well Construction and Pump Installation Standards* (HWCPIS) were amended to the HAR in January 1997, allowing subsequent revision as necessary. The HWCPIS provides for the safe and sanitary maintenance and operation of wells, to prevent waste, and to prevent contamination of ground water aquifers.

HAR Chapter 13-169: Protection of Instream Uses of Water

The purpose of this chapter is to provide for the establishment of a statewide program to protect, enhance, and reestablish, where practical, beneficial instream uses of water, including the development and establishment of standards for instream flows and the creation of a permit system to regulate the alteration of stream channels.

HAR Chapter 13-170: Hawaii Water Plan

This chapter provides guidelines for preparation of the HWP. Interagency consultation is advised between appropriate county, State, and federal agencies. CWRM is further advised to set forth programs to conserve, augment, and protect water resources, and to consider any other elements necessary or desirable for inclusion in the Hawaii Water Plan.

HAR Chapter 13-170: Hawaii Water Plan, Subchapter 6, Integration of Plan Elements

This subchapter delineates implementation priorities and the structure of the HWP:

- Integration of the HWP is dependent on the creation of a master water resource inventory, designation of hydrologic units as identified in Section 13-170-20, and formulation of water quality criteria as described in Section 13-170-52.
- The WRPP and the WQP shall be created as soon as practicable in order that the State and county may use the information in preparing their respective plans.
- The WRPP shall incorporate, where applicable, data contained within the WQP for the purpose of protecting, conserving and augmenting the state's water resources.
- Both the SWPP and each County WUDP shall be subject to the WRPP.
- The HWP shall guide CWRM in the designation of water management areas and in the issuance of permits as set forth in the State Water Code.

HAR Chapter 13-171: Designation and Regulation of Water Management Areas

The purpose of this section is to provide for the designation and regulation of hydrologic areas where water resources are being threatened by existing or proposed withdrawals or diversions of water, water quality problems, or serious disputes. The rules state, "[I]t shall be the duty of the [Water] Commission to designate areas for the purpose of establishing administrative control over the withdrawals and diversions of ground and surface water in threatened areas to ensure the most beneficial use, development, or management of the water resources in the interest of the people of the State."

C.2 Principles of Water Resource Management in Hawai‘i[1]

Hawai‘i's water law is an amalgamation of the ancient and historical Native Hawaiian water management system, surviving Kingdom law, and modern constitutional and statutory mandates. Water rights, therefore, exist in several forms and carry different obligations under the State Water Code and under common law. The following sections provide further discussion and insight as to the relationship between the Public Trust Doctrine, the State Water Code, and legal provisions for water rights.

[1] This publication is designed to provide general information prepared by professionals in regard to the subject matter covered. It is provided with the understanding that the publisher, authors, and editors are not engaged in rendering legal or other professional service herein. Due to the rapidly changing nature of the law, information contained in this publication may become outdated.

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C.2.1 The Public Trust Doctrine

Hawaii is one of several states that have included the Public Trust Doctrine into its State Constitution. As stated earlier in **Section 0**, the Legislature incorporated the Public Trust Doctrine into the State Water Code as follows:

> *It is recognized that the waters of the State are held for the benefit of the citizens of the State. It is declared that the people of the State are beneficiaries and have a right to have the waters protected for their use. (HRS §174C-2)*

Hawaii's constitutional, statutory, and administrative rule provisions for protecting public interests was reinforced by the Hawaii Supreme Court (the Court) decisions in the Waiāhole Ditch Contested Case (Waiāhole Water Case) proceedings (Docket No. CCHOA95-1) during the late 1990s and early 2000s. The Court's decisions emphasize the Public Trust Doctrine and the associated Precautionary Principle as essential to the application and administration of the State Water Code and have further helped to define current water rights in Hawaiʻi.

In its review of the Waiāhole Water Case, the Court held that:

- Title to the water resources is held in trust by the State for the benefit of its people;
- Article XI, sections one and seven of the State Constitution adopted the public trust doctrine as a fundamental principle of constitutional law in Hawaiʻi;
- The Legislature incorporated public trust principles into the State Water Code; and
- Nevertheless, the State Water Code did not supplant the protections of the Public Trust Doctrine, which the Court would continue to use to inform the Court's interpretation of the State Water Code, define its outer limits, and justify its existence.[2]

The Court has identified four trust purposes, three in the Waiāhole Water Case, and a fourth in its 2004 decision, In the Matter of the Contested Case Hearing on Water Use, Well Construction, and Pump Installation Permit Applications, Filed by Waiola o Molokaʻi, Inc. and Molokaʻi Ranch, Limited. These purposes are listed below and are equally protected under the law:

- Maintenance of waters in their natural state;
- Domestic water use of the general public, particularly drinking water;
- The exercise of Native Hawaiian and traditional and customary rights, including appurtenant rights; and
- Reservations of water for Hawaiian Home Land allotments.

[2] 94 Haw. 97, at 130-133; 9 P3d 409, at 443-445

The Court also identified the following principles for the water resources trust:[3]

- The State has both the authority and duty to preserve the rights of present and future generations in the waters of the State;
- This authority empowers the State to revisit prior diversions and allocations, even those made with due consideration of their effect on the public trust;
- The State also bears the affirmative duty to take the public trust into account in the planning and allocation of water resources and to protect public trust uses whenever feasible;
- Competing public and private water uses must be weighed on a case-by-case basis, and any balancing between public and private purposes begins with a presumption in favor of public use, access, and enjoyment;
- There is a higher level of scrutiny for private commercial uses, with the burden ultimately lying with those seeking or approving such uses to justify them in light of the purposes protected by the trust; and
- Reason and necessity dictate that the public trust may have to accommodate uses inconsistent with the mandate of protection, to the unavoidable impairment of public instream uses and values; offstream use is not precluded but requires that all uses, offstream or instream, public or private, promote the best economic and social interests of the people of the State.

C.2.2 The Precautionary Principle

When scientific evidence is preliminary and not conclusive regarding the management of the water resources trust, it is prudent to adopt "precautionary principles." The Court's interpretation as explained in the Waiāhole Water Case is as follows:

- As with any general principle, its meaning must vary according to the situation and can only develop over time. At a minimum, the absence of firm scientific proof should not tie the Water Commission's hands in adopting reasonable measures designed to further the public interest.
- The precautionary principle simply restates the commission's duties under the State Constitution and the State Code. The lack of full scientific certainty does not extinguish the presumption in favor of public trust purposes or vitiates the Water Commission's affirmative duty to protect such purposes wherever feasible. Nor does its present inability to fulfill the instream use protection framework render the statute's directives any less mandatory. In requiring the Water Commission to establish instream flow standards at an early planning stage, the State Water Code contemplates the designation of the standards based not only on scientifically proven facts, but also on future predictions,

[3] Note that, while these principles are directed at surface water resources, they apply equally to

ground water resources.

> generalized assumptions, and policy judgments. Neither the State Constitution nor the State Water Code constrains the Water Commission to wait for full scientific certainty in fulfilling its duty toward the public interest in minimum instream flows.

The Court's linking of the Public Trust Doctrine to the precautionary principle offers significant guidance to water resource management. The tenets of the precautionary principle state that:

- There is a duty to take anticipatory action to prevent harm to public resources;
- There is an obligation to examine the full range of alternatives before starting a new activity and in using new technologies, processes, and chemicals; and
- Decisions should be open, informed, and democratic and include affected parties.

In this regard, "precautionary actions" may include:

- Anticipatory and preventive actions;
- Actions that increase rather than decrease options;
- Actions that can be monitored and reversed;
- Actions that increase resilience, health, and the integrity of the whole system; and
- Actions that enhance diversity.

The Public Trust Doctrine establishes a general duty to take precautionary actions and thus shifts the burden of proof to non-trust purposes and requires preventive action in the face of uncertainty.

C.2.3 Recognized Water Rights in Hawai‘i

Water rights and uses in Hawaii are governed by the State Water Code[4] and the common law. The State Water Code preserved appurtenant rights but not correlative and riparian rights in designated water management areas. Thus, when a ground water management area is designated, existing correlative uses within that area can be issued water use permits under the existing use provisions of the State Water Code, but unexercised correlative rights are extinguished. Similarly, when a surface water management area is designated, existing riparian uses within that area are eligible for water use permits as existing uses, but unexercised riparian rights are extinguished. Furthermore, the Hawaii Supreme Court has ruled that when there is an undisputed, direct interrelationship between the surface and ground waters, designation of a ground water management area subjects both ground and surface water diversions from the designated area to the statutory permit requirement.[5] Presumably, permits would also be required for ground and surface water diversions when the interrelationship occurs in a surface water management area.

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[4] HRS 174C, §§ 174C-1 to 174C-101.

[5] *In re Water Use Permit Applications*, 94 Haw. 97, at 173; 9 P3d 409, at 485 (2000).

While water use permits are required only in designated water management areas and the common law on water rights and uses continue to apply in non-designated areas, other provisions of the State Water Code apply throughout the state. Thus, for example, well construction and pump installation permits are required for any new or modified ground water use, and stream diversion and stream alteration permits are required for any new or modified surface water diversions. If the proposed stream diversion will affect the existing instream flow standard, a successful petition to amend the interim instream flow standard is also required.

C.2.3.1 Correlative Rights

Under the common law, owners of land overlying a ground water source have the right to use that water on the overlying land, as long as the use is reasonable and does not injure the rights of other overlying landholders.[6] When the amount of water is insufficient for all, each is limited to a reasonable share of the ground water. Overlying landowners who have not exercised their correlative rights cannot prevent other landowners from using the water on the theory that they are using more than their reasonable share. They must suffer actual, not potential, harm. Only when landowners try to exercise their correlative rights and the remaining water is insufficient to meet their needs, can they take action to require existing users to reduce their uses.

C.2.3.2 Riparian Rights

Riparian rights are rights of land adjoining natural watercourses and are the surface water equivalent of correlative rights to ground waters; i.e., the use has to be on the riparian lands, the use has to be reasonable, and the exercise of those rights cannot actually harm the reasonable use of those waters by other riparian landowners. The Court had originally stated that the right was to the natural flow of the stream without substantial diminution and in the shape and size given it by nature,[7] but later concluded that the right should evolve in accordance with changing needs and circumstances. Thus, in order to maintain an action against a diversion which diminishes the quantity or flow of a natural watercourse, riparian owners must demonstrate actual harm to their own reasonable use of those waters.[8]

C.2.3.3 Appurtenant Rights

Appurtenant water rights are rights to the use of water utilized by parcels of land at the time of their original conversion into fee simple lands i.e., when land allotted by the 1848 Māhele was confirmed to the awardee by the Land Commission and/or when the Royal Patent was issued based on such award, the conveyance of the parcel of land carried with it the appurtenant right to water.[9] The amount of water under an appurtenant right is the amount that was being used at the time of the Land Commission award and is established by cultivation methods that

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[6] *City Mill Co. v Hon. S. & W. Com.*, 30 Haw. 912 (1929).

[7] *McBryde v Robinson*, 54 Haw. 174, at 198; 504 P.2d 1330, at 1344 (1973); *aff'd on rehearing*, 55 Haw. 260; 517 P.2d 26 (1973); *appeal dismissed for want of jurisdiction and cert. denied*, 417 U.S. 962 (1974).

[8] *Reppun v Board of Water Supply*, 65 Haw. 531, at 553; 656 P.2d 57, at 72 (1982).

[9] 54 Haw. 174, at 188; 504 .2d 1330, at 1339.

approximate the methods utilized at the time of the Māhele, for example, growing wetland taro.[10] Once established, future uses are not limited to the cultivation of traditional products approximating those utilized at the time of the Māhele,[11] as long as those uses are reasonable, and if in a water management area, meets the State Water Code's test of reasonable and beneficial use ("the use of water in such a quantity as is necessary for economic and efficient utilization, for a purpose, and in a manner which is both reasonable and consistent with the State and county land use plans and the public interest"). As mentioned earlier, appurtenant rights are preserved under the State Water Code, so even in designated water management areas, an unexercised appurtenant right is not extinguished and must be issued a water use permit when applied for, as long as the water use permit requirements are met (see **Figure C-1)**.

C.2.3.4 Extinguishing Riparian or Appurtenant Rights

Unlike appurtenant rights, which are based in the common law, the Court has interpreted riparian rights as originating in an 1850 statute.[12] This has led to a curious inconsistency in that, while unexercised appurtenant rights are preserved and unexercised riparian rights are extinguished in designated water management areas, actions by private individuals can extinguish appurtenant but not riparian rights. Both appurtenant and riparian rights cannot be severed from the lands they are attached to, and such rights pass with the title to the land whether or not the rights are expressly mentioned in the deed. If the transferor of the land attempts to reserve the riparian right in the deed, the reservation is not valid and the right nevertheless belongs to the transferee as the new owner of the land.

The law with regards to appurtenant rights is not clear. The Supreme Court in Reppun[13] held that where a landowner attempted to reserve an appurtenant right while selling the underlying land, the reservation is not valid and the attempt to reserve extinguishes the appurtenant right. In doing so, the Court reasoned that there is nothing to prevent a transferor from effectively providing that the benefit of the appurtenant right not be passed to the transferee.[14] This difference is due to the Court's interpretation that riparian rights had been created by the 1850 statute, so any attempt by the grantor to reserve riparian water rights in the deed when riparian lands are sold is invalid. Presumably, the inconsistency could be cured by legislation providing a statutory basis for appurtenant rights. In fact, the Court in the Waiāhole Water Case cited to the State Water Code's recognition of appurtenant rights and legislative comment to the effect that "[a]ppurtenant rights may not be lost."[15] However, the Court did not explicitly discuss its prior Reppun decision, so it is unclear whether its Waiāhole decision overruled Reppun.

[10] 65 Haw. 531, at 554; 656 P.2d 57, at 72.

[11] *Peck v Bailey*, 8 Haw. 658, at 665 (1867).

[12] 54 Haw. 174; 504 P.2d 1330.

[13] 65 Haw. 531, at 552; 656 P.2d 57, at 71 (1982).

[14] 65 Haw. 531, at 552; 656 P.2d 57, at 71 (1982).

[15] 94 Haw. 97 at 179, 9 P.3d 409 at 491 (2000).

In September 2011, CWRM approved a process for determining appurtenant rights in the newly-designated Na Wai ‘Ehā Surface Water Management Area. The process below may be applicable to other designated surface water management areas; however, the legal process and requirements in non-designated areas will be different and have yet to be determined.

Figure C-1 Generalized Process for Determining Appurtenant Water Rights in Designated Surface Water Management Areas

Step 1: Notice of Intent to Determine Appurtenant Rights

- Two notices mailed to all registered water users in water management area, water use permit applicants, and LCA awardees
- Notice published for two consecutive months in general circulation newspapers and island newspaper
- Notice posted on CWRM website and monthly bulletin
- 90-day filing deadline

Step 2: Determination of Appurtenant Right

- Surface water use permit application must be filed
- Title search is not required
- Applicant must provide documentation of claim
- Written notice sent to applicants of deficiencies or completeness of claim
- Completed applications posted on CWRM website
- Notice of completed applications published in general circulation newspaper and island newspaper with deadline for objections

Step 3: Quantification of Appurtenant Right

- To be done as part of the surface water use permitting process

C.2.3.5 Appropriated Uses

Appropriated uses are uses of surface or ground waters on non-riparian or nonoverlying lands. In the case of ground water, "[P]arties transporting water to distant lands are deemed mere 'appropriators,' subordinate in right to overlying landowners …[T]he correlative rights rule grants overlying landowners a right only to such water as necessary for reasonable use. Until overlying landowners develop an actual need to use ground water, non-overlying parties may use any available 'surplus' (citations omitted)."[16] For surface waters, "the effect of permitting riparian owners to enjoin diversions beneficial to others in the absence of a demonstration of actual harm may occasionally lead to wasteful or even absurd results…The continuing use of the waters of the stream by the wrongful diversion should be contingent upon a demonstration that such use will not harm the established rights of others."[17] Thus, appropriated uses are not based on water rights but are allowed as long as they are reasonable and do not actually impinge on correlative and riparian rights. Note that appurtenant uses would be a type of appropriated uses if they were not based on appurtenant rights, and that in fact, the history of appurtenant uses in the Kingdom of Hawaii has led to their establishment as water rights superior to riparian rights. Also note that when a water management area is designated, appropriated uses become superior to unexercised water rights, because appropriated uses become existing uses and are eligible for water use permits, while unexercised correlative and riparian rights are extinguished.

C.2.3.6 Obsolete Rights: Prescriptive and Konohiki Rights

Until 1973, surface waters were treated as private property and could be owned. Prescriptive water rights were the water equivalent of "adverse possession" in land ownership, where open and hostile occupation of another's private property for a specified number of years entitled the occupier to take legal ownership, because it exercisable only against the ownership of other private parties and not against the government. Thus, under prescriptive rights, appropriated uses could ripen into a prescriptive right superior to riparian rights. (Some early Court cases viewed appurtenant rights as a type of prescriptive right.) In 1973, the Court voided private ownership of water resources and prescriptive rights because of public ownership of all surface waters.[18] As for ground water, two early cases (1884[19] and 1896[20]) reflected the then prevailing law on surface waters that water could be private property, but those cases also concluded that prescriptive rights cannot be exercised against subterranean waters that have no known or defined course, i.e., you could not adversely possess what you could not see. In 1929, the Court adopted the correlative rights rule,[21] in which the overlying landowners could not use the water as they pleased, because it was a shared resource.

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[16] 94 Haw. 97, at 178; 9 P3d 409, at 490 (2000).

[17] 65 Haw. 531, at 553-554; 656 P.2d 57, at 72 (1982).

[18] 54 Haw. 174; 504 P.2d 1330 (1973);

[19] *Davis v Afong*, 5 Haw. 216 (1884).

[20] *Wong Leong v Irwin*, 10 Haw. 265 (1896).

[21] *City Mill Co. v Hon. S. & W. Com.*, 30 Haw. 912 (1929).

Until 1973, “konohiki lands,” or lands whose title had passed from persons documented as konohiki, owned the “normal daily surplus water” in excess of waters reserved by appurtenant and prescriptive rights. (Despite a number of earlier cases, in 1930 the Court had concluded that riparian rights had never been the law in Hawaii.[22] The 1973 Court, instead of overturning that decision, found a statutory basis for riparian rights in the 1850 statute.) In 1973, in addition to voiding any private property interest in water, the Court ruled that there can be no “normal daily surplus water,” because the recognition of riparian rights entitled owners of riparian lands to have the flow of the watercourse in the shape and state given it by nature.[23]

C.2.3.7 Native Hawaiian Water Rights

The State Water Code, HRS §174C-101, contains the following provisions on native Hawaiian water rights:

- Provisions of this chapter shall not be construed to amend or modify rights or entitlements to water as provided for by the Hawaiian Homes Commission Act, 1920, as amended, and by chapters 167 and 168, relating to the Molokaʻi irrigation system. Decisions of the commission on water resource management relating to the planning for regulation, management, and conservation of water resources in the State shall, to the extent applicable and consistent with other legal requirements and authority, incorporate and protect adequate reserves of water for current and foreseeable development and use of Hawaiian home lands as set forth in section 221 of the Hawaiian Homes Commission Act.
- No provision of this chapter shall diminish or extinguish trust revenues derived from existing water licenses unless compensation is made.
- Traditional and customary rights of ahupuaʻa tenants who are descendants of native Hawaiians who inhabited the Hawaiian Islands prior to 1778 shall not be abridged or denied by this chapter. Such traditional and customary rights shall include, but not be limited to, the cultivation or propagation of taro on one’s own kuleana and the gathering of hihiwai, ʻōpae, ʻoʻopu, limu, thatch, ti leaf, aho cord, and medicinal plants for subsistence, cultural, and religious purposes.
- The appurtenant water rights of kuleana and taro lands, along with those traditional and customary rights assured by this section, shall not be diminished or extinguished by a failure to apply for or to receive a permit under this chapter. (The *exercise* of an appurtenant water right is still subject to the water use permit requirements of the Water Code, but there is no deadline to exercise that right without losing it, as is the case for correlative and riparian rights, which must have been exercised before designation of a water management area.)

[22] *Territory v Gay*, 31 Haw. 376 (1930); *aff’d* 52 F.2d 356 (9th Cir. 1931); *cert. denied* 284 U.S. 677 (1931).

[23] 54 Haw. 174, at 198; 504 P.2d 1330, at 1344 (1973).

While recognized as a public trust purpose, protecting **Hawaiian traditional and customary practices** has proven to be a complex and difficult task and such protections have only begun to be addressed by State agencies, including the Commission. Earlier versions of the Water Resource Protection Plan recognize the protection of traditional and customary practices as a role of the Commission, but do not clearly state how this would be implemented.

In Ka Pa‘akai O Ka‘aina v. Land Use Commission,[24] the Hawai‘i Supreme Court recognized that the State has an obligation to protect Hawaiian traditional and customary practices to the extent feasible, and that the proponent of an action must show sufficient evidence that these types of practices are protected, if they exist in the location in question. Consequently, the Court required an assessment of the following:

(1) “the identity and scope of ‘valued cultural, historical, or natural resources’ in the petition area, including the extent to which traditional and customary native Hawaiian rights are exercised in the petition area;

(2) “the extent to which those resources -- including traditional and customary native Hawaiian rights -- will be affected or impaired by the proposed action; and

(3) “the feasible action, if any, to be taken … to reasonably protect native Hawaiian rights if they are found to exist”

This “Ka Pa‘akai framework” was created by the Court “to help ensure the enforcement of traditional and customary native Hawaiian rights while reasonably accommodating competing private development interests.” The Commission is obligated to conduct a “Ka Pa‘akai analysis” of a proposed action requiring CWRM approval independent of the entity proposing the action. This analysis should be used to inform any decision on the impact of the proposed action on traditional and customary practices.

C.3 Goals and Objectives of the Commission on Water Resource Management

The general mission of CWRM is to protect and enhance the water resources of the State of Hawaii through wise and responsible management. Pursuant to this mission, CWRM applies broad resource management principles in its decisions, actions, declaratory orders, and program implementation. These principles are captured in the following list of CWRM goals and objectives. Other CWRM goals specifically pertinent to resource assessment, monitoring, regulation, conservation, and planning are discussed in Section 3 of the WRPP.

[24] Ka Pa‘akai O Ka‘aina v. Land Use Commission, 94 Hawai‘i 31, 7 P.3d 1068 (2000)

CWRM Goals:

- To protect the water resources of the State and provide for the maximum beneficial use of water by present and future generations.
- To develop sound management policies and a regulatory framework to facilitate decisions that are: a) proactive and timely, b) based on best available information and sound science, c) focused on the long-term protection and reasonable and beneficial use of both ground and surface water resources, and d) protective of water rights and public trust purposes.
- To achieve sound water-resource planning, extensive baseline and current data collection for ground and surface water, and statewide compliance with the State Water Code.

CWRM Objectives:

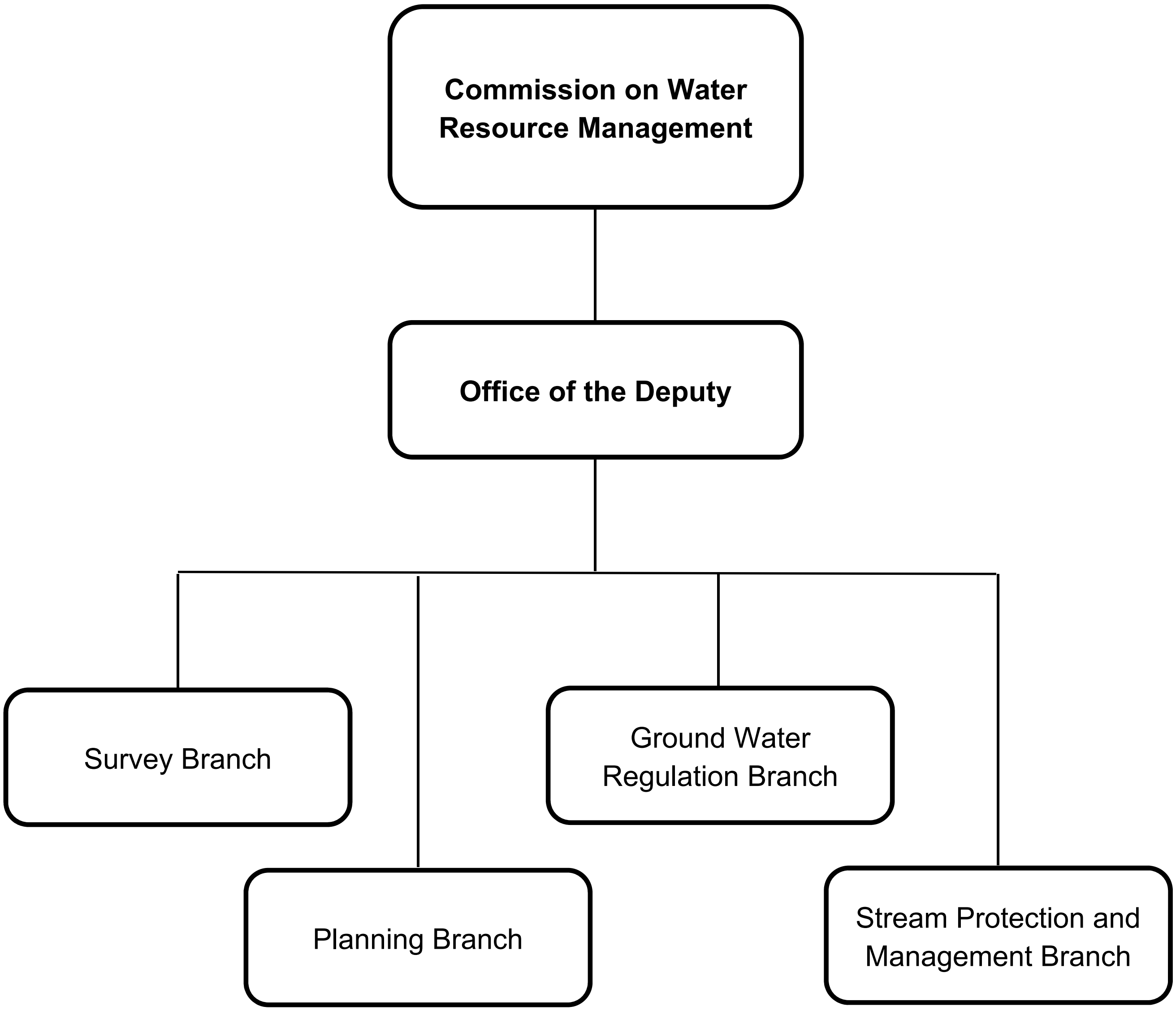
- Fulfill the State's responsibility, as trustee of water resources, to set policies, protect resources, define uses, establish priorities while assuring rights and uses, and establish regulatory procedures through the implementation and administration of the State Water Code.
- Seek legislative support, budget appropriations, federal funding, and grants to execute CWRM policies, goals, objectives, and programs, as they are defined and implied by the State Water Code and its directives for interpretation included in HRS §174C-2.
- Seek maximum beneficial use of the waters of the State with adequate provisions for the protection of public interest objectives, as declared in HRS §174C-2.
- Foster comprehensive water-resource planning for the development, use, protection, and conservation of water via implementing and updating the HWP, in accordance with the HWP requirements and objectives, as declared in the State Water Code and associated HAR.
- Fulfill the specific duties for research, resource protection, instream use protection, interagency cooperation, public education, program coordination, resource inventory and assessment, and determination of appurtenant rights, as declared in HRS §174C-5.
- Provide the regulatory and internal framework, including best use of information technology, for efficient ground and surface water management.
- Develop the best available information on water resources, including current and future water use monitoring and data collection, modeling activities, surface and ground water quality (chloride levels) and availability, stream flow, stream biota, and watershed health to make wise decisions about reasonable and beneficial use and protection of the resource.
- Support community-based management of water resources and develop short and long-range plans to avoid judicial and quasi-judicial disputes.

- Enhance and improve current stream protection and ground water protection programs for the benefit of future generations.
- Carefully consider the requirements of public trust uses, as determined by the Supreme Court’s use of the Public Trust Doctrine to inform the Court’s interpretation of the State Water Code.
- Administer and amend, as necessary, water use regulation programs to permit reasonable-beneficial uses of water in such a manner as to protect instream flows and maintain sustainable yields of ground water, as defined in the State Water Code.
- Execute, in conjunction with appropriate public, federal, State, and county agency consultation, CWRM’s responsibility to designate areas of the State for the purpose of establishing administrative control where water resources may be threatened by existing or proposed withdrawals, diversions, or water use.
- Strive to protect and improve the quality of the waters of the State through the administration of ground and surface water protection programs, in conjunction with the DOH.

C.4 CWRM Programs

CWRM currently seeks to meet these goals and objectives primarily through programs administered by CWRM staff. The core responsibilities of CWRM staff include planning, surveying, regulating, monitoring, and conserving the State's water resources within established plans that have been adopted by CWRM. Staff resources are organized into four branches: Survey, Planning, Ground Water Regulation, and Stream Protection and Management (see **Figure C-2**).

Figure C-2 CWRM Organizational Chart



The general duties and activities of each branch are summarized below.

Survey Branch Responsibilities:

- Collect basic hydrologic data and general water resource information in coordination and cooperation with other agencies.
- Conduct water availability and sustainable yield analyses for aquifers and watersheds statewide.
- Conduct topographic surveys, research, and investigations into all aspects of water occurrence and water use.
- Establish criteria for use by CWRM to determine the existence of water shortages.
- Identify areas of the state where saltwater intrusion is a threat to freshwater resources, and report findings to the appropriate county mayor and the general public.
- Provide technical services in support of CWRM programs administered by the Planning, Survey, Ground Water Regulation, and Stream Protection and Management Branches.
- Recommend acquisition of real property and easements through purchase, gift, lease, eminent domain, or otherwise for water resource monitoring, management and resource conservation purposes.

Planning Branch Responsibilities:

- Develop comprehensive, long-range plans for the protection, conservation, and management of water resources.
- Prepare, administer, and coordinate the development of the HWP and regular plan updates.
- Assist in the development of plans, studies, and scientific investigations involving assessments of water supply and demand, and instream uses of water, including biological, ecological, aesthetic, recreational and hydrological aspects of Hawaiian stream systems.
- Formulate water shortage and drought management plans for implementation during periods of prolonged water shortage.
- Formulate water conservation plans and resource augmentation strategies to address water supply and demand, and resource sustainability.
- Review and analyze statewide data on water consumption by municipal, agricultural, industrial, commercial, domestic, and instream uses.
- Establish and maintain interagency coordination between federal, State, and county governments and the private sector; and provide planning-related oversight in the processing of permits and the setting of instream flow standards to protect beneficial instream uses of water, as mandated by law.

Ground Water Regulation Branch Responsibilities:

- Implement Water Commission policies, procedures, and rules on ground water development and usage established in conformance with the State Water Code.
- Establish minimum standards for the construction of wells and the installation of pumps and pumping equipment.
- Administer permit systems for the construction of wells and installation of pumps and pumping equipment.
- Administer the designation of water management areas and the processing of applications for ground water use permits.
- Administer the investigation and enforcement actions necessary for permit conformance, citizen complaints and in the resolution of ground water related disputes.

Stream Protection and Management Branch Responsibilities:

- Implement CWRM policies, procedures, and rules on stream protection and instream flow standards, appurtenant rights, surface water development, and surface water usage established in conformance with the State Water Code.
- Administer the designation of surface water management areas and the processing of applications for surface water use permits.
- Administer a permit system for the alteration of stream channels and diversion of stream flow.
- Administer a statewide instream use protection program, including the establishment and amendment of instream flow standards.
- Administer the investigation and enforcement actions necessary for permit conformance, citizen complaints and in the resolution of surface water related disputes.

C.5 Summary

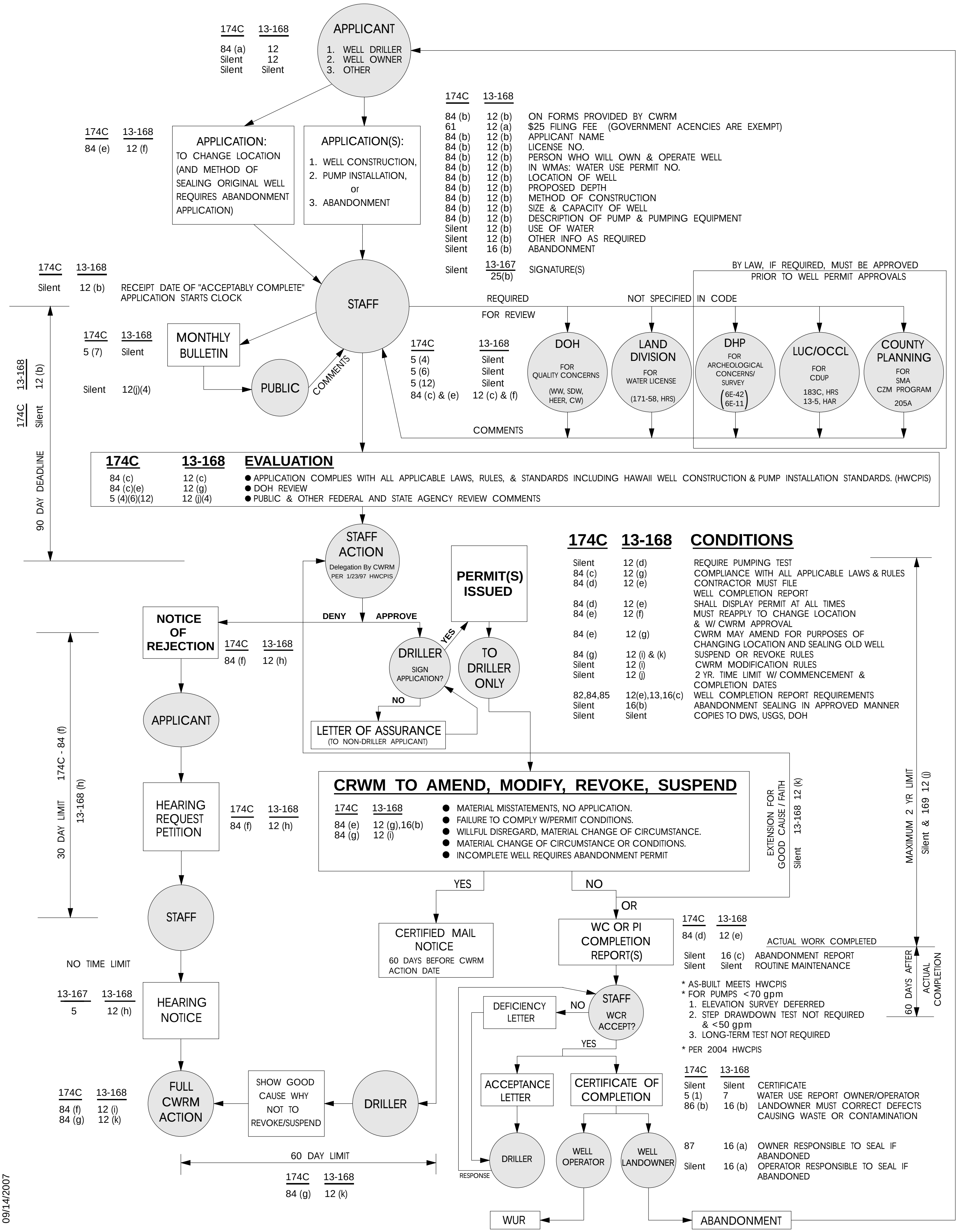
As demonstrated by the extensive documentation and literature that resulted from the Waiāhole Water Case proceedings, it is difficult to briefly summarize the spectrum of water management and policy issues, and this section is not intended for such a discussion. This section provides an overview of existing water management policies and tools, as well as background information to assist in understanding the provisions of the State Water Code, its applicability, and the extent of water rights. The remaining sections of the WRPP are presented within this context. Additional discussion of the legislative and administrative context for water planning in Hawaii is provided in **Appendix B Planning Context for the WRPP**.

APPENDIX D

Permit Process Diagrams

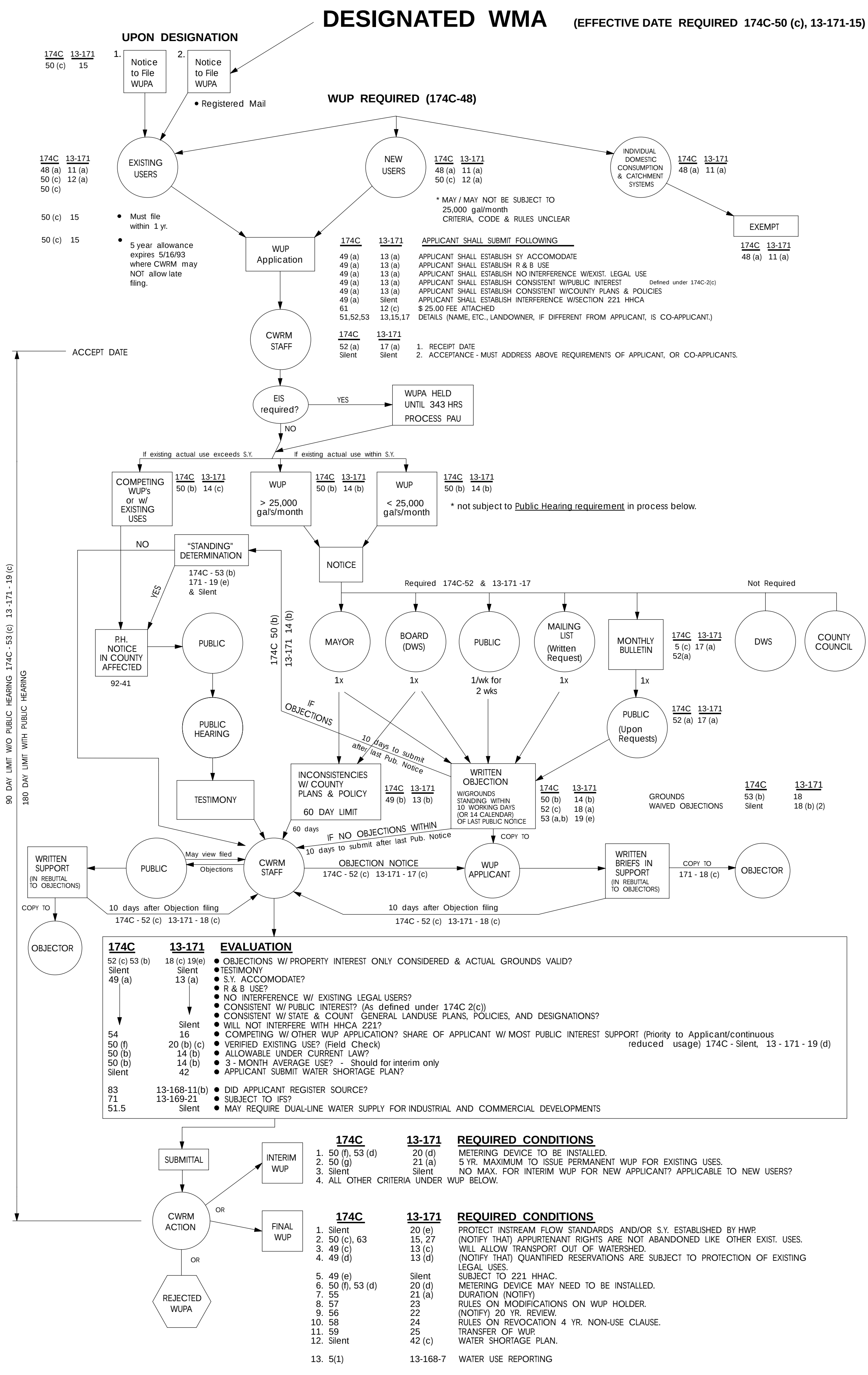
Water Resource Protection Plan 2019 Update

WELL CONSTRUCTION / PUMP INSTALLATION PERMIT PROCESS



09/14/2007

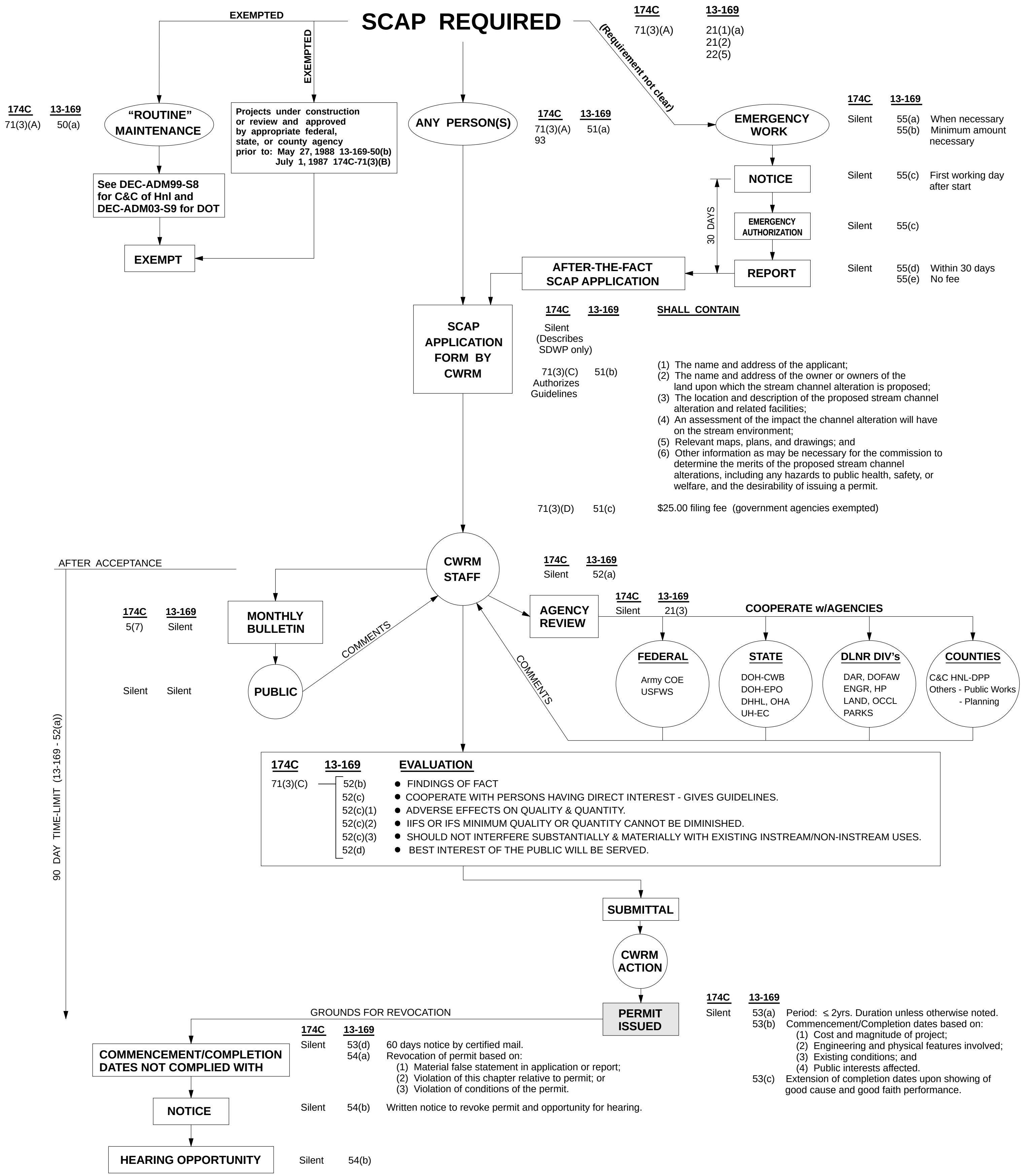
WATER USE PERMIT PROCESS



6/03/2004

SCAP PROCESS 174C-71(3)(C) & 13-169-50

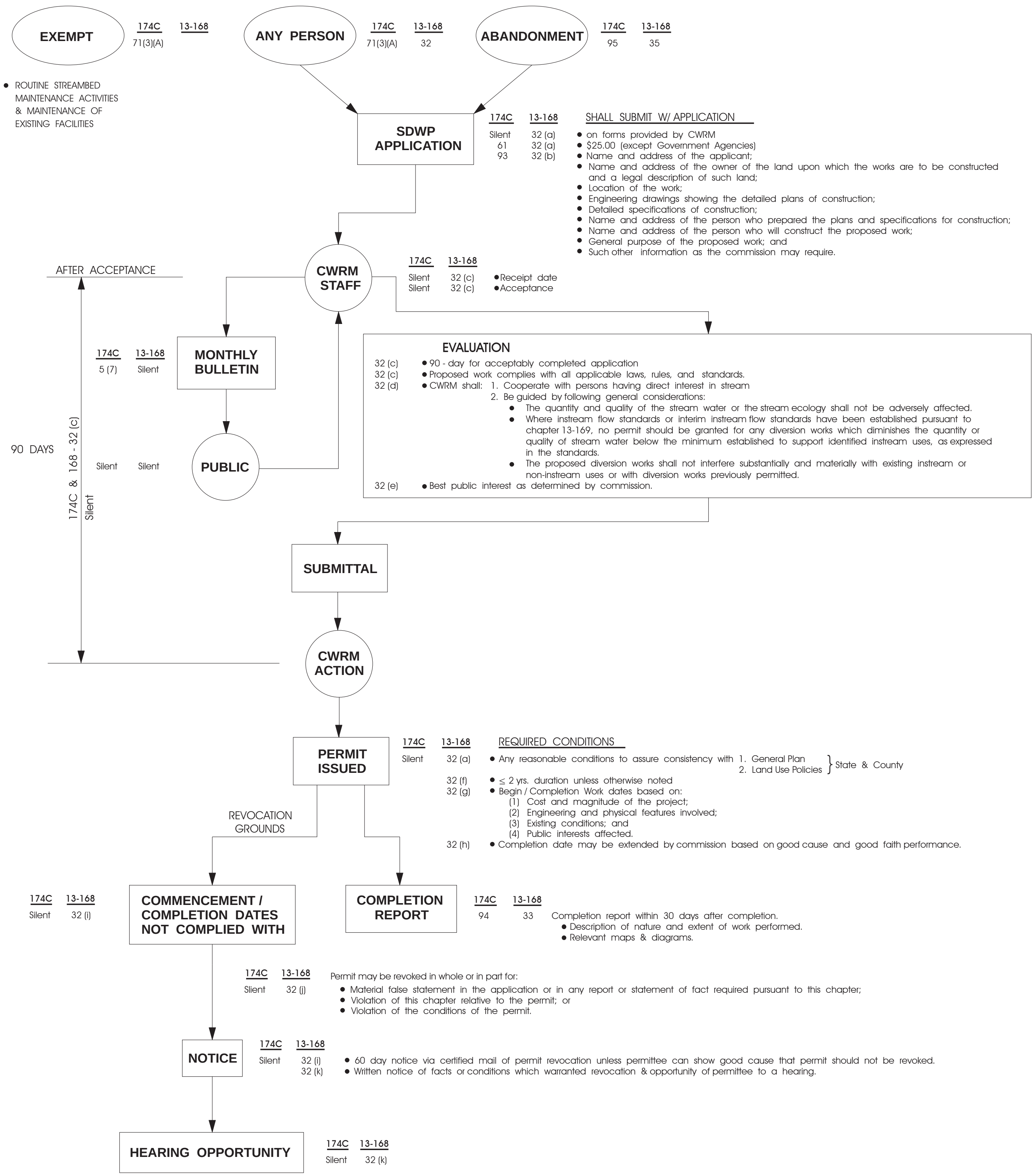
PURPOSE	174C	13-169	
	5(3)&71(3),(4)	1	Protect, enhance, and reestablish, where practical, beneficial instream uses of water including the creation of a permit system to regulate the alteration of stream channels.



4/9/2007

STREAM DIVERSION WORKS PERMIT (SDWP) 174C & 13-168

PURPOSE	174C	13-168	
	2(c)	Silent	• Adequate provision for protection and procreation of fish & wildlife, the maintenance of proper ecological balance and scenic beauty (in Public Interest)
	2(c)	1	• Maximum beneficial use



4/9/2007

INSTREAM FLOW STANDARD (IFS) PROCESS (174C-5,71(2) & 13-169-21(1))

PURPOSE	174C / 5,71(4)	13-169 / 1	To provide for the establishment of a statewide program to protect, enhance, and reestablish, where practical, beneficial instream uses of water, including the development for instream flows.

174C 3 — 13-169 2

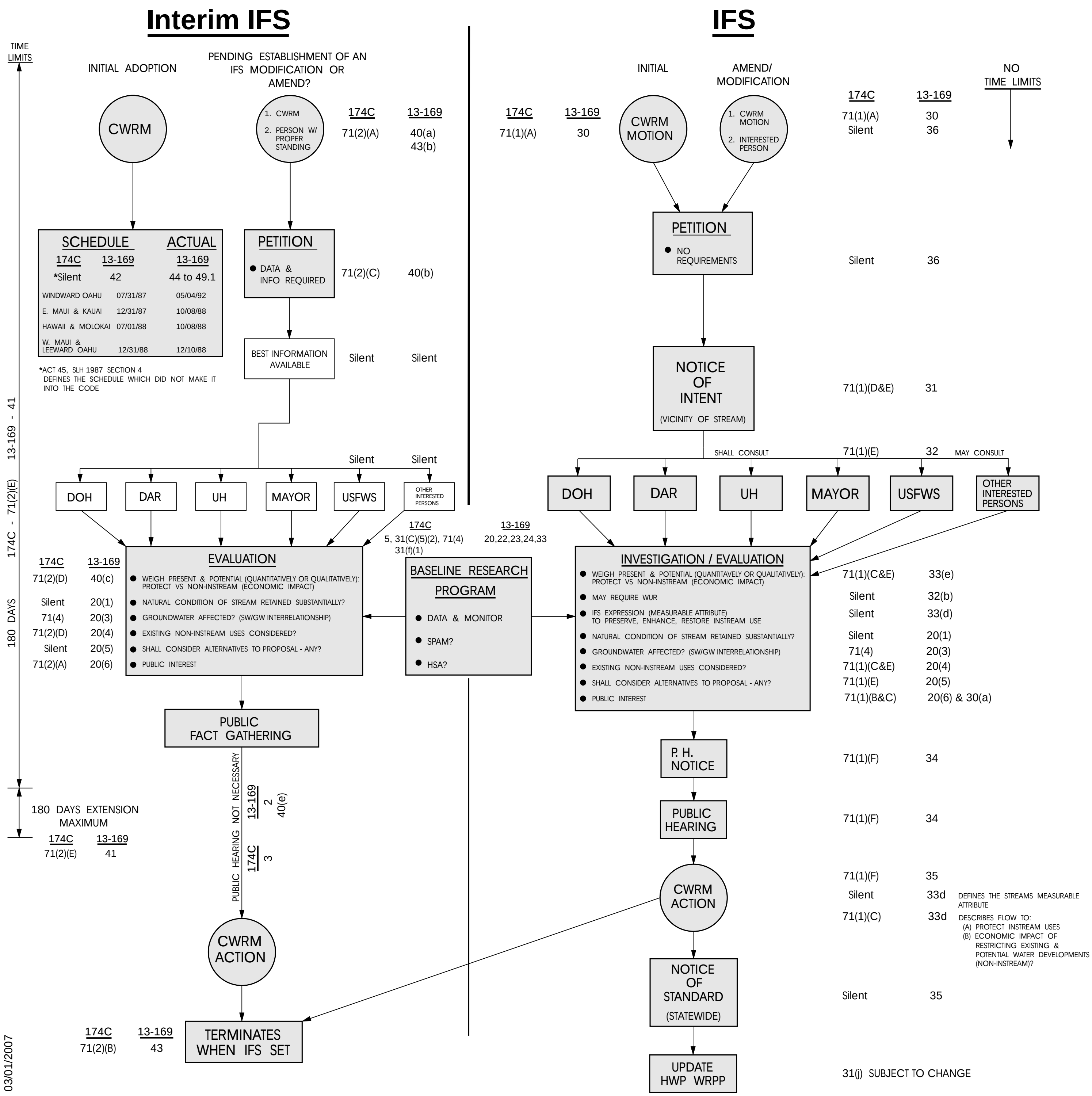
INSTREAM USES:

(1) MAINTENANCE OF FISH & WILDLIFE HABITAT;
(2) OUTDOOR RECREATIONAL ACTIVITIES;
(3) MAINTENANCE OF ECOSYSTEMS SUCH AS ESTUARIES, WETLANDS, AND STREAM VEGETATION;
(4) AESTHETIC VALUES SUCH AS WATERFALLS AND SCENIC WATERWAYS;
(5) NAVIGATION;
(6) INSTREAM HYDROPOWER GENERATION;
(7) MAINTENANCE OF WATER QUALITY;
(8) THE CONVEYANCE OF IRRIGATION AND DOMESTIC WATER SUPPLIES TO DOWNSTREAM POINTS OF DIVERSION; AND
(9) THE PROTECTION OF TRADITIONAL AND CUSTOMARY HAWAIIAN RIGHTS.

NON-INSTREAM USES:

- DOMESTIC
- AGRICULTURAL
- INDUSTRIAL

OUTSIDE OF STREAM CHANNEL



APPENDIX E

WRPP Update – Stakeholder Outreach Process

Water Resource Protection Plan 2019 Update

E WRPP Update Stakeholder Outreach Process

The major objective of the Water Resource Protection Plan (WRPP) is “to protect and sustain statewide ground- and surface-water resources, watersheds, and natural stream environments” (Statewide Framework for Updating the Hawaii Water Plan, February 2000, p. 3-1). In order to understand the issues, questions, values, and priorities that Hawai‘i’s communities have regarding water, the Commission on Water Resource Management (Commission) engaged in a multi-level stakeholder outreach process. A project fact sheet was developed to provide basic information on the WRPP Update, with links to the WRPP website for more and updated information and contact information, should stakeholders have any questions or want to provide further comments.

The planning team then conducted interviews with the following 13 governmental agencies or entities, non-governmental organizations, and private water consultants to get perspectives on different aspects of water science, use, and management:

- Consultant for private water users
- Department of Hawaiian Home Lands, Planning Office
- National Park Service
- Native Hawaiian Legal Corporation
- The Nature Conservancy
- Office of Conservation and Coastal Lands
- Office of Hawaiian Affairs, Public Policy Advocacy Division
- Pacific Regional Integrated Sciences and Assessments (Pacific RISA)
- State Attorney General's Office
- State of Hawai‘i Department of Health
- University of Hawai‘i Kamakakuokalani Center for Hawaiian Studies
- William S. Richardson School of Law, Ka Huli Ao Center for Excellence in Native Hawaiian Law; Environmental Law Program

The Commission also met with a working group of water system owners, utilities, scientists, and professional engineers who periodically provide professional critique and commentary on Commission plans, policies, methodologies, and strategies. Following this, the Commission held a series of “Hawai‘i Water Workshops” to inform the general public of the WRPP Update and to understand local water issues from various communities throughout the State. Workshops were held on O‘ahu, Lāna‘i, Maui, Moloka‘i, Kaua‘i, and in Kona and Hilo on Hawai‘i Island.

Comments and input from these various meetings and letters provided context and added perspective to the issues that the Commission is focused on. All of these various inputs were considered when identifying water resource issues and goals, as well as projects and tasks for inclusion in this WRPP Update. Included in this appendix are the Project Fact Sheet, Notes from the Water Professionals Meeting, and a Summary of the Hawaii Water Workshops.

WRPP Update Fact Sheet

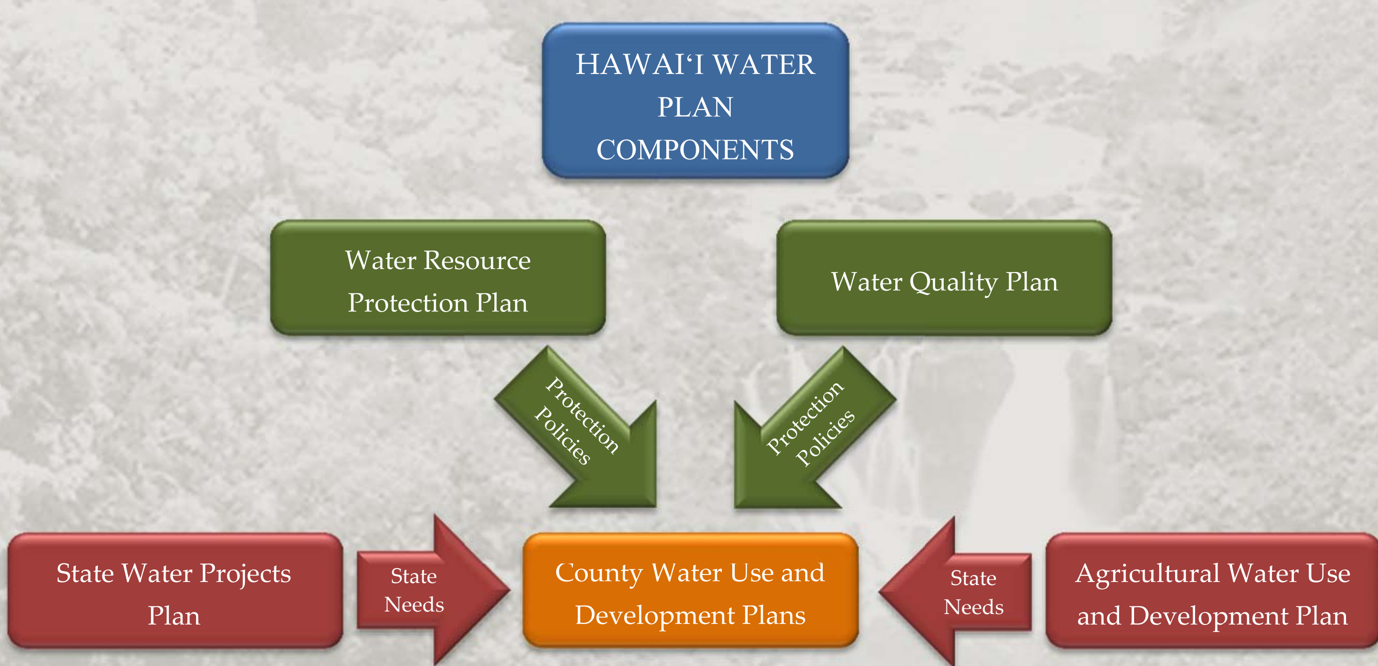
Water Resource Protection Plan Update

Water Resource Protection Plan Update

Guiding the Protection and Management of Our Fresh Water Resources

The Commission on Water Resource Management (Commission) is currently updating the 2008 Water Resource Protection Plan (WRPP). The WRRP is a key component of the Hawai'i Water Plan. Its objective is to protect statewide public trust water resources and uses, watersheds, and natural stream environments. At a minimum, the WRPP will:

- Document the types of water resources available, identifying hydrologic units and characterizing them by quantity and quality;
- Identify requirements for beneficial instream use and environmental protection;
- Describe Commission regulatory programs and resource monitoring efforts by the Commission and others;
- Describe existing and potential future water uses and their impacts on the resource, as well as their consistency with the objectives and policies presented in the WRPP; and
- Describe programs to conserve, augment, and protect water resources.



WATER RESOURCE PROTECTION PLAN UPDATE PROCESS AND SCHEDULE

2014 → 2015 → 2016 → 2017 → 2018 → 2018

WATER RESOURCE STATUS UPDATES

- Organize the project team
- Update 2008 WRPP chapters with new information
- Analysis of data and status of programs

- - - - - - - - - - - - - - - - -

- Water Commission Briefings
- Water Professionals Group Meetings
- Meetings with Agencies, Non-Governmental Organizations , and other stakeholders

DRAFT WRPP UPDATE

- Hold public "Water Workshops" to brief communities on water and to hear their issues
- Develop an Implementation Plan and Schedule
- Identify potential sources of funding
- Compile the Draft WRPP Report

- - - - - - - - - - - - - -

- Water Commission Briefing

PUBLIC REVIEW

- Distribute Public Review Draft WRPP
- Solicit and respond to public comments

- - - - - - - - - - - - - -

- Water Commission Briefing
- Public Hearings
  - Kona
  - Hilo
  - Maui
  - Lānaʻi
  - Molokaʻi
  - Oʻahu
  - Kauaʻi

FINAL WRPP UPDATE

- Revise Draft WRPP Update Report
- Finalize WRPP Update Report

- - - - - - - - - - - - - -

- Water Commission Briefing

As a part of this update, the Commission will:

- Incorporate new information obtained since the last update in 2008;
- Integrate the results of recent Commission and other relevant agency program activities with existing protection measures and management strategies;
- Further address emerging issues such as climate change; and
- Develop a succinct, action-oriented plan.

For more information, please contact:

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Commission on Water Resource Management
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Email: Jeremy.l.kimura@hawaii.gov

Sherri Hiraoka
Townscape, Inc.
Phone: (808) 536-6999, ext. 6
Email: sherri@townscapeinc.com

http://state.hi.us/dlnr/cwrm/planning_wrpp.htm

Water Professional Group Meeting Notes

Water Resource Protection Plan Update

TOWNSCAPE, INC.
ENVIRONMENTAL AND COMMUNITY PLANNING

900 Fort Street Mall, Suite 1160, Honolulu, HI 96813
Telephone (808) 536-6999 Facsimile (808) 524-4998
email address: mail@townscapeinc.com

WATER RESOURCES PROTECTION PLAN (WRPP) UPDATE
MEMORANDUM NO. 18

Date: **December 17, 2013**
To: **Project Files**
From: **Townscape, Inc.**
RE: **Water Professionals Group Meeting**

Meeting Participants:

Private Sector Professionals

- David Barnes, Waimea Water Services (WWS)
- Stephen Bowles, Waimea Water Services (WWS)
- Dan Lum, Water Resource Associates
- Tom Nance Water Resource Engineering
- Glenn Bauer (retired)

Commission on Water Resource Management (CWRM)

- Roy Hardy, Ground Water Regulation Branch
- Patrick Casey, Ground Water Regulation Branch
- Paul Eyre, Ground Water Regulation Branch
- Lenore Ohye, Planning Branch
- Jeremy Kimura, Planning Branch
- Neal Fujii, Planning Branch

County of Hawai'i Department of Water Supply

- Larry Beck (*phone*)

National Park Service (NPS)

- Paula Cutillo

UH Mānoa

- Clark Liu, Civil & Environmental Engineering, Water Resources Research Center
- Tom Giambelluca, Geography
- Craig Glenn, Geology & Geophysics
- Joseph Fackrell, Geology & Geophysics
- Aly El-Kadi, Geology & Geophysics, Water Resources Research Center
- Donald Thomas, Hawaii Institute of Geophysics & Planetology

Meeting Participants (continued)

U.S. Geological Survey (USGS)

- Stephen Anthony
- Delwyn Oki
- John Engott (*phone*)

Jeremy opened the meeting and reviewed its purpose: to present proposed revisions to the sustainable yield (SY) for Hawai‘i Island and to discuss concerns with the revisions and the methodology that was used to develop them. After a brief background on the Hawaii Water Plan and Water Resource Protection Plan (WRRP) Update process, Roy provided background on SY, the model used to develop the revised SYs, basic caveats associated with the numbers, and proposed SYs for Hawai‘i island (see attached slideshow)

Water Budget Model and Assessment of Groundwater Recharge for the Island of Hawai‘i (2011). John Engott then presented the results of the USGS study (*31:16 in audio file*)

- Report available on-line at: http://pubs.usgs.gov/sir/2011/5078/
- In forested areas, two reservoirs were used: forest canopy and soil. In unforested areas, only one reservoir was used: soil.
- The model calculated the water budget for each sub-area and aggregated the results. Hawaii Island had over 467,000 subareas.
- The estimated recharge distribution was based on:
    - Land cover (2008)
    - Mean rainfall from 1986 Rainfall Atlas of Hawaii (1916-1983 rainfall)
    - Mean Pan Evaporation 1985 study
- Differences in recharge between 2008 WRPP numbers and the new estimates: some were lower, some higher, and some over 100% higher. The new model:
    - Used a daily time step vs. an annual time step (2008 WRPP)
    - Included fog interception
    - Subtracted runoff from baseflow
    - Used a more rigorous approach to calculate evapotranspiration (ET)
- 2011 water budget report
    - Is a transient recharge model
    - Identified four aquifer systems in Kona: Kiholo, Keahou, Kealakekua, Kaapuna
    - Ran the model in 5-year increments
    - Used estimated rainfall from the time period: 1984-2008
    - The 1984-2008 rainfall estimates are presented in terms of the percent of the 1916-1983 rainfall mean presented in the 1986 Rainfall Atlas of Hawai‘i.
    - Shows that using more current rainfall could make a substantial difference in recharge estimates, particularly in the Kona area.

- New datasets being incorporated into the water budget studies:
  - 2011 Rainfall Atlas (1978-2007 rainfall data)
  - Updated historical rainfall – monthly rainfall (1920 – 2007, to be extended to 2010)
  - New ET datasets being finalized by T. Giambelluca (UH)
  - Updated methods for calculating runoff
  - New climate data
  - Estimating runoff in ungaged basins
  - Updated how canopy interception is calculated
- Ongoing recharge projects:
  - Kauai 1978-2007 recharge estimate (uses 2011 Rainfall Atlas) : long-term average for a given area
  - 2010-2011 recharge estimates; Cooperator: USGS Ground Water Resources Program; expected in 2015
  - Oahu 1870: predevelopment condition
  - Oahu long term average 2010-2011
  - Oahu future scenario: incorporates climate change estimates
  - Oahu 1900-2010 transient study in 10 –year periods; Cooperators: CWRM, BWS, USGS GWRP; expect incremental reports from mid-2014 to early 2015
  - Maui 1978-2007 recharge estimates
  - Maui 2001-2010 drought scenario; Cooperators: GWRP, CWRM, Maui DWS; expected 2014-2015
  - Molokai 1940 – 2010 transient study in ten year period; Cooperators: USGS, Office of Hawaiian Affairs, Department of Hawaiian Home Lands, Maui Department of Water Supply; expected late 2014
- Would like to update Hawaii Island with new datasets but currently no funding

PROPOSED 2014 WRPP HAWAIʻI ISLAND SY (*44:40 in audio file*)

- Generally affected upper range of SY; did not affect lower range of SY as much
- Yellow: lower ranges affected (*slide 19 of presentation*)
- Red: upper ranges affected (*slide 19 of presentation*)

DISCUSSION

- Hawi SY is too low
  - The original pumping numbers from sugar plantation days are a good starting point in determining more realistic numbers.
  - Water is being imported from Honokane and probably accounts for 50% of SY.
- Waimea and ʻAnaehoʻomalu aquifers – best available data is not being used
  - The table shows over 176 mgd recharge in ʻAnaehoʻomalu, but only about 20 percent of that in Waimea.

- We are currently pumping 14 mgd out of Waimea (nearing the lower end of the SY range) and only 4.3 mgd out of ʻAnaehoʻomalu, but sampling of shoreline discharge shows that there is at least an order of magnitude greater flow coming out of Waimea than ʻAnaehoʻomalu.
- The aquifer boundaries here do not make sense.
- The implication of recharge study is that there is more water in ʻAnaehoʻomalu, but on the ground observations contradict that. All wells drilled in ʻAnaehoʻomalu have been less productive and higher salinity than on the Waimea side of boundary.
- Northern side (Waimea) wells are tapping water from the Kohala Mountains. There are wells close to the boundary on both sides of Waiʻulaʻula Gulch at the 700′ elevation that are drinking-water fresh.
- **Starting with the recharge numbers is misleading. We need to start by redrawing the aquifer boundaries.**
    - The north boundary is far more important than the south.
    - This would shortchange the Mahukona aquifer, but a portion of the Kohala Mountains in the Mahukona aquifer above Waimea Town is a source of recharge to the Waimea aquifer.
- **Would not use the subsurface boundary as the aquifer boundary, but would move the aquifer boundary to the north to include the top of the Kohala Mountains.**
- Recharge for ʻAnaehoʻomalu would suggest that there is an average of 20 mgd coming out at the shoreline, but it's not coming out.
- There may be subsurface paths where groundwater is moving, which would explain the lack of coastal discharge from ʻAnaehoʻomalu, but there is actually a small fraction of that coming out. The water was never there.
- This area will become a hot spot in the future because it is slated for development.
- **Suggest new deep monitor wells in the Waimea/ʻAnaehoʻomalu Aquifer System Area (ASYA)**
- Puʻuanahulu State well (drilled but not cased) on the south boundary of ʻAnaehoʻomalu area. The open-hole pump test at the 1500-1600-foot well elevation yielded <100 Cl and eight-foot water level.

- **SY should be ranges, rather than a single number, but how should we determine the minimum and maximum?**

1:10:06 in the audio file – break for move

- Basal vs. High Level Aquifers (*1:18:55 in audio file*)
  - Hawai‘i Island is expected to develop both basal and high level water.
  - The RAM model only works for basal aquifers, so how do we determine SY for high-level aquifers?
    - For high level water, we make a conservative estimate. Is the 0.44 draft/recharge (D/I) ratio in the table (*slide 19 of the presentation*) a conservative estimate?
    - The 0.44 D/I ratio is from J. Mink's suggestion for basal aquifers, but it's the best we have for high level water.
  - Hilo borehole hit water at 10,000 feet below msl
  - Schofield SY was left at the status quo; no additional pumping is allowed. Not sure how much water is going to Pearl Harbor vs. North Aquifer Sector Area (ASA)
  - "Water budgeting" is problematic in that it suggests that we know all of the other parameters and are trying to figure out one "left-over" number, but in reality, there are two or three parameters subject to uncertainty.
  - For water budgeting, a daily time step may not make sense because the other data is averaged.
  - There are other methods to estimate recharge beyond the water budget method.
  - Numerical modeling is not ready to replace RAM or RAM2 models for estimating SY, but it is still valuable for other roles, such as delineating boundaries, testing conceptual models, etc.
  - **Recommendations for more study:**
    - Delineate boundaries between basal and high-level aquifers
    - How to evaluate high level SY; D/I estimation
    - How to utilize the RAM2 model in basal aquifer evaluation, which requires monitor well data (RAM does not require monitoring data)
    - In the long-term, we need to investigate other methods beyond hydrological budgeting and investigate the underlying physics more: recharge vs. how much infiltration actually takes place under different scenarios.
    - More research on water budget estimation
- Water budget models are useful in that they provide recharge data to be used in determining SY estimates, which is what the State needs.
- Suggest using SY as a starting point. Come up with a reasonable SY with an "easy" methodology that people can understand and agree on. Assuming there is a reasonable SY, what is the process for determining when things are ok or not ok, so we know when/where to enforce management? How do you know where there's a problem? Is there an alternative method other than SY to manage water resources?
  - **We need to simplify water resource management – use direct observation as a tool.**
  - **Monitor measurable elements: rainfall and water levels + pumpage + salinity + streamflow**

  - **Need to monitor in the high level area**
  - **Need to monitor on a regular basis to be able to see changes**
  - If we use SY as a starting point, how often and under what circumstances should we be revisiting SY? When data show evidence of some change in factors affecting SY.
- Professional vs. casual/citizen observer. CWRM is using technology to allow for each user to report use. Is it sufficient to have "non-professional" monitoring at a monthly interval?
  - Take advantage of data we can get, but have some quality assurance/quality control (QA/QC) for monitoring – how good is the data collected?
  - **Provide periodic training to those providing the data to check calibration methods and ensure that the data being used to make decisions (water levels, pumpage, etc.) is good data.**
  - CWRM is planning to hire a consultant to help get users on board with reporting and to verify that the older wells have a meter. New wells after 1997 are supposed to have meters, based on construction standards.
  - **It might it be better to get a good representation of wells across a given area, rather than try to get 100% compliance in reporting? Water professionals could agree to a set of key monitor wells.**
  - Kiholo USGS well had good data in real time, but it was discontinued due to vandalism.
  - Honolulu BWS collected island-wide water level data which was readily available, but CWRM doesn't have this kind of data set.
  - Due to limited resources and personnel, CWRM began its groundwater data collection program in "hot spot" areas. Complicating factors: collecting data on neighbor islands and on private property, large sampling areas. Resources will limit the amount of data that an organization is able to collect.
  - **Develop better collaboration between private and public partners to maintain a useful monitoring network.**
- CWRM will build off of existing data and analysis – e.g., Kona area.
  - Kona high-level wells are responsive to rainfall, so we should **concentrate on the high level aquifers** (e.g., Keopu). Look at where water is coming out from high-level to the basal. If water is coming out, identify where it is coming out.
  - Need to both get additional data and analyze existing data to find out what is happening in the high-level Keauhou-Kona area
  - Some high level well trends are inconclusive – there are large changes, +/-10 feet
  - **Need to re-establish the "Bauer-era" monitor well network**
- **In areas where the SY range is changing, CWRM should look at monitoring data and identify how to correlate monitoring efforts with management, then bring that up for discussion.**

- Water budgets and recharge estimates can be a starting point to revising SY, but there should be multiple lines of evidence for getting at SY, e.g., operational data. How do we incorporate operational data in the setting of SY?
- How are we going to address high level data if RAM does not provide that? Especially now that we've found high level water in the Keahou area, there is uncertainty as to how we are going to manage that resource.

- Results of the isotope study may help to ascertain the elevation that water is recharging and the path of ground water, but there are uncertainties.
  - Preliminary results suggest that recharge may be coming from high elevation rainfall and that water may not be going where most people think it is going.
  - Isotope analysis is complicated by mixing with seawater.
- Role of geologic data (i.e., deep borehole, gravity survey, data) in explaining ground water occurrence, aquifer boundaries, water movement and barriers (inferred dike systems, etc.) (*2:01:45 in audio file*)
  - Modeled gravity data and inferred substantial diking
  - Geologic structure is a major player in where groundwater is moving, but we do not understand the geologic structure.
  - Future expansion of magnetotelluric groundwater (MT) surveys could indicate where fresh water is and where the transition is between fresh and saltwater. There may be sharp boundaries in the ground water system. Study areas include Waimea region and the Hualalai transect.
  - Land access and permission are challenges to MT research projects.
  - Data expected hopefully by 2015.
- To model high elevation water, we need to know aquifer thickness.
  - Beyond a certain depth we assume that water will be stagnant.
  - Based on what we see at the Saddle borehole, porosity is maintained for about one kilometer. Beyond that, things "pancake."
  - At 5,000 feet, we can see the flow boundaries but they are "pancaked." Do not see the same loose formations we see at 2,000 feet.
  - Saddle borehole cores can help to determine porosity and find barriers. This type of analysis was not included in the current study, but the cores are available to others for analysis.
- Purpose of the borehole was to determine the elevation ground water is at and what is its water quality because the Army is interested in it as a potential water supply.
  - The first 2,900 feet of the hole is unstable and experienced a lot of caving. The team needed to install casing to 2,918 feet to stabilize the hole. Will be perforating the casing and doing a pump test in spring 2014.

  - The hole diameter is about 4-1/2-inched (casing) to the 2,918 foot depth, then HQ coring size from there to 5,786-foot depth. The only water that could be sampled is 1,100-feet below the surface of what appears to be the stable water table.
  - At about 3,000' to 4,000 feet below the surface, the rocks lose permeability.
  - The Waiki'i pump well went to 3,700 feet.
- At what depth is an aquifer non-water bearing or impermeable?
  - Hilo borehole saw different results from the Saddle borehole.
  - Hilo borehole drilled to 3,600 feet and found fractures that are much more open.
  - Started at about 25 feet above msl, drilled through 2,760 feet of lava before hitting submarine haloclastites, but even those were open.
  - Saw a flat temperature gradient until 4,500 feet, then saw conducted gradient. Core got mineralized and compacted. This seemed to happen sooner in Saddle borehole.
  - The Saddle borehole hit the first perched water at 500 feet depth to about 540 feet, hit another perched aquifer at 700 feet to 1200 feet, then hit a sequence of unsaturated zones. All standing water in the borehole was lost at around 1,500 feet, then the final water table was hit at 1,800 feet and the borehole never lost water after that. The bottom of the hole is at 600 feet above msl.
  - Large scale perching formations will affect water flow.
- Traditional and Customary (T&C) Practices (*2:16:00 in audio file*)
  - Is how we currently define sustainable yield enough? We currently allow for 56% of recharge to flow into the ocean?
  - Do we need a monitoring for outflow? Is that an end-use?
- Climate Change Impacts
  - There is a current study on climate change impacts (sea level rise) on O'ahu aquifers
  - Climate change (sea level rise) will affect anchialine ponds
    - Rising sea level will make the ponds more saline
    - It will occur faster on Big Island since it is sinking
    - Impacts depend on how sea level rise interacts with nearshore topography
  - Change in storage boundaries due to rising sea level
  - Changes in rainfall will also affect recharge. Has there been an analysis in rainfall patterns in Kona area (there are still a number of active gages)?
- Volcanic Eruption Impacts
  - Rainfall decrease of about 30% in Kona due to vog (data shows this in downwind rain gages).
  - Rainfall is corrosive due to atmospheric sulphur from volcanic emissions (acid rain)
  - Possible increased sulphur in rainfall, and thus in the groundwater?
  - Really high concentrations of pollutants in the rift zone area – Ka'ūpūlehu wells are enriched in every dissolved constituent. The water becomes semi carbonated and fouls up the R-O filters at Four Seasons resort.

   - Is the decline in rainfall in Kona exacerbated by volcanic activity (vog)? There is a correlation between decreased rainfall and vog, but there are no known studies that show causation. There are papers on polluted cities (where there are more particulates in the air) getthing reduced rainfall Water does not rain out of the atmosphere, but there tends to be more fog. There may be more fog interception in the upland Kona area.
- Is Kona high-level water moving into the basal aquifer – spillover vs. throughflow. The actual mechanism will affect management.

   Are the water bodies separate? How should we be treating this? Isotope studies are crucial so we can determine this.
   - Is basal water really just high level water just coming down? This is how we have been treating it. If not, how do we treat it?
   - If high level water is spilled over from the high level aquifer, then drawdown will have a more drastic effect than if we have throughflow, which would be driven by hydrostatic head. Drawdown of a few percent would affect throughflow by a few percent.
   - **Monitoring is essential. It will inform our understanding of how the systems work and we can then adjust our management.**
- Do we need something in Kona similar as the Pearl Harbor Monitoring Working Group that agreed on a monitoring network and triggers were proposed for management actions?
   - If we do not have a proactive approach, we will permit a lot of wells and development will occur, and we would have to pull back.
   - Oʻahu was developed and had to cut back, but we should be able to plan for it better now.
   - What is the best management philosophy?
- **We need to have better monitoring. We need to identify the most critical data points, and get data in a timely manner.**
- How do we factor T&C into the SY? How much is sufficient? Is leaving a certain percentage of the water in the ground enough?
   - **Begin with SY as a starting point. Do not modify SY, but take that and other things into consideration when evaluating T&C impacts: well location, drilling, site specific studies on ecosystems, and other factors which may impact T&C practices.**
   - T&C is very site specific but SY is over a broad area.
   - Ascertain T&C practices through the permitting process (Ka Paʻakai analysis).

<u>Next Steps</u>

- There are areas where SY numbers are in question: CWRM staff should take a look at those and re-send the table out to the group.
- D. Thomas to send Flinders, et.al., paper to CWRM.
- Bowles and Nance to propose boundary changes on aquifer map.
- Isotope study analysis may help to identify aquifer boundaries, but data will not come out until after the WRPP.
    - New sampling point: Pace's Ranch well (hit water 1,000 feet above msl) – for isotope study.
- University group to identify relevant academic research in the area.
- Group should suggest new research projects in the area to improve knowledge in the area.
- Locations for new deep monitor wells, particularly in Kona
- Potential to meet again, if needed.

Hawaiʻi Water Workshops Overall Summary

Water Resource Protection Plan Update

WATER RESOURCE PROTECTION PLAN UPDATE

HAWAI‘I WATER WORKSHOPS – OVERALL SUMMARY

March 2015

1 INTRODUCTION

The Commission on Water Resource Management (Commission) is currently updating the State Water Resource Protection Plan (WRPP), a long-range plan that provides guidance and direction for protecting and managing Hawai‘i's water resources. As a part of the WRPP update process, the Commission held seven public meetings, called "Hawai‘i Water Workshops," in March 2015 to inform the Commission's thinking as it formulates the WRPP Update.

Slideshow presentations were made at each workshop to share information on the State Water Code, Commission, WRPP and its current update, known water issues, and management practices engaged by the Commission. After the slideshow, workshop participants broke out into small groups to discuss water management issues and ideas in their communities. The small groups reconvened to share their main issues and suggested solutions before closing the meeting. Participants at the Kaua‘i Workshop had so many questions and discussion points after the slideshow that they did not break into smaller groups.

Table 1 Hawaiʻi Water Workshops

Island		Location	Date (2015)	Number of Participants Signed In
1	Oʻahu	DLNR Board Room 1151 Punchbowl Street, Room 132	March 3	40
2	Lānaʻi	Lānaʻi Senior Center 309 7th Street	March 11	21
3	Maui	Wailuku Community Center 395 Waena Street	March 12	76/100*
4	Molokaʻi	OHA/DHHL Kulana Oiwi Halau 600 Mauna Loa Highway, Suite D-2	March 17	24/30*
5	Kauaʻi	Planning Commission Meeting Room 4444 Rice Street, Suite A473	March 19	37/50*
6	Hawaiʻi (Kona)	West Hawaii Civic Center 74-677 Kealakehe Parkway	March 24	68
7	Hawaiʻi (Hilo)	Aupuni Center 101 Pauahi Street, Suite 1	March 30	51
				317/360*

* In some instances, rough visual counts exceeded the number of participants who signed in. The second number provided is an estimate of the number of participants that actually attended the workshop.

1.1 Types of Water Resource Comments

Hawaiʻi Water Workshop participants commented on a wide range of water resource topics. In some cases, comments related to topics that are not under the purview of the Commission and instead come under the responsibility and jurisdiction of other agencies and entities, such as the State Department of Health (water quality), County water departments (water transmission and pricing), or DLNR Division of Forestry and Wildlife (watershed health and management). All comments were recorded, regardless of whether or not the comment pertained to a Commission function or not.

Comments from each of the Workshops were recorded on large chart paper for participants to review. After the workshops, these hand-written notes were then transcribed and posted to the Commission web page on the Water Resource Protection Plan Update Hawaiʻi Water Workshops. Workshop materials, including the Workshop flyer, slideshows, and meeting notes are posted to the Commission website at:

http://dlnr.hawaii.gov/cwrm/planning/hiwaterplan/wrpp/wrpp2014/hiwaterworkshops/

The transcribed comments from each Workshop were sorted into the following water resource topics:

1. **Future Community Outreach**
2. **State Water Code**
3. **Governance**
4. **Community Representation/Involvement**
5. **Collaborative/Integrated Long-Range Water Management Planning**
6. **Management of Water and Enforcement**
7. **Data Collection. Monitoring, and Analysis**
8. **Stream Protection**
9. **Ground Water Protection**
10. **Climate Change**
11. **Integration of Land Use and Water Use**
12. **Water Scarcity, Availability of Water, and New Source Development**
13. **Waste and Conservation**
14. **Alternative Water Sources**
15. **Water Quantity and Quality**
16. **Watershed Management**
17. **Infrastructure/Conveyance, and Water Pricing**
18. **Implementation Management Strategies**

2 ISLAND/REGION SPECIFIC WATER RESOURCE ISSUES

A wide range of topics were discussed over the course of the seven Workshops, with region-specific issues emerging at each Workshop. The following is an overview of the water resource issues and topics that seemed to get the most discussion at each location.

2.1 Oʻahu

There was concern by participants that the Commission did not have the **resources** to fulfill its responsibilities. One noted area that participants felt was in need of improvement was **data collection, monitoring and analysis**. Several comments were made that additional data collection is needed to ensure wise decision-making. To supplement Commission data collection, suggestions were made to partner with other agencies, schools, universities, and communities to contribute data.

As an extension of the discussion on **collaborative efforts**, participants also expressed a desire for the Commission to bring all relevant stakeholders, including private sector, academic, environmental, and community entities, into **long-range planning** for water. At the same time, government agencies that share water resource responsibilities should also come together.

2.2 Lānaʻi

On Lānaʻi, the main discussion topics were related to **local input on decision making**, either through a community-based water management body, greater Commission presence on-island, or both. There was frustration that management decisions were being made at the State and County levels, with little understanding of what was actually happening on Lānaʻi. Participants also expressed a desire to have **access to the water resource monitoring data** that is used to make management decisions.

Additionally, concern was expressed over Lānaʻi's limited water supply and the need for **watershed protection** to maintain ground water recharge, promotion of a **conservation** ethic amongst residents, and investment in **alternative water supply options**, such as desalination.

2.3 Maui

The water resource issue that was raised the most on Maui related to **stream flow** and **impacts to native Hawaiian rights**. Many workshop participants questioned the need for stream diversions that were created decades ago to supply irrigation water to sugar plantations, leaving reduced flows in the streams for traditional and customary practices, including kalo farming for subsistence. Additional discussion focused on providing **water for agriculture**, particularly for DHHL lots and for food products to ensure food security.

A commonly cited strategy to address these and other water resource issues was a **return to traditional Hawaiian management systems**, including incorporation of the ʻAha Moku Council into decision-making, **community management and enforcement**, and **holistic, ahupuaʻa-based thinking**.

2.4 Molokaʻi

Molokaʻi Workshop participants were concerned with **water rights** and the hierarchy of uses. The protection of Hawaiian water rights were of particular concern, with several questions raised regarding the clarification and definition of water rights and the Waiola Case. **Water for DHHL residential and agricultural uses** was another topic that was raised often.

Regarding specific water supplies, many people were concerned with **protecting the Kaulapuʻu Aquifer** from overpumping. Some participants requested data on the sustainable yield of the aquifer and the quality of the water, along with **water resource data** – sustainable yields and pumpage - in general.

2.5 Kauaʻi

Workshop participants expressed frustration with the **level of interaction between the Commission and the Kauaʻi community**. In general, participants said that the Commission is inaccessible to residents and out of touch with their concerns and issues. It was recommended that more time and effort be spent in the places where water resource issues and problems are occurring, either through more time spent on-island by Commissioners and staff, an on-island Commission staffer, or use of technology. Additionally, the Commission should outreach to other agencies such as the County Planning Department and DHHL to help spread the word about meetings and the availability of data.

Another concern was **stream protection** and the impact of diversions on the health of surface water. Participants reported diversions that should be decommissioned, as well as issues with water not being available for **agriculture** due to the closing of reservoirs after recent tightening in regulations.

2.6 Kona

Much of the Workshop discussion was focused on the pending **petition to designate the Keauhou Aquifer as a Ground Water Management Area** (WMA). Concerns ranged from ensuring sustainable protection of the resource to the economic impacts of designation to the use of current data to support decision-making. There were many comments that questioned the validity of how the Keauhou Aquifer sustainable yield was calculated and inclusion of recent data and methods. Many participants were concerned with the added layer of regulation, especially because they said that it was already difficult to get water allocations for new uses.

This sentiment led to the idea that **decision-making should be kept at the county level**, as that provides the most direct link to the issues and people. With the current system, people have limited access to the decision makers (Commissioners). Issues should at least be heard on the island that it impacts and there should be enough time for all testimony. There should also be additional outreach using technology to **include a wider audience in the decision-making process** and to **disseminate data**.

2.7 Hilo

Many of the participants in the Hilo Workshop represented the rural areas of Hawaiʻi island where there is no County water service. As such, there was much discussion on alternative water sources, and water catchment systems in particular. Many were concerned about the **public health and safety issues related to catchment systems**, such as water pressure for fire protection and the potential for infectious disease from improper maintenance of the systems. Participants requested research on the vulnerabilities of catchment systems, education to users on proper maintenance of the system and treatment of water, and future County water service to eliminate the need for catchment systems.

Several other issues received significant discussion, including the desire for more **collaboration** among agencies, better **data collection**, greater **local control over decision-making**, clarification and protection of **Hawaiian water rights**, including those of DHHL, and protection of **water quality**.

3 COMMON WATER RESOURCE ISSUES THROUGHOUT THE STATE

While each island/region had its own water resource issues and concerns, several topics were raised repeatedly throughout the State. The following is a discussion of some of the issues that were raised at several, if not all workshops.

Participants at nearly all of the workshops discussed the importance of **local involvement in water management**. There was frustration over what is perceived to be a “Honolulu-centric” decision-making body that is not in tune with the local context of the neighbor islands. Some suggestions presented at the workshops included local water committees that are given advisory power, on-island Commission staff, and more access to Commissioners and staff. To assist in local community participation in decision-making processes, it was suggested that Commission meetings be held on the island that will be affected by major decisions, and sufficient time allocated for public testimony; that data be presented in easily understood formats and posted on-line; and that the Commission adopt technology such as video-conferencing for meetings and digital submittals of testimony.

Another universal concern was the identification, clarification, and protection of **water rights**, particularly Hawaiian water rights. All of the workshops included at least some discussion of protecting traditional and customary practices and providing for DHHL water needs. Associated with that was the Commission’s task of balancing various uses and water rights. To address this, workshop participants recommended that water rights be clearly defined, that the type of water and water sources be matched with specific water needs, and that traditional Hawaiian water management systems and methods be adopted.

A water use that was supported on every island was **agricultural irrigation**, and in some cases, agricultural water needs on DHHL lots. Water for agriculture was seen as important for food security, warranting a higher priority. There was some tension between private uses of water vs. public uses, with many large private water users evolving from former sugar plantations into diversified private uses, such as residential and resort development.

With so many competing uses for water, workshop participants wondered about the **future availability of water, the potential for drought, the impacts of climate change, protection of water quality, and impacts to surface and ground water**. To prepare for future water needs, participants proposed enforcement of management and monitoring requirements, replenishing ground water supplies via watershed protection, matching water quality and sources with types of water use (i.e., non-potable water for irrigation vs. potable water for drinking), finding ways to decentralize water sources and treatment, emphasis on demand-side management, promotion of conservation through education, exploration of alternative sources of water, proper maintenance of water infrastructure, better integration of land use planning with water use planning and water quality with water quantity, and collaboration with all relevant stakeholders, including government, private, and community sectors.

In order to implement such long-range planning, every island recognized that consistent and relevant **water resource data** needs to be collected. In addition to more data collection, participants wanted to be able to publicly access the data. To supplement the Commission’s data collection programs, participants recommended partnerships with other agencies, schools, universities, and community groups. This highlighted a general consensus that the Commission lacks the resources to carry out the responsibilities that they are tasked with. **Additional resources** in terms of budget and staffing were recommended to allow the Commission to perform their duties.

APPENDIX F

Inventory and Assessment of Resources

Water Resource Protection Plan 2019 Update

F Inventory and Assessment of Resources

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F Inventory and Assessment of Resources

This section provides information on the nature and occurrence of water resources in the State of Hawaiʻi, as mandated by the State Water Code. It also includes discussions on the human impacts to those resources and the issues, challenges, and opportunities for improving management and protection practices. A “systems area” approach to water resource management is taken to recognize the connections between ground and surface water resources. CWRM encourages the exploration and application of this approach through the information presented herein and through State actions to support sustainable management of water resources. The remaining sections are generally organized as follows:

- **Evolving Issues in Water Resource Management**: This section highlights major issues that impact water resources in Hawaiʻi. CWRM considers these issues when inventorying and assessing water resources for management purposes.

- **Managing Hawaiʻi’s Water Resources for Sustainability:** Human beings are constantly impacting the natural hydrologic cycle. To address climate change and increased populations and water needs, CWRM’s “Systems Area” hydrologic unit approach and goals and objectives for water resource inventory efforts and tracking are described. Also listed are items specifically applicable to ground water and surface water inventory and assessment.

- **The Hydrologic Cycle:** A short overview of how water moves among the ocean, the atmosphere, and the Earth is provided to set the stage for the subsequent discussion on the nature and occurrence of ground and surface water.

- **Nature and Occurrence of Ground Water:** Information on ground water occurrence and aquifer settings is followed by an explanation of the ground water hydrologic units as delineated by CWRM and how ground water availability is quantified and assessed. Finally, an inventory of hydrologic unit aquifer system areas and their sustainable yields are presented with additional supporting information incorporated by reference.

- **Nature and Occurrence of Surface Water:** Similar to the previous section on ground water, surface water occurrence and settings are described and followed by an explanation of the surface water hydrologic units delineated by CWRM. Information on the quantification of stream flow is accompanied by a summary of issues associated with quantification and assessment of resources. The section on surface water concludes with an inventory of surface water hydrologic units with information on instream flow standards as determined thus far.

F.1 Evolving Issues in Water Resource Management

F.1.1 Ground and Surface Water Interaction

> *Traditionally, management of water resources has focused on surface water or ground water as if they were separate entities. As development of land and water resources increases, it is apparent that development of either of these resources affects the quantity and quality of the other. Nearly all surface-water features (streams, lakes, reservoirs, wetlands, and estuaries) interact with ground water. These interactions take many forms. In many situations, surface-water bodies gain water and solutes from ground-water systems and in others the surface-water body is a source of ground-water recharge and causes changes in ground-water quality. As a result, withdrawal of water from streams can deplete ground water or conversely, pumpage of ground water can deplete water in streams, lakes, or wetlands. Pollution of surface water can cause degradation of ground-water quality and conversely pollution of ground water can degrade surface water. Thus, effective land and water management requires a clear understanding of the linkages between ground water and surface water as it applies to any given hydrologic setting.*
>
> *– Robert M. Hirsch, Chief Hydrologist, USGS*[1]

In the above excerpt from the 1998 United States Geological Survey (USGS) Circular 1139, author Robert M. Hirsch summarizes the difficulties faced by scientists and water managers in understanding the integrated nature of ground and surface water systems. From a government perspective, the typical administrative separation of ground and surface water management creates additional challenges for most water managers, especially as research efforts constantly reveal new aspects, venues, and extent by which ground and surface water systems are interdependent. The intent of USGS Circular 1139 is to help Federal, State and local agencies construct a scientific base for the development of policies governing the management and protection of aquifers, streams, and watersheds.

The author further asserts that, "**Effective policies and management practices must be built on a foundation that recognizes that surface water and ground water are simply two manifestations of a single integrated resource**." The document emphasizes that management of one component of the hydrologic system, such as a stream or an aquifer, tends to be only partly effective because each hydrologic component is in continuous interaction with other components. Concerns related to water supply, water quality, and degradation of aquatic environments are frequently at the forefront of water management issues, and the interaction of ground water and surface water has been, and continues to be, a significant area of focus and deliberation. Hirsch provides an example where contaminated aquifers that discharge to streams can result in long-term contamination of surface water and, conversely, streams can be

[1] *USGS Circular 1139: Ground Water and Surface Water: A Single Resource,* <http://water.usgs.gov/ogw/gwsw.html>.

a major source of contamination to aquifers. Although this scenario may be more common throughout the Continental US, this could also occur in Hawaiʻi, where the implications and impacts of cross-contamination may be devastating to our limited water resources, population, and environment.

Although surface water typically has a hydraulic connection to ground water, according to Hirsch, the interactions are difficult to observe and measure and "commonly have been ignored in water-management considerations and policies." The limited understanding of ground and surface water interactions makes it difficult to characterize the processes.

In Hawaiʻi, water managers, government agencies, and hydrologists struggle with ground and surface water interactions, as most dramatically demonstrated by high-profile water disputes in East Maui, in the Wailuku area on Maui (ʻĪao Aquifer System Area), and in Windward Oʻahu (Waiāhole Ditch System). Due to the volcanically-formed aquifers, island topography, and tropical climate, surface water and ground water interactions are typically unique in comparison with the larger-scale river basin watersheds and expansive sedimentary aquifer systems typical of mainland US areas. Nevertheless, the large-scale concepts, themes, issues, and investigations related to ground and surface water interaction remain pertinent to Hawaiʻi in that they provide insight for consideration and adaptation for island systems. The following examples of common water-resource issues, as adapted from Hirsch, are provided to demonstrate how understanding the interconnections between ground water and surface water are "fundamental to development of effective water-resource management and policy."

F.1.2 Water Supply

- It has become difficult in recent years to construct or even maintain reservoirs for surface storage of water because of environmental and safety concerns and because of the difficulty in locating suitable sites. An alternative, which can reduce or eliminate the necessity for surface storage, is to use an aquifer for temporary storage of water. For example, water stored underground during times of high streamflow can be withdrawn during times of low streamflow. The characteristics and extent of the interactions of ground water and surface water affects the success of such conjunctive-use projects.

- Decisions impacting instream flow standards should account for surface water diversions and ground water interaction, if applicable. These decisions should consider ground water withdrawals and changes to recharge from changes in irrigation source and end use patterns and other land-surface applications of water. However, accounting for these ground water components can be difficult and controversial.

- In some regions, the water released from reservoirs decreases in volume, or is delayed significantly, as it moves downstream because some of the released water seeps into the streambanks. These losses of water and delays in travel time can be significant, depending on antecedent ground water and stream flow conditions as well as on other factors such as the condition of the channel and the presence of aquatic and riparian vegetation.

- Ground water pumping impacts to stream flow and coastal leakage are becoming an increasing concern in regard to setting sustainable yields. Although the advantage of using aquifers for storage is clear when utilizing ground water for domestic public trust purposes, pumpage may change the shape and size of such storage, possibly changing the locations and outflows from the aquifer to streams and coastal leakage. These changes, in turn, are raising concerns regarding the protection of traditional and customary rights, even when the sustainable yield of the aquifer itself is protected. To address these concerns, studies are needed to identify and quantify the impacts of reducing aquifer discharge and to clarify the impacts on ecosystems and related traditional and customary rights. In turn, these impacts should be considered when setting sustainable yields for aquifer system areas. These will most likely be localized and site specific, even within individual hydrologic units. (i.e. aquifer system areas). This issue is discussed more fully in **Section F.2.1**.

F.1.3 Water Quality

Hawaii Department of Health is responsible for managing and regulating contamination and pollution of both surface and ground water. Their roles and responsibilities are further described in **Appendix M**.

- Much of the ground water contamination in the United States is in shallow aquifers that are directly connected to surface water. In some settings where this is the case, ground water can be a major and potentially long-term contributor to contamination of surface water. Determining the contributions of ground water to contamination of streams and lakes is a critical step in developing effective water management practices.

- A focus on watershed planning and management is increasing among government agencies responsible for managing water quality as well as broader aspects of the environment. The watershed approach recognizes the interactions between ground and surface water. Integrating ground water into this “systems” approach is essential but challenging because of limitations in knowledge of the interactions of ground water and surface water. These difficulties are further complicated because the boundaries between surface water watersheds and ground water aquifers may not coincide.

- To meet water quality standards and criteria, State and local agencies need to quantify the contaminants entering surface waters (wasteload) so they can issue permits and control discharges of waste. Typically, ground water inputs are not included in estimates of wasteload; yet, in some cases, water quality standards and criteria cannot be met without reducing contaminant loads from ground water discharges to streams. Even under natural conditions, ground water inputs may elevate the levels of some contaminants above water quality standards.

- It is generally assumed that Hawai‘i’s ground water is safe for consumption without treatment. However, there has been increasing concern about the quality of ground water from wells that may be impacted by contaminated surface water and increasing interest in identifying when filtration or treatment of ground water is needed.

- Wetlands, marshes, and wooded areas along streams (riparian zones) are protected in some areas to help maintain wildlife habitat and the quality of nearby surface water. Greater knowledge of the water-quality functions of riparian zones and of the pathways of exchange between shallow ground water and surface water bodies is necessary to properly evaluate the effects of riparian zones on water quality.

- More recent concerns have been raised concerning the impacts of ground water discharge to the water quality of anchialine ponds and submarine coastal leakage and its effects on nearshore ecology and traditional and customary rights.

F.1.4 Characteristics of Aquatic Environments

- Human activities that alter the acidity, nutrients, temperature, chlorides, and dissolved oxygen of either or both ground and surface water may have a significant effect on aquatic environments, particularly where ground and surface water mix, or where there are changes in the natural interaction of ground and surface water.

- The flow between surface water and ground water creates a dynamic habitat for aquatic fauna near the interface. These organisms are part of a food chain that sustains a unique ecological community. Studies indicate that these organisms may provide important indications of water quality changes.

- Many wetlands are dependent on a relatively stable influx of ground water throughout changing seasonal and annual weather patterns. Wetlands can be highly sensitive to the effects of ground water development and to land use changes that modify the ground water flow regime of a wetland area. Understanding the interaction between wetlands and ground water flow is essential to assessing how wetlands impact water quality, ground water flow, and stream flow in large areas.

- The success of new wetlands constructed to replicate those that have been destroyed depends on the extent to which the replacement wetland is hydrologically similar to the destroyed wetland. For example, the replacement of a wetland that is dependent on ground water for its water and chemical input needs to be located in a similar ground water discharge area if the new wetland is to replicate the original. Although a replacement wetland may have a water depth similar to the original, the communities that populate the replacement wetland may be completely different from communities that were present in the original wetland because of differences in hydrogeologic setting.

F.2 Managing Hawai‘i’s Water Resources for Sustainability

The movement of water between the atmosphere, the land, and the ocean is described by the hydrologic cycle. In Hawai‘i, solar energy and other factors cause the evaporation of water from the ocean. Clouds form and render their moisture over the islands. This rainfall supports stream flow and replenishes ground water, while a portion returns to the atmosphere.

Human settlement has changed the land-related components of the hydrologic cycle. For example, early Hawaiians diverted the natural flow patterns of streams through ‘auwai (a ditch or canal) to provide water for agriculture, but much of the water was eventually returned to downstream segments of the stream. Later, as the sugar industry became established in Hawai‘i, large-scale stream diversions and wells were constructed and exported water to out-of-basin areas to support the plantations and the needs of the growing population. Most recently, the decline of plantation agriculture and increasing urbanization have significantly altered drainage and ground water recharge patterns. The cumulative effects of land use changes and other human activities can shift the natural balance of the hydrologic cycle. Such changes can have profound social, environmental, and economic impacts within our island communities.

F.2.1 Ground Water Dependent Ecosystems and Sustainable Yield

Ground water supplies about 90% of the drinking water in Hawai‘i and demands for this water resource are expected to grow as population increases. An issue that is of growing concern is the impact of ground water development on near shore ecosystems dependent on ground water to meet some or all of their water requirements. Known as ground water dependent ecosystems (GDEs), these biological communities should be assessed in greater detail with respect to their relationship with ground water discharge. In Hawaii, GDEs support a variety of valuable ecosystem services, such as flood control, water supply, water purification, recreational opportunities, biodiversity, and traditional and customary rights. However, the current approach for managing ground water in Hawaii does not explicitly account for the ground water discharge needs of GDEs.

The current management approach involves the establishment of sustainable yields for delineated aquifer system areas. For most aquifers, CWRM uses a Robust Analytical Model (RAM) to derive sustainable yield estimates. RAM is a simple tank model based on fundamentally accepted hydraulic principles that can be applied quickly and easily to any aquifer for which estimates of recharge, original head, and equilibrium head are available with the purpose of protecting optimally placed wells and the aquifer itself. While RAM limits ground water development to roughly half the recharge for most basal aquifers - allowing the other half to continue to discharge at the coast - no analysis of the actual needs of GDEs is conducted. In addition, the actual amount of discharge at any given point along the coast is influenced by the location of wells, the distribution of pumpage, and localized coastal discharge points such as springs. There are a number of other assumptions and limitations associated with RAM. RAM was developed for unconfined basal aquifers and assumes a sharp interface between freshwater and saltwater, homogenous and isotropic aquifer conditions, and uniform, laminar ground water flow. RAM also assumes optimal well spacing and an even pumpage distribution, which is not the case for most aquifers. Please refer to **Section F.4.3.3** for a more detailed discussion of RAM.

Our precautionary approach to management warrants a review of other management tools. A review of global policy initiatives for the protection and management of GDEs undertaken by Rohde et al[2] in 2017 reveals that specific reference to ecosystems dependent on ground water has only been incorporated into a handful of legislation in the United States, the European Union, South Africa, and Australia. Of these, Australia was found to have the most comprehensive framework to manage and protect GDEs. Following is a summary of Australia's approach, as presented by Rohde, et al.

Australia has embraced an adaptive management approach to protecting GDEs as required under its National Water Initiative of 2004[3]. The adaptive management strategy utilizes ongoing monitoring and targeted research to determine ecological water requirements and thresholds of GDEs and uses best available information to inform management decisions. Due to the diversity of GDEs, thresholds must be ***locally*** [emphasis added] determined. Choosing appropriate indicators and developing monitoring protocols are a key part of implementation. Due to the large degree of uncertainty and knowledge gaps at the onset, Australia has taken a precautionary approach by incorporating risk management to help to minimize adverse consequences to vulnerable GDEs of high ecological value in the interim.

California also utilizes an adaptive management approach to protect GDEs. Recognizing that "environmental uses of groundwater" is a beneficial use,[4] local ground water sustainability agencies must identify and consider impacts on all beneficial uses and users in their ground water sustainability plans by setting measurable objectives to avoid undesirable outcomes. A 2015 review of literature and existing ground water management plans by the Union of Concerned Scientists[5] indicates that effective measurable objectives achieve the following:

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[2] Rohde, M.M., Froend, R., and Howard, J., 2017 May, A Global Synthesis of Managing Groundwater Dependent Ecosystems Under Sustainable Groundwater Policy, *Ground Water*, 55(3):293-301.

[3] *Intergovernmental Agreement on a National Water Initiative*, http://www.agriculture.gov.au/SiteCollectionDocuments/water/Intergovernmental-Agreement-on-a-national-water-initiative.pdf

[4] 2014 Sustainable Groundwater Management Act (with 2015 amendments). <http://groundwater.ca.gov/docs/2014%20Sustainable%20Groundwater%20Management%20Legislation%20with%202015%20amends%201-15-2016.pdf>

[5] Union of Concerned Scientists. September 2015, *Measuring What Matters.* <http://www.ucsusa.org/sites/default/files/attach/2015/09/measuring-what-matters-california-sustainable-groundwater-report.pdf>

- define a clear baseline;
- set quantitative thresholds
- develop protective triggers that require action before reaching a threshold;
- incorporate regular measurement and monitoring;
- account for uncertainty; and
- adapt to changing conditions and new information.

Each local ground water sustainability agency must set interim milestones in five-year increments and achieve the sustainability goal for each basin within 20 years of plan implementation. Each agency's plan must also summarize the type of monitoring sites, measurements, and frequency, as well as protocols to detect changes in ground water conditions.

In Hawaii, concerns over GDE impacts due to ground water withdrawals have been raised in several water cases over the years. Most recently, this was the central issue in a petition to designate the Keauhou Aquifer System Area on Hawaii Island as a ground water management area. (Please refer to **Appendix I CWRM Regulatory Programs** for more information on water management areas and associated regulatory controls.) The National Park Service (NPS) filed the petition in 2013 to preserve and protect the underground fresh water flows that support cultural and natural resources along the Kona coast, including the Kaloko-Honokōhau National Historical Park. Through its adjudication of the case, CWRM recognized the need to refine its management approach to ground water and requested that its staff study ways to refine the estimation of sustainable yields to account for the needs of GDEs. For more up-to-date information on this issue, please visit our website at <http://dlnr.hawaii.gov/cwrm/groundwater/activities/keauhou/> (accessed June 24, 2019)

Based on the best available information, CWRM staff should propose action triggers and develop a suite of possible management actions for consideration by CWRM. It is recommended that CWRM build on the work done by NPS to establish an adaptive management approach for the Kaloko-Honokōhau National Historical Park as a priority pilot project. This approach can then be applied to other areas in the State where concerns over the impacts of ground water withdrawals on GDEs have been raised.

F.2.2 Applying the "Systems Area" Approach to Water Resource Management

The WRPP encourages effective ground and surface water management through the application of a hydrologic unit systems approach that focuses on the interaction and feedback that occurs between ground and surface water systems and management decisions. Imposed stresses impact the physical ground water system (geologic framework, hydraulic properties, and boundary conditions); with changes observed to ground water levels, discharge rates, and water-quality conditions.

F.2.3 Goals for Water Resource Inventory and Assessment

It is evident that short- and long-term climate change is shifting the natural balance of the hydrologic cycle. Measured long- and short- term declines in Hawai‘i’s rainfall and streamflow are well documented. These can also produce profound social, environmental, and economic impacts within our island communities.

To sustainably manage water resources, it is critical to apply an organized program for measuring, assessing, and communicating water-related information to decision makers and to the public. Government agencies, resource managers, private purveyors, and the general public benefit from the continued investigation and study of water resources. The best information available should be applied to explore the processes and resource interdependencies implicit in the water cycle. With increasing insight, better resource management strategies can be developed and implemented to achieve sustainability. The following CWRM goals are intended to guide and influence water resource inventory and assessment efforts in support of sustainable water planning and management activities.

- Continually study and update the inventory the water resources of the State (occurrence, location, extent, and behavior) to support resource management, policy and regulatory decisions, and planning efforts, and to protect and sustain resource viability and to provide for the maximum beneficial use of water by present and future generations.

- Promote the administrative use of management boundaries designated by CWRM to define the extent of ground water and surface water hydrologic units and ensure the consistent application of these boundaries throughout the State and across State and county jurisdictions.

- Commit to long-term, reliable, and collaborative data collection programs and use of improved methods of analyses.

- Seek the advice of other professional hydrologists in assessing, monitoring, analyzing, and reviewing the resource inventory defined in this plan.

- Apply inventory and assessment information to manage the conservation, protection, and use of the State’s water resources for social, economic, and environmental needs as mandated by the State Water Code.

- Apply inventory and assessment information toward managed conjunctive use of ground water and surface water supplies and the artificial recharge of ground water systems.

- Apply best science practices, improved understanding of resources, and informed consensus of stakeholders toward addressing both challenges and opportunities.

- Establish measurable interim instream flow standards on a stream-by-stream basis whenever necessary to protect the public interest in waters of the State.
- Utilize the best available information on the potential impacts of climate change in the setting of instream flow standards and the calculation of ground water sustainable yield.
- Incorporate provisions for management and protection of ground water dependent ecosystems in the establishment of ground water sustainable yield.

F.3 The Hydrologic Cycle

The hydrologic cycle (**Figure F-1**) refers to the constant movement of water between the ocean, the atmosphere, and the Earth. A continuous cycle of water can be easily observed on small oceanic islands like Hawai‘i. Solar energy drives the hydrologic cycle by causing **evapotranspiration (ET).** Evapotranspiration is the loss of water from soils, canopy, and open water bodies through evaporation and the transfer of water from plants to the air through transpiration. Moisture in the air is carried by trade winds up mountain sides, where it cools and condenses, and finally falls to the land surface as rain or fog drip. Plants immediately absorb and use some of the rain and fog drip, but the remaining volume of water infiltrates through the ground surface, runs off to the ocean or streams, evaporates into the atmosphere, or ends up recharging the ground water aquifers.

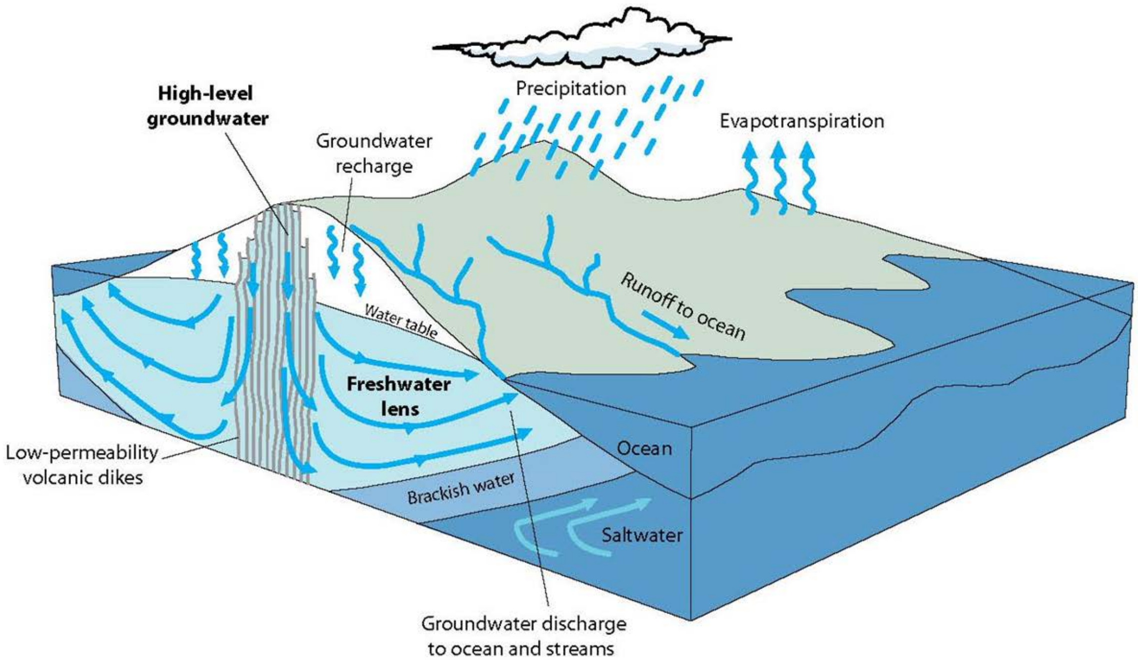
The four main elements of the hydrologic cycle are: 1) precipitation; 2) infiltration and recharge; 3) runoff; and 4) evapotranspiration. These can be summarized in the equation:

$$R = P - RO - ET$$

where “R” is natural recharge due to infiltration and subsequent deep percolation, “P” is precipitation, “RO” is runoff, and “ET” is evapotranspiration.

Infiltration is key to sustaining ground water resources. Human activities, especially agricultural and urban activities, alter infiltration and runoff patterns, affecting the components of the hydrologic cycle. As rainwater wets the land surface, shallow infiltration saturates the uppermost soil layer and replaces soil moisture used by plants. Thereafter, excess water percolates slowly downward to recharge ground water bodies and support stream flow in perennial sections. One factor that affects the rate of infiltration is the permeability of the ground surface. Permeability describes the ease with which water travels through a material. Ground surfaces with high permeability allow rapid infiltration of rainfall. Conversely, low-permeability surfaces like concrete and asphalt inhibit infiltration, causing water to pond or flow across the surface as runoff. Therefore, different land uses can encourage or inhibit infiltration.

Figure F-1 Hydrology of Ocean Islands



Source: USGS Pacific Islands Water Science Center.
<http://hi.water.usgs.gov/studies/GWRP/islhydro.html> (accessed June 24, 2019)

F.4 Nature and Occurrence of Ground Water

Much research and study has been devoted to the nature and occurrence of ground water in Hawai‘i. Over the past century, various private, federal, State, county, and university ground water investigations have helped scientists understand the unique and complex nature of Hawai‘i's ground water resources. An internet search for ground water hydrology of the Hawaiian Islands will return over 314,000 articles related to this subject.

To help communicate Hawai‘i ground water concepts to the public, the USGS and CWRM cooperatively developed and published in 2000 the reference brochure entitled *Ground Water in Hawai‘i*. The document contains descriptions of Hawai‘i's hydrologic settings and hydrogeology. The Honolulu Board of Water Supply (BWS), in consultation with CWRM, has also developed descriptions of Hawai‘i's ground water settings for inclusion in the BWS's *Ko‘olau Loa Watershed Management Plan* and *Waianae Watershed Management Plan*. The information in the following sections adapts CWRM's collaborative work with the USGS and BWS to provide a basic overview of the nature and occurrence of ground water in the State.

F.4.1 Ground Water Occurrence

The State Water Code defines ground water as "any water found beneath the surface of the earth, whether in perched supply, dike-confined, flowing, or percolating in underground channels or streams, under artesian pressure or not, or otherwise." Water beneath the ground surface occurs in two principle zones: the unsaturated zone and the saturated zone. In the unsaturated zone, the pore spaces in soils and rocks contain both air and water, whereas in the saturated zone, the pore spaces are entirely filled with water. The saturated zone of ground water is what is known as an aquifer.

Ground water occurs within portions of geologic formations that are favorable for receiving, storing, and transporting water. Subsurface formations that are saturated are called aquifers. The USGS defines an aquifer as follows:

> "Aquifer - *a geologic formation(s) that is water bearing. A geological formation or structure that stores and/or transmits water, such as to wells and springs. Use of the term is usually restricted to those water-bearing formations capable of yielding water in sufficient quantity to constitute a usable supply for people's uses".*
>
> - USGS Dictionary of Water Terms <https://www.usgs.gov/special-topic/water-science-school/science/dictionary-water-terms?qt-science_center_objects=0#qt-science_center_objects> (accessed June 24, 2019)

Lava erupted during the principal growth stage, or shield building stage, of a volcano tends to form the most extensive and productive aquifers throughout the Hawaiian Islands. Lava from the shield building stage consists of basalts that characteristically form thin flows ranging in thickness from a few feet to a few tens of feet. The shield stage is the most voluminous phase of eruptive activity during which 95 to 98 percent of the volcano is formed. Lava flows erupt from the central caldera and rift zones. Intrusive dikes fed by rising magma extend down the rift zones and may erupt if they reach the surface. Some volcanoes have a postshield-stage during which younger lava flows form over the shield-stage basalts. The postshield-stage lava flows are marked by a change in lava chemistry and character that commonly leads to the formation of massive lava flows that can be many tens of feet thick. After a period of volcanic inactivity, lava might issue from isolated vents on the volcano during a final rejuvenated stage.

Permeability refers to the ease with which fluids can move through rock. The permeability of volcanic rocks is variable and depends of the mode of emplacement, amount of weathering, and thickness of the rocks. The three main groups of volcanic rocks (lava flows, intrusive dikes, and pyroclastic deposits) are formed by different modes of emplacement. Weathering reduces the permeability of all types of volcanic rocks. The thickness of a lava flow can depend of the lava chemistry and the topography over which it cooled. Thicker flows generally are less permeable and form from lava accumulating on flat topography or in depressions.

Lava flows are mainly composed of two lava morphologies: pāhoehoe and ʻaʻā. Pāhoehoe flows are thinner and form from more fluid lava. Pāhoehoe flows have smooth, undulating surfaces, and commonly exhibit ropy textures. ʻAʻā flows have coarse surfaces of rubble, or clinker, and thick interior sections composed of massive rock. A typical geologic profile will show a sequence of both ʻaʻā and pāhoehoe flows. The interconnected void spaces in a sequence of pāhoehoe flows may lead to high permeability. The layers of clinker at the top and bottom of ʻaʻā flows also impart high permeability (similar to that of coarse-grained gravel) to volcanic-rock aquifers. However, the lava in the core of an ʻaʻā flow typically cools as a massive body of rock with much lower permeability. The most productive and most widespread aquifers consist of thick sequences of numerous thin lava flows; however, ground water occurs in a variety of geologic settings in Hawaiʻi, as described in the sections below.

F.4.1.1 Basal Water

The freshwater lenses in basal aquifers occur in dike-free volcanic rocks and in sedimentary deposits and are the most important sources of freshwater supply in Hawaiʻi. Basal waters can be either confined or unconfined. Unconfined aquifers are where the upper surface of the saturated aquifer is the water table itself. Confined aquifers are where the aquifer is overlain by low or poorly permeable formation boundaries that cause the ground water under the formation to be pressurized. Water levels in a confined aquifer will rise above the confining formation through breaches in the formation such as wells or natural flowing springs.

In some coastal areas there is a sediment sequence of low permeability commonly called "caprock." This caprock barrier tends to confine and restrict the seaward flow of freshwater and causes the thickness of the freshwater lens to be greater than it would if the caprock was absent. Depending upon the effectiveness of the caprock, the resulting lens could range from local thickening of a relatively thin lens of a hundred feet to over 1800 feet. Therefore, the amount of water stored in a basal lens bounded by caprock is significant. Water is withdrawn from the basal aquifer for various uses; basal aquifers provide the primary source for municipal water in Hawaiʻi.

The thickness of the freshwater basal lens can be estimated using the Ghyben-Herzberg formula, which assumes a hypothetical sharp interface between freshwater and seawater, and states that every foot of freshwater above mean sea level indicates 40 feet of freshwater below mean sea level. For example, if freshwater is known to occur at an elevation 20 feet above mean sea level, it can be reasonably estimated that the hypothetical sharp interface would be approximately 800 feet below sea level.

The Ghyben-Herzberg formula provides a reasonable estimate of the freshwater basal lens thickness; however, in actuality, the interface between freshwater and seawater occurs as a brackish transition zone, rather than a sharp interface, with salinity gradually increasing with depth. Therefore, the Ghyben-Herzberg formula is used to estimate the midpoint of the transition zone, which is 50% seawater and 50% freshwater. The thickness of transition zone depends on various chemical and physical parameters including, but not limited to geology, advection and dispersion, mechanical mixing, physical properties of the aquifer, tidal fluctuation, and atmospheric pressure variation. The movement of the brackish transition zone, both horizontally inland from the seacoast and vertically upward, presents a constant potential danger of saline contamination to the freshwater portion of the system. Surface water and ground water interactions in these areas predominantly occur near coastal areas in streams, wetlands, and achialine ponds.

F.4.1.2 Dike Water

Ground water impounded behind dikes in the mountains is often called "dike-impounded water," or "high-level water." Dikes are low permeability magmatic intrusions, usually wihin rift zones or calderas, that typically consist of nearly vertical slabs of dense, massive rock, generally a few feet thick, which can extend for considerable distances and cut across existing older lava flows. High-level water impounded in permeable lavas occurring between dikes in the interior portions of the islands is usually of excellent quality due to the elevation of dike impounded aquifers, the low permeability of dike structures, and the distance from the ocean, which prevents sea water intrusion. Tunnels and shafts have been drilled through multiple dike compartments to develop this water source. Dike water can occur in low elevation rift or caldera zones such as Windward Oahu.

Some water leakage occurs across dike boundaries, and this water flows to down-gradient dike compartments or to the basal aquifer. However, the interaction between these dike-confined and basal aquifers is not well understood and is difficult to quantify. In fact, recent discoveries of deep freshwater aquifers beneath saltwater underlying basal aquifers on the Big Island are modifying the conceptual models of ground water, at least on the Big Island. These may be related to dike water impounded geology. Also, additional discoveries of very high-level water on the Big Island may also modify the current conceptual models for ground water.

Dike-impounded water may overflow directly to a stream at the ground surface where stream erosion has breached dike compartments. Once breached to the water table, the percentage of overall contribution to total stream flow depends on the head of the stored water, how deep the stream has cut into the high-level reservoir, the permeability of the lavas between dikes, the size of the compartments as well as connections to other compartments, and the amount of recharge into the breached compartment. Surface water and ground water interactions in these aquifers are assumed to have a one to one relationship for management purposes.

F.4.1.3 Perched Water

Water in perched aquifers is also classified as high-level water. In this type of system, water is "perched" on top of layers of low permeability material such as dense volcanic rock, weathered and solidified ash, or clay-bearing sediments that may overlie basal or dike aquifers. Discharge of perched water sometimes occurs as springs where the water table breaches the land surface by erosion. Perched water supplies can be developed by tunnels or by constructing masonry chambers around spring orifices to collect flow and to prevent surface contamination. This type of water is of excellent mineral quality, and like most dike water, is free from seawater encroachment.

Perched water can also be found in alluvial deposits. Alluvial water is found in the more recent alluvial layers in valley fills and remains perched because of older compacted alluvial layers below. Sometimes small wells can be productive in this area but generally the alluvium provides small amounts of water.

Related to dike water, recent discoveries of very high-level water on the Big Island may also modify the current conceptual models for ground water if they are shown to effectively be perched water. Surface water and ground water interactions in these aquifers depend on the local conditions and physical construction of wells.

F.4.1.4 Caprock Water

Caprock units found in Hawaiian aquifer systems are generally composed of sedimentary formations and are commonly seen in oceanic islands with emergent shorelines. They show a dominant presence of reefal limestone, consisting of fringing coralline build-up and associated calcareous sediments interlayered by fine-grained alluvial sedimentation. This suggests sedimentation in shallow marine and littoral environments. Having formed in submarine conditions and with high clay content, young calcareous sedimentary units may preserve the brackish or saline caprock water as interstitial fluid or as perched water within the formation. Moreover, intertidal fluctuation and sea-level rise allows sea water intrusion into the caprock units, creating a broad transition zone of brackish water along coastal areas. Recharge from surface flows, local rainfall, return irrigation water, and leakage from unconfined or confined basal water could result into a potential resource of caprock water, but may be of limited direct use due to its saline quality. Caprock water occurs, and perhaps is fairly common, around older, emergent Hawaiian Islands, such as O‘ahu. A good example of an extensive caprock formation is the ‘Ewa and Honolulu Caprock, where brackish water has been pumped and utilized. Surface water and ground water interactions in these aquifers predominantely occur near coastal areas in streams, wetlands, and achialine ponds. Sustainble yields for caprock aquifers are not counted against sustainable as is basal, dike, perched, and alluvial aquifers.

F.4.1.5 Brackish Water

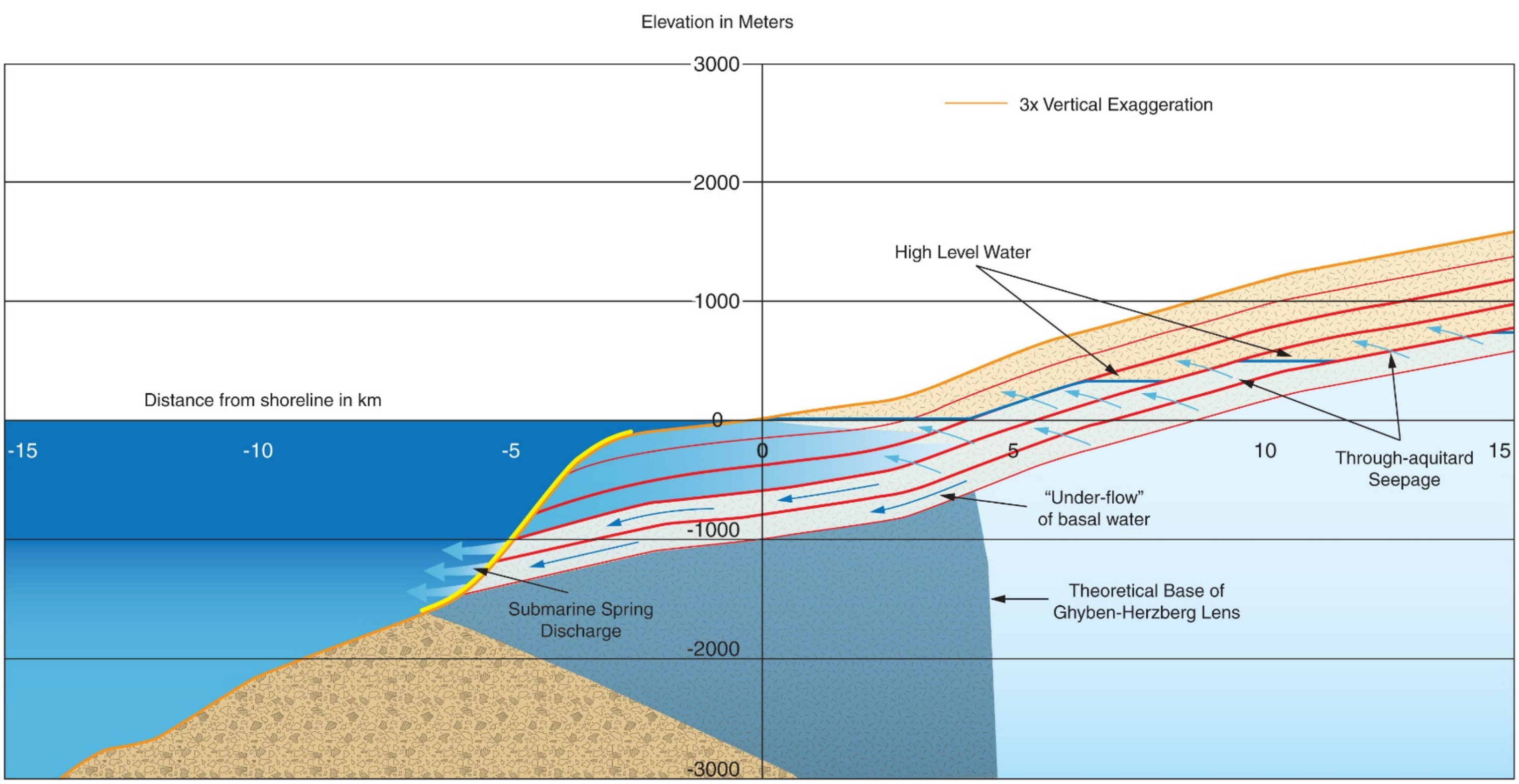
Water occurring in the caprock, in a transition zone, and in near-shore basal springs comprises a large resource that is presently unused for municipal supplies due to excessive chlorides (salt) content. Chlorides range from just above recommended drinking water guidelines to that nearly of seawater. With respect to its potential as an alternative source of water supply, brackish water desalination is generally more cost-effective and environmental-friendly than seawater desalination.

While slightly brackish water can be used for irrigation purposes, utilization of brackish water sources for municipal supplies requires the reduction of chloride concentration through blending and/or demineralization. Water exhibiting chloride concentrations greater than 250 milligrams per liter (mg/L or part per million - ppm) is generally considered unacceptable for drinking purposes. The county water departments generally limit chloride levels of water within their municipal system to less than 160 milligrams per liter (mg/L or parts per million – ppm).

F.4.1.6 Deep Confined Freshwater

On Hawaiʻi Island, there are at least four deep monitor wells that have penetrated through basal aquifers and underlying saltwater and have encountered freshwater in confined artesian aquifers. Two such wells are in each of the Hilo and Keauhou Aquifer System Areas. These discoveries have altered the traditional island conceptual model of freshwater completely floating on top of higher density saltwater. More study is necessary to better understand the extent and nature of this ground water occurrence.

Figure F-2 Deep Confined Freshwater



Source: Donald Thomas, June 21, 2014, *Revised Conceptual Model of Hawaii's Hydrology and Implications for the Keauhou Aquifer*, Public testimony received at the December 10, 2014 CWRM meeting <http://files.hawaii.gov/dlnr/cwrm/submittal/2014/sb20141210E2.pdf> (accessed June 24, 2019).

Future updates of this plan may include discussions of other geologic settings where ground water occurs.

F.4.2 Ground Water Hydrologic Units

Ground water hydrologic units have been established by CWRM to provide a consistent basis for managing ground water resources. An aquifer coding system is used to reference and describe the ground water hydrologic units delineated by CWRM. This section describes the aquifer coding system and lists all ground water hydrologic units by island. Maps illustrating the hydrologic unit coundaries are included in **Section 0**.

F.4.2.1 Purpose of Aquifer Coding

As described earlier in **Section F.4.1**, ground water occurs in variable settings throughout the State of Hawaiʻi. The aquifer coding system described herein was established to provide a consistent method by which to reference and describe ground water resources and to assist in various water planning efforts. The coding system encourages public understanding of ground water hydrology by delineating areas that are related and exhibit similar characteristics.

The primary objective of the coding system is to provide standard aquifer delineations and framework for the coordination of data, information, and resource management practices. The aquifer coding system provides the following benefits:

- Establishment of a consistent and uniform aquifer coding system and a reference for statewide planning, surveying, and regulatory purposes.
- Facilitation of consistent collection and sharing of ground water information amongst CWRM, community organizations, private and public entities, and other agencies;
- Facilitation of public and private implementation of resource protection measures. Such measures include, but are not limited to, permitting, monitoring, best management practices, and ground water availability;
- Effective coordination of monitoring, data collection, and data interpretation.

F.4.2.2 Basis for Ground Water Hydrologic Unit Delineations

In general, each island is divided into regions that reflect broad hydrogeological similarities while maintaining hydrographic, topographic, and historical boundaries where possible. These divisions are known as Aquifer Sector Areas. Smaller sub-regions are then delineated within Aquifer Sector Areas based on hydraulic continuity and related characteristics. These sub-regions are called Aquifer System Areas, which are the basic ground water hydrologic unit. In general, these units allow for optimized spreading of island-wide pumpage on an aquifer-system-area scale.

It is important to recognize that Aquifer Sector Area and Aquifer System Area boundary lines were based largely on observable surface conditions (i.e. topography, drainage basins and streams, and surface geology) and limited subsurface geological data such as water level characteristics. In general, only limited subsurface information (i.e. well logs and well cores) is available. Hydrogeologic features and conditions at the surface may not adequately or accurately reflect subsurface conditions that directly affect ground water flow. As a result, the Aquifer Sector Area and Aquifer System Area boundary lines should be recognized as management lines and not strict hydrologic boundaries where ground water flow does not cross. Communication of ground water between Aquifer Sector Areas and between Aquifer System Areas is known to occur.

The aquifer coding system was first initiated by the State Department of Health in response to directives from the U.S. Environmental Protection Agency. Since then, boundary delineations of ground water hydrologic units were manually drawn or re-traced by the DLNR Division of Water and Land Development (DOWALD) General Flood Control Plan of Hawaii (1983), the State Department of Health (1987), and the Commission on Water Resource Management (1990).

The naming convention for ground water hydrologic units indicates regional and sub-regional divisions as follows:

Island division	= Island
Regional division	= Aquifer Sector Area
Sub-regional division	= Aquifer System Area

F.4.2.3 Aquifer Coding System

The aquifer coding system is based on a hierarchy in which the island is the largest component, followed by the Aquifer Sector Area as the regional component, and the Aquifer System Area as the sub-regional component. The island is identified by a single-digit number in conformance with the first digit of the Hawaiʻi State well numbering system, derived from the U.S. Geological Survey (1976). Each Aquifer Sector Area is identified by a two-digit number and a Hawaiian geographic name or a geographic term such as Windward. Finally, the Aquifer System Area is identified by a two-digit number. Therefore, ground water hydrologic units are assigned a unique code in the five-digit format as follows:

0	**00**	**00**
Island	Aquifer Sector Area	Aquifer System Area

The individual components of the aquifer system area code are described below.

Island **0**0000

The island code component identifies the major Hawaiian island by a unique number assigned by USGS and DLNR. Each island is considered by the USGS to be a distinctive hydrologic unit.

Aquifer Sector Area 0**00**00

The Aquifer Sector Area code component identifies regional hydrologic units within each island. These Aquifer Sector Areas represent large regions with hydrogeological similarities.

Aquifer System Area 000**00**

The Aquifer System Area code component identifies sub-regional hydrologic units within each Aquifer Sector Area. Aquifer System Areas represent aquifers that exhibit hydrogeological continuity.

There is a total of 114 Ground Water Hydrologic Units delineated across the islands of Kauaʻi, Oʻahu, Molokaʻi, Lānaʻi, Maui, and Hawaiʻi. **Table F-1 to Table F-6** below list all units by island and are accompanied by **Figure F-2 to Figure F-7** showing the unit boundaries.

Table F-1 Kauaʻi (2) Ground Water 13 Hydrologic Units

Līhuʻe Aquifer Sector Area (01)	
20101	Kōloa
20102	Hanamāʻulu
20103	Wailua
20104	Anahola
20105	Kīlauea
Hanalei Aquifer Sector Area (02)	
20201	Kalihiwai
20202	Hanalei
20203	Wainiha
20204	Nāpali
Waimea Aquifer Sector Area (03)	
20301	Kekaha
20302	Waimea
20303	Makaweli
20304	Hanapēpē

Table F-2 Oʻahu (3) Ground Water 27 Hydrologic Units

Honolulu Aquifer Sector Area (01)	
30101	Pālolo
30102	Nuʻuanu
30103	Kalihi
30104	Moanalua
30105	Waiʻalae-West
30106	Waiʻalae-East
Pearl Harbor Aquifer Sector Area (02)	
30201	Waimalu
30203	Waipahu-Waiawa
30204	ʻEwa-Kunia
30205	Makaiwa
30207	ʻEwa Caprock - Malakole
30208	ʻEwa Caprock - Kapolei
30209	ʻEwa Caprock - Puʻuloa
Waiʻanae Aquifer Sector Area (03)	
30301	Nānākuli
30302	Lualualei
30303	Waiʻanae
30304	Mākaha
30305	Keaʻau
North Aquifer Sector Area (04)	
30401	Mokulēʻia
30402	Waialua
30403	Kawailoa
Central Aquifer Sector Area (05)	
30501	Wahiawā
Windward Aquifer Sector Area (06)	
30601	Koʻolauloa
30602	Kahana
30603	Koʻolaupoko
30604	Waimānalo
Waiāhole Ditch Area (07)	
30701	Waiāhole Ditch

Table F-3 Moloka‘i (4) Ground Water 16 Hydrologic Units

West Aquifer Sector Area (01)	
40101	Kaluako‘i
40102	Punakou
Central Aquifer Sector Area (01)	
40201	Ho‘olehua
40202	Pālā‘au (formerly Manawainui)
40203	Kualapu‘u
Southeast Aquifer Sector Area (01)	
40301	Kamiloloa
40302	Kawela
40303	‘Ualapu‘e
40304	Waialua
Northeast Aquifer Sector Area (01)	
40401	Kalaupapa
40402	Kahanui
40403	Waikolu
40404	Hā‘upu
40405	Pelekunu
40406	Wailau
40407	Hālawa

Table F-4 Lāna‘i (5) Ground Water 9 Hydrologic Units

Central Aquifer Sector Area (01)	
50101	Windward
50102	Leeward
Mahana Aquifer Sector Area (02)	
50201	Hauola
50202	Maunalei
50203	Paoma‘i
Ka‘ā Aquifer Sector Area (03)	
50301	Honopū
50302	Kaumalapau
Kanao Aquifer Sector Area (04)	
50401	Keālia
50402	Mānele

Table F-5 Maui (6) Ground Water 25 Hydrologic Units

Wailuku Aquifer Sector Area (01)	
60101	Waikapū
60102	ʻĪao
60103	Waiheʻe
60104	Kahakuloa
Lahaina Aquifer Sector Area (02)	
60201	Honokōhau
60202	Honolua
60203	Honokōwai
60204	Launiupoko
60205	Olowalu
60206	Ukumehame
Central Aquifer Sector Area (03)	
60301	Kahului
60302	Pāʻia
60303	Makawao
60304	Kamaʻole
Koʻolau Aquifer Sector Area (04)	
60401	Haʻikū
60402	Honopou
60403	Waikamoi
60404	Keʻanae
Hana Aquifer Sector Area (05)	
60501	Kūhiwa
60502	Kawaipapa
60503	Waihoʻi
60504	Kīpahulu
Kahikinui Aquifer Sector Area (06)	
60601	Kaupō
60602	Nakula
60603	Lualaʻilua

Table F-6 Hawaiʻi (8) 24 Ground Water Hydrologic Units

Kohala Aquifer Sector Area (01)	
80101	Hāwī
80102	Waimanu
80103	Māhukona
East Mauna Kea Aquifer Sector Area (02)	
80201	Honokaʻa
80202	Paʻauilo
80203	Hakalau
80204	Onomea
West Mauna Kea Aquifer Sector Area (03)	
80301	Waimea
Northeast Mauna Loa Aquifer Sector Area (04)	
80401	Hilo
80402	Keaʻau
Southeast Mauna Loa Aquifer Sector Area (05)	
80501	ʻŌlaʻa
80502	Kapāpala
80503	Nāʻālehu
80504	Ka Lae
Southwest Mauna Loa Aquifer Sector Area (06)	
80601	Manuka
80602	Kaʻapuna
80603	Kealakekua
Northwest Mauna Loa Aquifer Sector Area (07)	
80701	ʻAnaehoʻomalu
Kīlauea Aquifer Sector Area (08)	
80801	Pāhoa
80802	Kalapana
80803	Hilina
80804	Keaīwa
Hualālai Aquifer Sector Area (09)	
80901	Keauhou
80902	Kīholo

Figure F-3 Island of Kaua‘i Ground Water Hydrologic Units

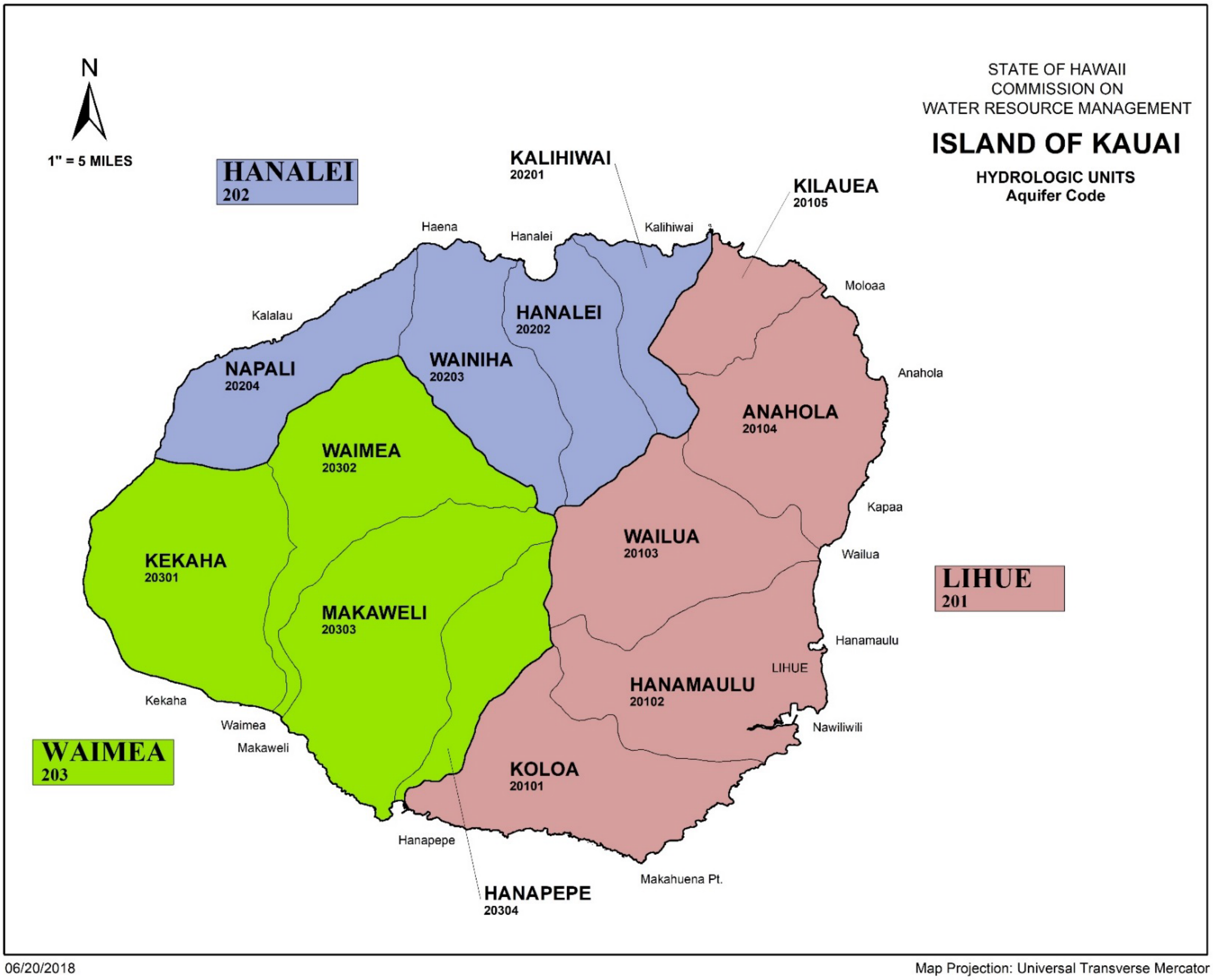


Figure F-4 Island of O‘ahu Ground Water Hydrologic Units

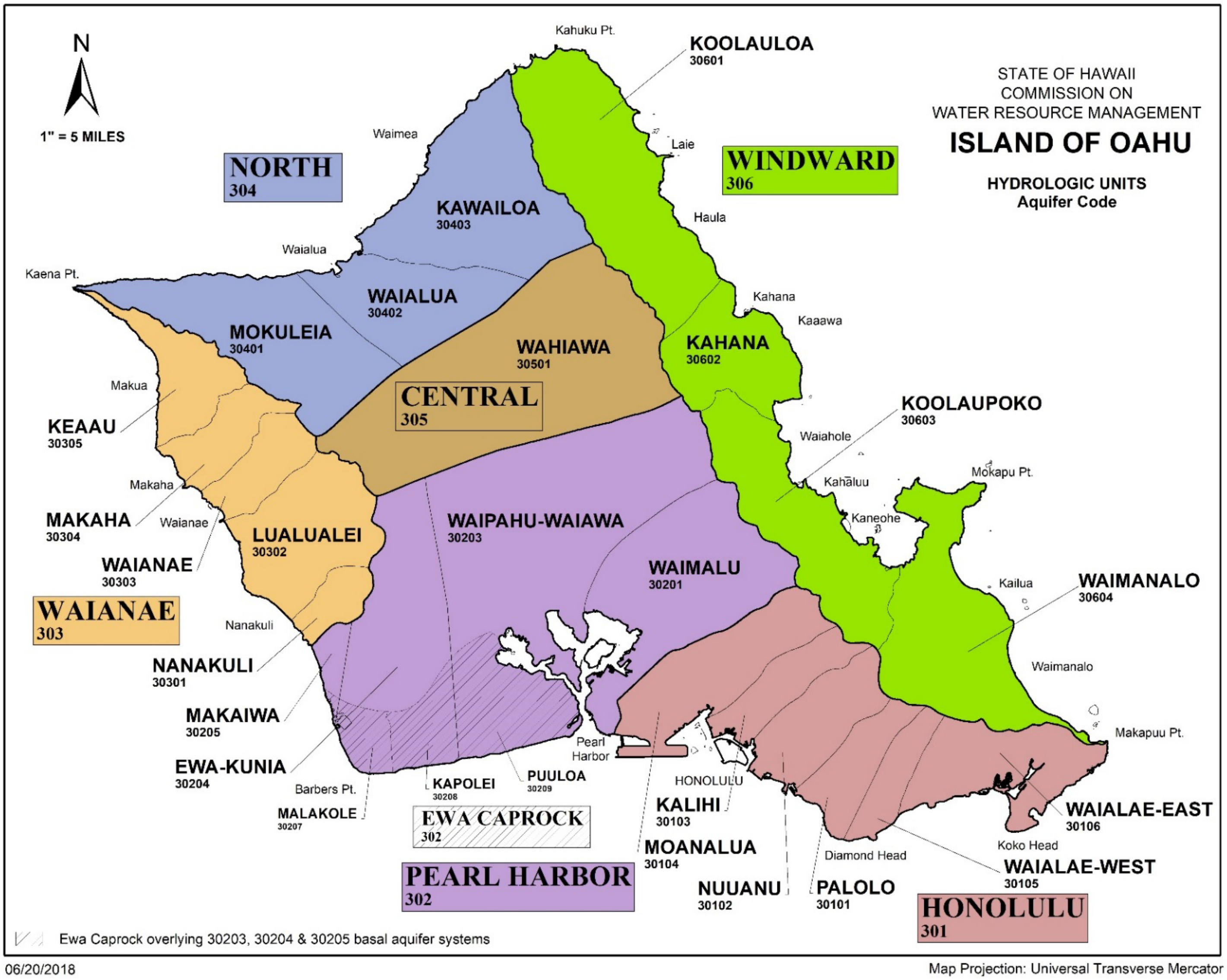
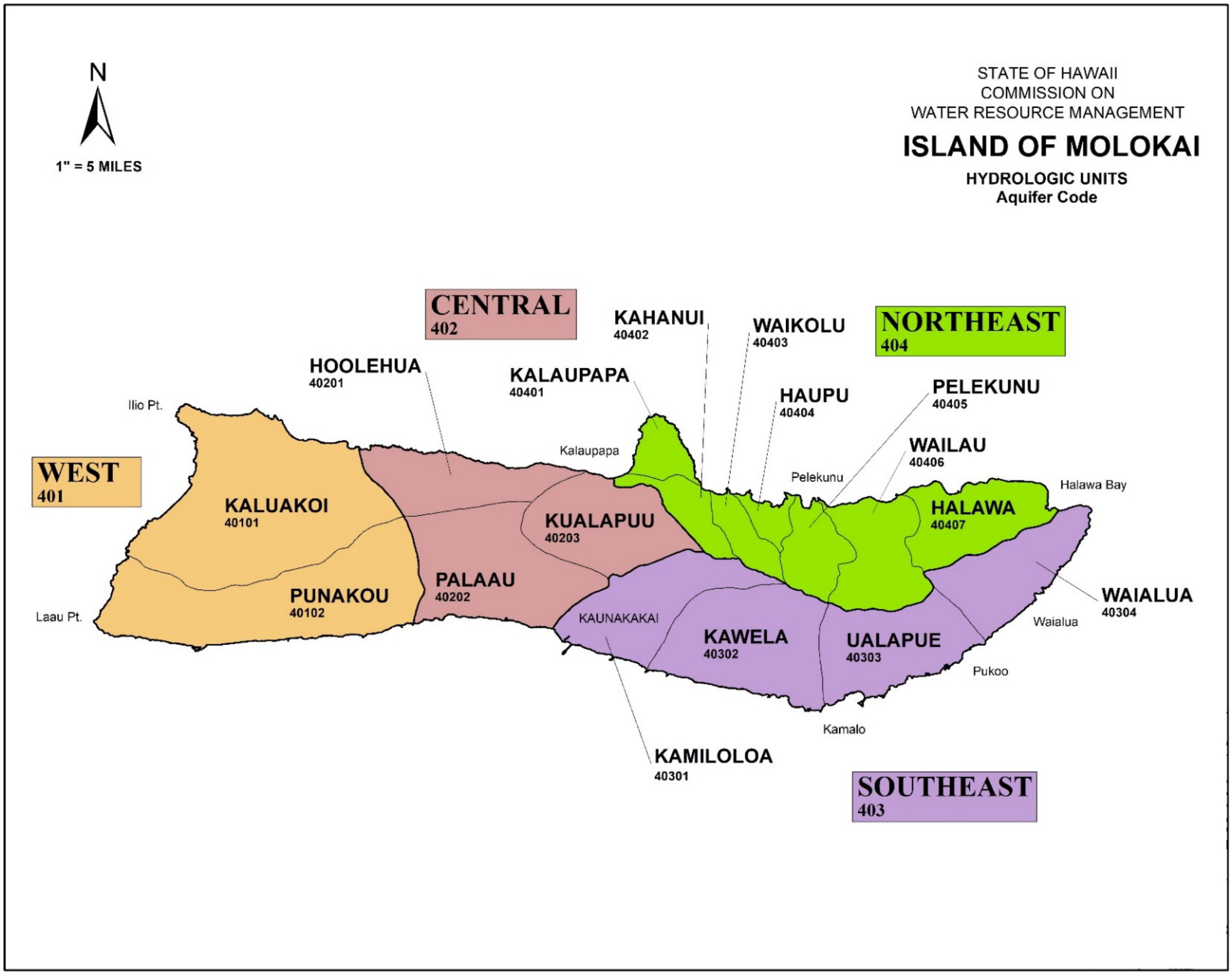


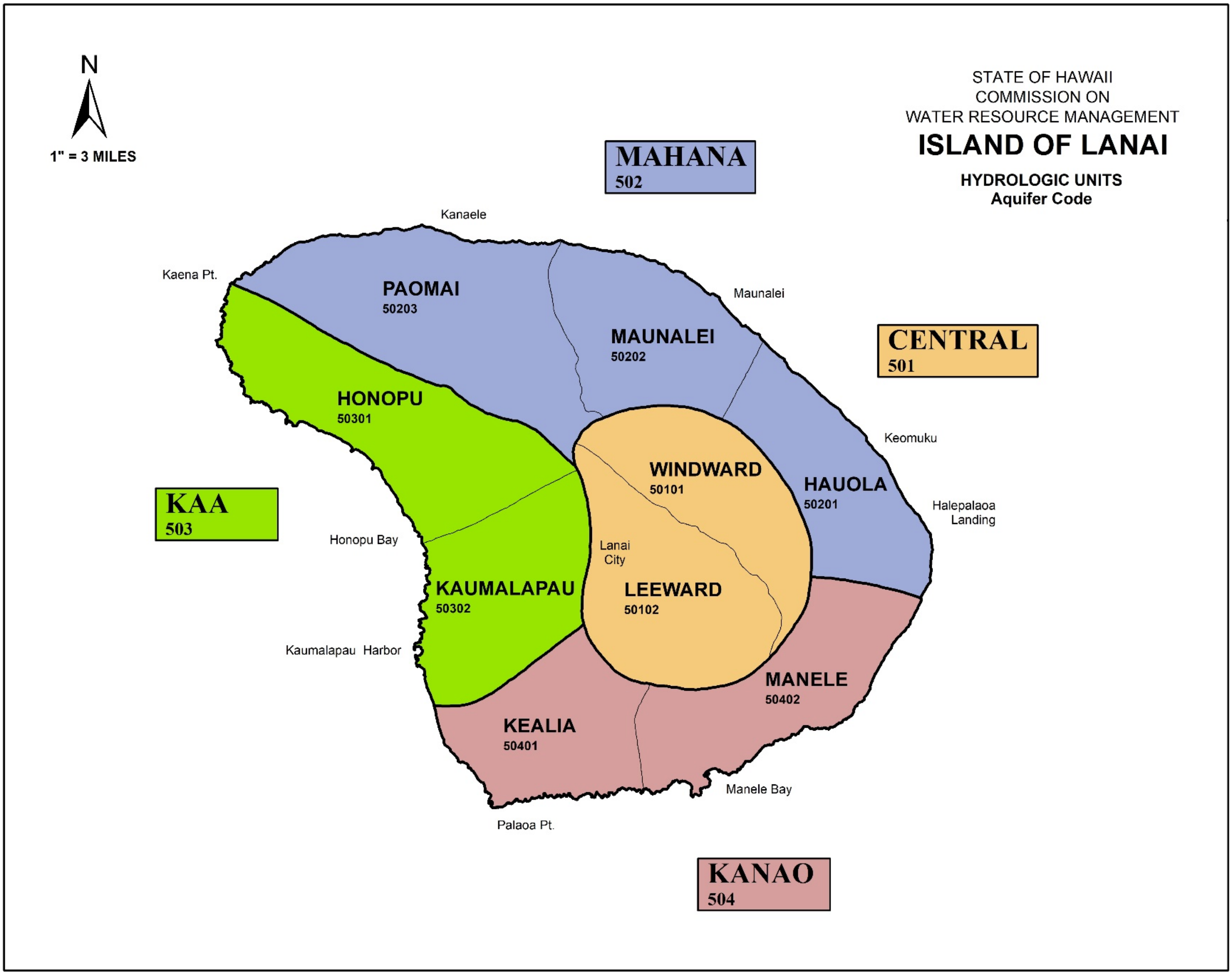
Figure F-5 Island of Moloka‘i Ground Water Hydrologic Units



06/20/2018

Map Projection: Universal Transverse Mercator

Figure F-6 Island of Lānaʻi Ground Water Hydrologic Units



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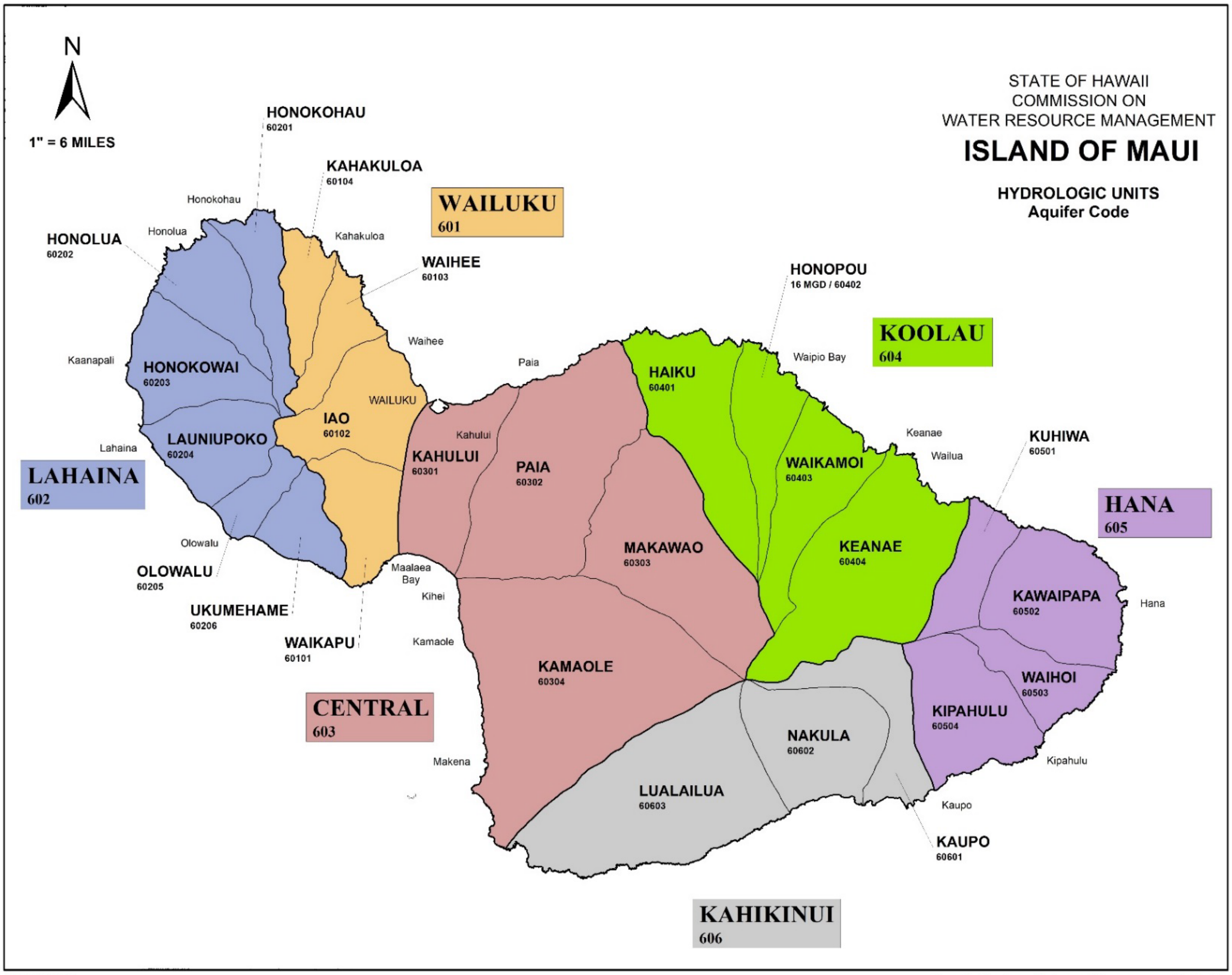
Map Projection: Universal Transverse Mercator

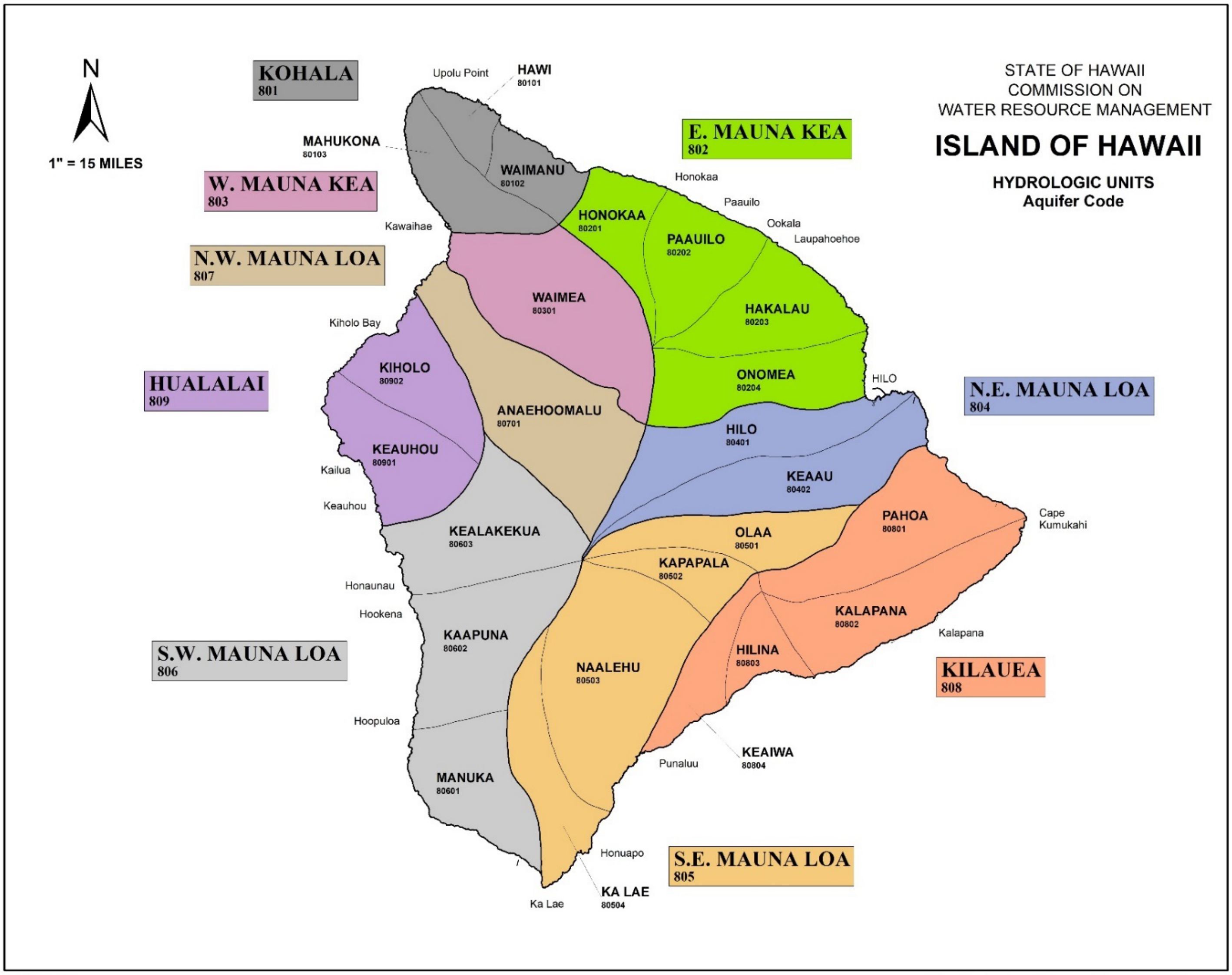
Figure F-7 Island of Maui Ground Water Hydrologic Units



06/20/2018

Map Projection: Universal Transverse Mercator

Figure F-8 Island of Hawai‘i Ground Water Hydrologic Units



06/20/2018

Map Projection: Universal Transverse Mercator

F.4.3 Determining the Availability of Ground Water Resources: Assessing Recharge, Ground Water/Surface Water Interactions, and Sustainable Yields

Ground water flow patterns and chemical transport processes within that flow can be difficult to understand and predict because they occur below the ground surface. Therefore, scientists must often infer and interpolate the status and characteristics of ground water resources from limited data and modeling tools. Use of these tools requires the establishment of certain assumptions and inputs, which inherently possess varying degrees of uncertainty. The following sections provide an overview of the primary issues related to the quantification of recharge, ground and surface water interaction, and sustainable yield. These issues contribute to uncertainties in the estimation of available ground water resources.

F.4.3.1 Assessing Ground Water Recharge

Ground water recharge is the replenishment of fresh ground water and depends on many natural and human-related factors. Recharge can change over time and in response to changes and events in climatological trends and land use. Ultimately, the goal of water-budget and recharge analysis is to quantify how much and where freshwater eventually reaches and becomes part of a saturated ground water aquifer.

Estimating Recharge

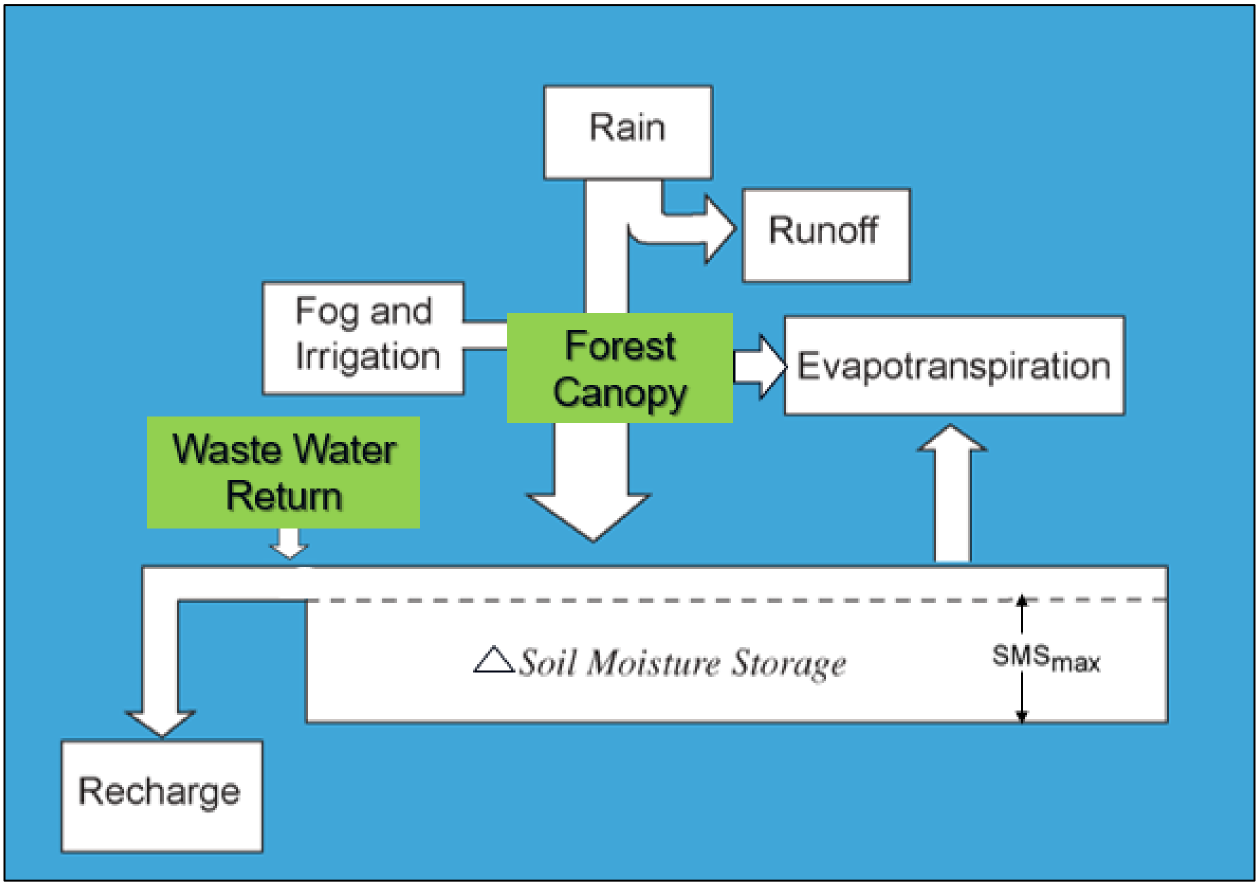
The ground water recharge equation (or 'soil-moisture water-budget' or 'mass-balance' equation) considered in this plan to estimate ground water recharge over a specified area is:

$$R = RF + FD + IR + WWR - DRO - \Delta SMS - ET\text{-}FCIE \quad \text{(equation 1)}$$

where:

R = Recharge
RF = Rainfall
FD = Fog drip
IR = Irrigation return
WWR = Waste-water return (e.g. cesspools, injection well, etc.)
DRO = Direct surface runoff
ΔSMS = Change in soil-moisture storage
ET = Evapotranspiration
FCIE = Forest canopy interception-evaporation

Figure F-9 Factors Contributing to Ground Water Recharge



Various methods have been derived using the above equation in varying levels of complexity and analysis to estimate ground water recharge. Each of the components within this equation have their own 'best estimate' quantification issues. Some of these major issues regarding the application of this equation are:

- Spatial Data Coverage
- Time Steps
- Direct Runoff Estimation; and
- Soil-Moisture & Forest Canopy Storage/ Evapotranspiration Interaction

These are discussed in more detail in the subsections below.

Spatial Data Coverage. The number and location of rainfall, fog-drip, evaporation, streamflow, irrigation return flow, soils, and land use cover data collection and analysis affect the estimation of recharge. There are three entities that maintain major climatological networks: the USGS; the U.S. Department of Commerce, National Oceanic & Atmospheric Administration (NOAA), National Weather Service (NWS); and the University of Hawai‘i - State Climate Office (SCO). The SCO is currently updating the statewide rainfall station index.

Many investigations relied on the DLNR's *Rainfall Atlas*, R76, 1986, which has been used as the standard long-term baseline monthly rainfall average and median throughout the state. This has been updated with CWRM's *The Rainfall Atlas of Hawai‘i 2011*, for the 30-year base period of 1978-2007. Likewise, the DLNR *Pan Evaporation: State of Hawai‘i 1894-1983*, R74, 1986 provided the best long-term statewide annual estimate of pan evaporation. This has also been updated with CWRM's *Evapotranspiration of Hawai‘i 2014*, for the approximate 10-year base period of 2001-2011. The best spatial soil coverage is the United States Department of Agriculture (U.S. DOA) Soil Conservation Service's *Soil Survey of Islands of Kaua‘i, O‘ahu, Maui, Moloka‘i, and Lāna‘i, State of Hawai‘i*, 1972-73 has been updated by U.S. DOA with the Natural Resources Conservation Service, Soil survey geographic (SSURGO) database to: U.S. Department of Agriculture, Natural Resources Conservation Service, at https://sdmdataaccess.nrcs.usda.gov/. Another source of significant historic and spatial climactic and irrigation data is the Hawai‘i Agricultural Research Center (formerly the Hawai‘i Sugar Planters Association and the Pineapple Research Institute of Hawai‘i), which compiles data collected by sugar plantations for irrigation activities.

Spatial data coverage density varies for both rainfall and streamflow data collection and return irrigation areas such that some areas will have higher density of data compared to others. The most current land cover data is compiled through the Gap Analysis Program (GAP) run by the U.S. Geological Survey that maps, in part, the land cover of the dominant plant species. This mapping of land use cover will greatly enhance potential evapotranspiration spatial coverage data. Lastly, spatial data coverage differences can be best represented in recharge analysis through the use of Geographic Information Systems (GIS) and preferably on a basin wide scale, coincident with aquifer system area boundaries.

Time Steps. Time steps are periods over which data is available and comparable to each other. Time steps can be annual, monthly, daily, or even hourly. In ground water management, annual recharge is the most conservative approach (monthly or daily recharge data is only needed for detailed modeling analysis). Usually, annual time-step water budget averages are more conservative estimates than monthly, daily, or hourly water budget averages because ‘spikes’ in precipitation and evaporation intensities and effects of soil-moisture storage are attenuated and significant inputs to recharge can be lost. Another way to phrase this is that annual averages tend to overestimate actual evaporation; thus, underestimates recharge.

Annual water budgets were used in the 1990 WRPP assessment of recharge and are therefore considered reasonably conservative. However, the recharge water budget equation above works best with shorter time steps, with daily time-steps being the most realistically achievable data set. Unfortunately, it is also difficult for all data points to have daily time-steps over the same period of analysis. For example, daily readings for rainfall are readily available whereas pan evaporation daily data is much more limited.

Precipitation and evaporation intensities as well as soil-moisture storage vary significantly between and during the wet and dry seasons and have a significant effect on seasonal recharge rates. For numerical ground water modeling, monthly and daily time-steps provide a better way to look at transitory behavior of an aquifer and should provide a better calibration opportunity than annual time-steps. Further, if sufficient data is available, daily time-steps is preferable to monthly time steps.

Total Direct Runoff Estimation. Total direct runoff for an entire drainage basin is difficult to measure. Estimates of total direct runoff do not account for the amount of overland flow to the ocean (which does not contribute to stream flow). Soil properties and land use also change and affect this component. If adequate rainfall and streamflow data is available, direct runoff-to-rainfall ratios can be computed on a basin-wide scale. There is also a recent issue whether baseflow from streams should be subtracted from the recharge budget; however, the baseflow is considered comparable to coastal leakage, which is a discharge of ground water after recharge has taken place and is not subtracted from recharge. Also, baseflow is often not uniform throughout an entire stream reach where some are gaining while others are losing (returning to the ground water) in the same stream.

Soil-Moisture & Forest Canopy Storage/Evapotranspiration Interaction. Another critical consideration is when to subtract ET in the water budget. Past recharge studies using the above recharge equation, which includes soil-moisture storage considerations, have used the following two methods:

1. ET is subtracted before soil-moisture storage capacity considerations. Any water left over then goes to soil storage and any water in excess of soil storage then goes to recharge.

2. ET is subtracted only after soil-moisture storage capacity considerations and any recharge has occurred. In other words, ET potential is limited by soil-moisture storage capacities.

Method 1 is considered to be more realistic and conservative than method 2, especially for daily recharge calculations. Method 2 has been used for monthly recharge estimates when daily calculations are not possible, or Method 1 seemed to unreasonably underestimate monthly recharge. The best GIS based soil datasets are available from the U.S. Department of Agriculture's Natural Resources Conservation Service, Soil Survey Geographic Database.

Also, the lastest ET studies have added the forest canopy capture in heavily forested areas as another storage reservoir where additional evaporation can occur prior to reaching the soil reservoir. This provides an additional conservative element to the more recent recharge estimations from the USGS.

Simplified Ground Water Recharge Calculation: The 1990 WRPP

The June 1990 WRPP used a simplified version of the recharge calculation to determine recharge and is the statewide standard under that portion of the HWP. It can be generally represented as follows:

$$R = RF - DRO - ET \quad \text{(equation 2)}$$

where:

R	= Recharge
RF	= Rainfall
DRO	= Direct runoff (surface water flows)
ET	= Evapotranspiration

all values are in average annual values (inches/year)

Fog drip, irrigation, and changes in soil-moisture storage, were generally not considered. In some well-studied areas, such as the Pearl Harbor area on Oʻahu, irrigation return contributions were considered in calculating net draft or pumping rate, which is the actual pumping rate minus the rate of irrigation return flow. In general, though, the 1990 WRPP plainly states that no adjustments to the statewide water budgets were made to account for return irrigation and sought to reflect pre-agricultural and pre-urbanization conditions.

Estimates for rainfall, direct runoff, and evapotranspiration were based on simple but reasonable methods for estimating these recharge parameters at the time. Weighted annual averages for rainfall, direct runoff and evapotranspiration in inches per year (in/yr) over aquifer system areas, based on DLNR rainfall maps,[6] were used. Direct runoff calculations were based on empirical correlations between annual average rainfall and runoff based on the following empirical equation:

[6] Giambelluca, T.W., Nullet, M.A., and Schroeder, T.A., 1986, Rainfall Atlas of Hawaii, Report R76, Deptartment of Land and Natural Resources, Division of Water and Land Development, State of Hawaii, 267 p.

$$DRO = aRF^n$$

where:

DRO = Direct runoff (surface water flows)
RF = Rainfall
a = empirical constant
n = empirical constant

The 1990 WRPP states these are not very good estimators for direct runoff compared to actual streamflow data but are reasonable estimators at the system area scale where actual data is lacking and provide a simple consistent method for statewide application. Lastly, pan evaporation maps from DLNR pan evaporation maps[7] were not used directly to estimate evapotranspiration. Instead, where rainfall exceeded 55 in/yr, evapotranspiration was assigned as 40 in/yr, while in areas where rainfall was less than 55 in/yr, evapotranspiration was assigned to be 73% of rainfall.

The differences imparted by seasonal variations and the order in which to subtract evapotranspiration from its relationship with soil-moisture storage were not addressed in the 1990 WRPP. Other soil characteristics available in terms of direct runoff/rainfall ratios available were not considered in detail either.

Though the 1990 WRPP did not consider all of the generally accepted recharge considerations (it did not recognize soil-moisture storage for example), it was a reasonably conservative first cut that could be quickly applied statewide to estimate recharge, especially in areas with little or no data. This was based on the fact that using annual averages overestimated the effect of annual evaporationtranspiration.

Ground Water Recharge Studies in Hawai‘i since the 1990 WRPP

Since the publication of the June 1990 WRPP, there have been many ground water recharge related studies published for various locations within the state that use the more generalized recharge calculation rather than the 1990 WRPP simplified version. There have also been unpublished private reports that are purported to use the more generalized ground water recharge calculation recognized as the minimal standard by this update of the WRPP.

Further investigation is needed to refine estimates of natural recharge rates. At this time, there are significant variations between reported values of natural recharge to Hawai‘i basal aquifers. For example, the rate of natural recharge in the Iao Aquifer System Area on Maui was estimated by CWRM in 1990 at 15 MGD (based on a 17.81 square mile recharge area) and by Engott in

[7] Ekern, P.C., and Chang, J.H., 1985, Pan Evaporation: State of Hawaii, 1894-1983, Report R74, Deptartment of Land and Natural Resources, Division of Water and Land Development, State of Hawaii, 172 p.

2007 at 42 MGD[8] (based on an 18.12 square mile recharge area). These reported values were both derived by hydrologic balance analysis, but Engott's method also included fog drip, daily (instead of annual) time steps, and areal issues with valley fill, caprock, and irrigation return scenarios. According to the principle of hydrology balance, natural recharge equals precipitation minus the total of surface runoff and evapotranspiration. Therefore, more accurate estimation of the rate of natural recharge can only be achieved with an improved understanding of precipitation, including fog drip and rainwater, surface runoff, and evapotranspiration.

The most recent recharge estimates by the USGS have been for the islands of Hawai'i (2011), Maui (2014), and O'ahu (2015) that are based on approximately the most recent 30 years of data using more updated form of the water budget.

Recommendations for Recharge Assessment

- Achieve more accurate estimation of the rate of natural recharge through further study of relevant hydrologic processes such as precipitation (including canopy throughfall of fog water and rainwater), surface runoff, and evapotranspiration.

- Identify the rainfall isohyets described in CWRM's *Rainfall Atlas of Hawaii*, 2011 as the minimum standard to be used in estimating ground water recharge.

- Incorporate the Evapotranspiration of Hawaii 2014 data for recharge estimates.

- Update recharge estimates statewide for complete island coverage using the general ground water recharge equation (equation 1) in its entirety.

- Review ground water recharge components with other state and federal agencies and produce GIS coverage formats for various time-steps (annual, monthly, and if feasible, daily) and update where feasible.

- Consider current and future land use (urban vs. rural vs. agriculture) impacts to water budget component processes.

- Provide recharge updates in GIS coverage format to be placed on the State GIS system.

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[8] Engott, John A., and Vana, Thomas T. 2007, Effects of agricultural land-use changes and rainfall on ground-water recharge in central and west Maui, Hawaii, 1926-2004: U.S. Geological Survey Scientific Investigations Report 2007-5103, 56 p. Available online at http://pubs.usgs.gov/sir/2007/5103 .

F.4.3.2 Assessing Ground and Surface Water Interactions

In Hawaiʻi, ground water and surface water interactions may occur under the following conditions:

- High-level water seeps into stream channels to provide baseflow to streams;
- Basal water in coastal areas flows into stream channels to provide baseflow;
- Stream water between marginal dike zones and coastal areas infiltrates into ground water, as evidenced by losing stream reaches in these areas; and/or
- Basal water also discharges through basal and/or caprock springs to provide water to wetlands and ponds.

Author Gordon A. Macdonald and Agatin T. Abbott, in their 1970 book entitled *Volcanoes in the Sea, The Geology of Hawaii*, describe the close interrelationship between surface water and ground water in many of Hawaiʻi's watersheds. The discharge of excess water stored in high-level aquifers provides "a significant portion of the low water flow of many Hawaiian streams." In the following statement, the authors accurately anticipate that controversy over ground water development impacts to streamflow would soon manifest:

> *"This is certain to become a source of major conflict in future years, not only on Oahu but also on the neighbor islands, because increasing groundwater development from the headwater areas of the stream basins will surely reduce down-stream supplies for irrigation as well as water for other instream uses such as wildlife habitats and recreation and aesthetic enjoyment."*

In more recent publications, ground and surface water interactions are discussed in the context of the contested case hearing over the Waiāhole Ditch irrigation system, located in Windward Oʻahu. The system provides an example of how the development of water tunnels and stream diversions can impact the base flow (flow supplied by ground water discharge to the stream) of diverted streams as well as the recharge of the basal lens. In his 2002 book Hawaiian Natural History, Ecology, and Evolution, Alan C. Ziegler wrote of the Waiāhole Ditch System and its water resource impacts as follows:

“The entire Waiāhole Ditch System is approximately 43.5 km (27 miles) long, and since its opening in 1916 has had an average water flow of over 1.4 m^3/s (32 mg/d). Of the average flow over the life of the project, 1.2 m^3/s (27 mg/d) is estimated to have been groundwater. The average amount of surface water the system collected from streams and perched springs might thus seem to be 0.2 m^3/s (4.5 mg/d). Because the withdrawal of high-level groundwater caused less to seep out to these surface water sources, however, the reduction from predevelopment Windward surface water flow was substantially greater than this amount, conceivably at least twice as much, although no exact figures are available.” [9]

Surface and ground water relationships are further complicated by human impacts and infrastructure installed to transport water between different hydrologic units. The built environment can create artificial relationships between surface and ground water resources, and these situations can be difficult to manage. In his book Water and the Law in Hawaiʻi, published in 2004, Lawrence H. Miike notes that the laws regulating surface and ground water resources have developed separately, although natural and man-made interaction exists. An example of this is the artificial relationship between Windward Oʻahu surface water and Leeward ground water created by the Waiāhole Ditch System. Miike further notes that, as a result of the 2000 Waiāhole Ditch Contested Case, where there exists an undisputed interrelationship between surface and ground water, the State’s water use permitting authority extends to both ground and surface water withdrawals if there is a designation of either a ground or surface water management area (see **Appendix I CWRM Regulatory Programs** for discussion on water management areas and CWRM’s regulatory programs).

From a regulatory perspective, CWRM is primarily concerned with ground and surface water interaction issues as they affect surface water resources and estimates of ground water availability. Where ground water aquifers contribute to streamflow, well withdrawals from the contributing aquifer may cause depletion in stream base flow. This is a concern, as adequate stream flow must be maintained to support instream uses. In the interest of responsible management and protection of surface water resources, CWRM assesses ground and surface water relationships during staff evaluations of well permit applications. CWRM also must consider such relationships in the evaluation of sustainable yield estimates where aquifers are hydraulically connected to streams. The following sections provide examples of different types of interactions, information on methods for assessing ground and surface water interaction, and recommendations for improving monitoring and assessment.

[9] Estimates for natural flow in streams affected by the Waiahole Ditch System can be found in the USGS Scientific Investigations Report 2006-5285, available online at http://pubs.usgs.gov/sir/2006/5285. (Yeung, C.W., and Fontaine, R.A., 2007, Natural and diverted low-flow duration discharges for streams affected by the Waiahole Ditch System, windward Oahu, Hawaii: U.S. Geological Survey Scientific Investigations Report 2006-5285.)

Ground Water Contributions to Stream Flow

Ground water can provide a significant contribution to stream flow. Most perennial stream segments in Hawaiʻi rely on input from dike-impounded ground water or basal water contributions at the coast. **Figure F-10** provides a schematic cross section of a dike-impounded ground water system along the length of a stream.

The upper reaches of many Hawaiian streams are within or near the area where volcanic dikes (near-vertical sheets of massive, low-permeability rock that cut through older rocks) impound ground water to high levels. Streams that intersect the water table of the dike-impounded ground water body are commonly perennial because they are continually recharged by the ground water body.[10] A stream that receives ground water discharge is called a “gaining” stream. In general, the flow increases as one moves downstream within dike zones. The development of a system to capture dike-impounded ground water can affect natural springs and reduce the amount of springflow that feeds the perennial streams in the upper reaches, resulting in diminished streamflows. An example of where such streamflow impacts have occurred is in the Windward Oʻahu watersheds affected by the Waiāhole Ditch system of tunnels and ditches.[11]

At low altitudes, water levels in streams and ground water bodies may be affected by ocean tides. Thus, streams in coastal areas may either gain or lose water during the day depending on the relative effects of the ocean tide on streams and ground water levels. Streams may also flow perennially in areas where dikes are not present. For example, in southern Oʻahu, ground water discharges to streams from a thin freshwater-lens system in permeable rocks at altitudes less than a few tens of feet.[12] Another example can be seen in eastern Kauai, where ground water discharges to streams from a vertically extensive freshwater-lens system in low-permeability rocks at altitudes of several hundred feet.[13]

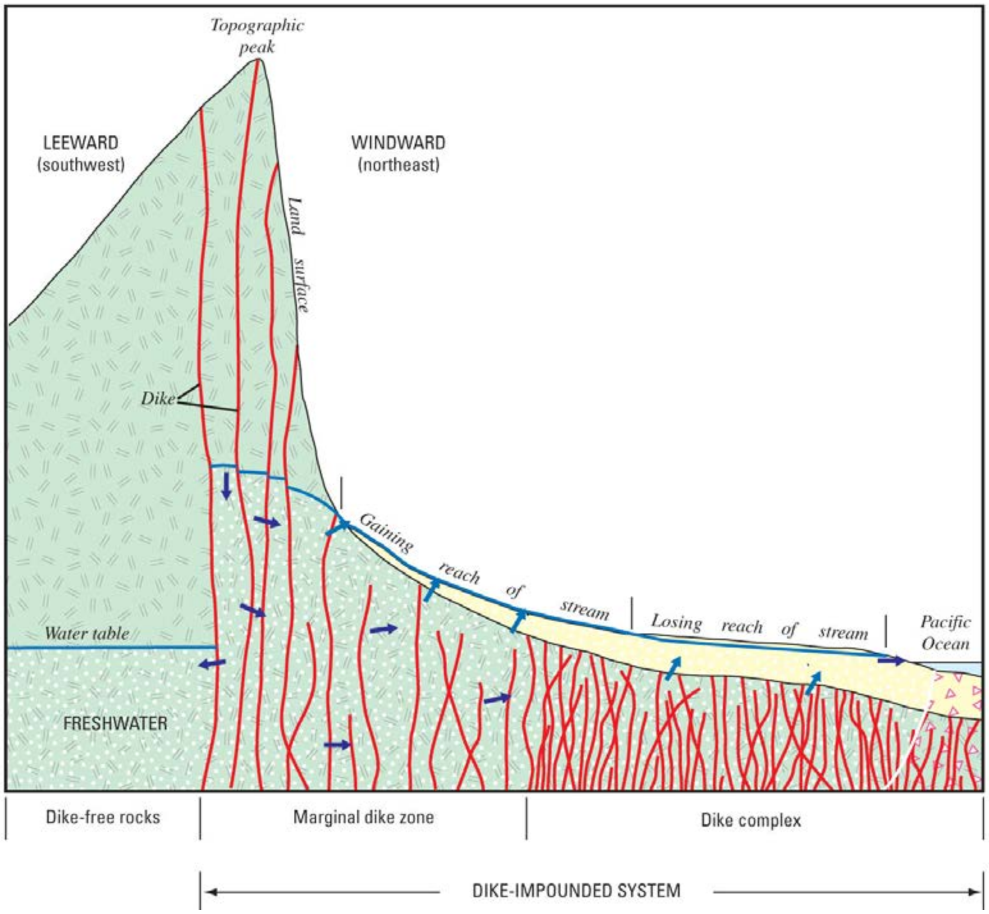
[10] Oki, D.S., 2003, Surface Water in Hawaii: U.S. Geological Survey Fact Sheet 045-03, 6 p.

[11] Hirashima, G.T., 1971, Tunnels and dikes of the Koolau Range, Oahu, Hawaii, and their effect on storage depletion and movement of ground water: U.S. Geological Survey Water-Supply Paper 1999-M, 21 p.

[12] Oki, D.S., 2003, Surface Water in Hawaii: U.S. Geological Survey Fact Sheet 045-03, 6 p.

[13] Izuka, S.K., and Gingerich, S.B., 1998, Ground water in the southern Lihue Basin, Kauai, Hawaii: U.S. Geological Survey Water-Resources Investigations Report 98-4031, 71 p.

Figure F-10 Schematic cross section showing a dike-impounded system (adapted from Oki and Brasher, 2003[14])



Stream Flow Contributions to Ground Water

Some streams run dry at lower reaches because water infiltrates into the streambed before reaching the coast. Depending on the local geology and soils, there are stream segments, or reaches, where water seeps down through the stream bed into ground water bodies. These reaches are referred to as "losing" stream reaches because stream flow is lost to ground water recharge. **Figure F-10** illustrates both gaining and losing stream reaches.

[14] Oki, Delwyn S. and Anne M.D. Brasher, 2003, Environmental Setting and the Effects of Natural and Human-Related Factors on Water Quality and Aquatic Biota, Oahu, Hawaii: U.S. Geological Survey Water-Resources Investigatons Report 03-4156, 98 p. Available online at http://pubs.usgs.gov/wri/wri034156.

Where ground water development has occurred in areas known to be subject to ground water/surface water interaction, the volume of surface water loss attributable to well pumping is usually not equal to the volume of ground water withdrawal. In rare cases, there is a direct and equal relationship between ground water withdrawals and stream flow depletion. However, this type of relationship depends on many factors, such as a well's proximity to a stream, well depth, and surrounding geology. **Figure F-11** illustrates how well pumping can affect the interaction between a ground water system and a stream. Therefore, it is important to have methods to assess the extent of ground and surface water interaction and the degree to which water development may influence stream discharge.

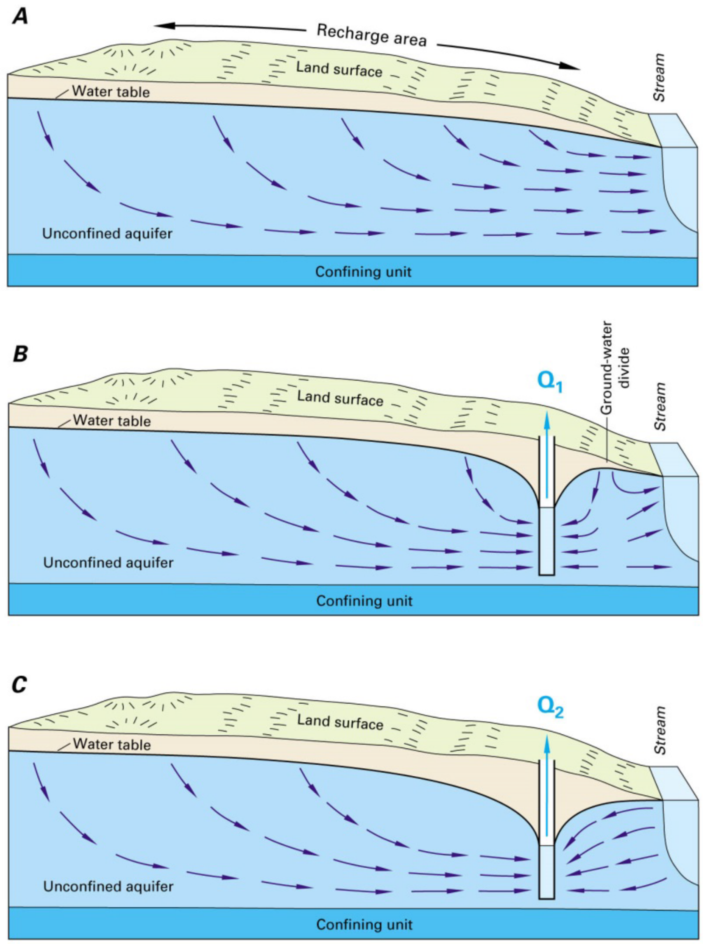
Water can move from the stream into the ground if the water table is at a lower elevation than the streamflow level. Losing stream conditions can occur if a rainfall event in the upper reaches, or a water diversion causes an increased stream discharge, bulking up the flow to a height above the water table, and subsequently forcing the stream water into the ground water system. Another example of losing stream conditions is where an active water supply well lowers the local water table and attracts the stream water towards the pumping well.

Methods to Assess Ground Water/Surface Water Interaction

Direct Measurement Within the Stream Channel. Base flow is the volume of water in a stream due solely to ground water input. It may be possible to directly measure the interaction of ground and surface water within a stream channel, although such efforts may not be feasible across the vast majority of the State because the investigations are field intensive, time consuming, and very costly. According to the USGS, "Future goals associated with the issue of ground water/surface water interaction can only be minimally addressed with the existing surface water data-collection program (continuous recording, low-flow partial record stations, and crest-stage gages). The current program is structured primarily to provide streamflow data at specific points. Streamflow data that describe the magnitude of changes in base flow (flow supplied by ground water discharge to the stream) or data from seepage runs along stream reaches are required to address the issue of ground water/surface water interaction."[15] Data sets that indicate changes in base-flow characteristics (e.g. changes in low-flow discharge) are generally not available for most areas of the State. Therefore, the wide application of these investigations may not be practicably implemented.

[15] Fontaine, R. A., 1996, Evaluation of the surface-water quantity, surface-water quality, and rainfall data-collection programs in Hawaii, 1994: U. S. Geological Survey, Water-Resources Investigations Report 95-4212, prepared in cooperation with the Commission on Water Resource Management, Dept. of Land and Natural Resources, State of Hawaii, 125 p.

Figure F-11 Effects of pumping from a hypothetical ground water system that discharges to a stream (Adapted from Alley and others, 1999[16]).



Under natural conditions (A), recharge at the water table is equal to ground-water discharge to the stream. Assume a well is installed and is pumped continuously at a rate, Q_1, as in (B). After a new state of dynamic equilibrium is achieved, inflow to the ground-water system from recharge will equal outflow to the stream plus the withdrawal from the well. In this new equilibrium, some of the ground water that would have discharged to the stream is intercepted by the well, and a ground-water divide, which is a line separating directions of flow, is established locally between the well and the stream. If the well is pumped at a higher rate, Q_2, a different equilibrium is reached, as shown in (C). Under this condition, the ground-water divide between the well and the stream is no longer present, and withdrawals from the well induce movement of water from the stream into the aquifer. Thus, pumping reverses the hydrologic condition of the stream in this reach from ground-water discharge to ground-water recharge. Note that in the hydrologic system depicted in (A) and (B), the quality of the stream water generally will have little effect on the quality of ground water. In the case of the well pumping at the higher rate in (C), however, the quality of the stream water can affect the quality of ground water between the well and the stream, as well as the quality of the water withdrawn from the well. Although a stream is used in this example, the general concepts apply to all surface-water bodies, including lakes, reservoirs, wetlands, and estuaries.

[16] Alley, W.M., T.E. Reilly, and O.L. Franke, 1999, Sustainability of Ground-Water Resources: U.S. Geological Survey Circular 1186, 79 p. Available online at http://pubs.usgs.gov/circ/circ1186/html/gw_effect.html.

A series of continuously recording stream gages on a stream can provide long-term flow data for analyses using the base-flow index (BFI) or flow duration curves. Such analyses can be used to separate out gains or losses of base flow between the gages. A pumping well can change the quantity of water naturally discharging to a stream, as well as the direction of ground water flux to a stream under different pumping rates.[17] The closer the well is to a stream, the more likely measurable affects will occur. Moreover, the greater the long-term pumping rate, the greater the likelihood that the stream will be affected. In cases where a gaged stream is influenced by the presence of a well, it may be possible to observe and directly measure streamflow losses due to pumping withdrawals. The effects of well withdrawals could be observed at one or multiple stream gages, along the stream reach adjacent to the well, depending on the distance between the well and the stream. Procedures for utilizing continuous gaging techniques have been published by the USGS and are available through the USGS website, "Techniques of Water-Resources Investigations Reports" (https://pubs.usgs.gov/twri/index090905.html). Continuous gaging is discussed in "Techniques of Water-Resources Investigations Reports" Book 3, Chapter A6, General procedure for gaging streams.[18]

A seepage run is a direct way to accurately measure gains and losses of stream discharge. The process is an intensive data collection effort where discharge measurements are made at several locations along a stream reach. The time between the first and last discharge measurement is minimized to reduce the effects of temporal variability. Ideally, a seepage run would be performed on a day where stream discharge is stable, during base-flow or low-flow conditions. A current meter is used to measure flow velocities in designated subsection areas across the stream channel. The product of the subsection areas and velocities (perpendicular to flow direction) are summed to provide the total flow for that stream section. Procedures used in measuring stream discharge across a section have been outlined, and the following formula[19] represents how stream discharge is computed at a specific section:

$$Q = \sum (a\ v)$$

Where: Q = total cross-sectional discharge
a = individual subsection area
v = mean velocity normal to the subsection

[17] Alley, W. M., Reilly, T. E., and Franke, O. L., 1999, Sustainability of ground-water resources: U. S. Geological Survey Circular 1186, 86 p.

[18] Carter, R.W. and Davidian, J., 1968, Chapter A6, General procedure for gaging streams, Book 3, Applications of Hydraulics, Techniques of Water Resources Investigations of the U.S. Geological Survey. Available online at http://pubs.usgs.gov/twri/twri3-A6/html/pdf.html.

[19] Rantz, S. E. and others, 1982, Measurement and computation of streamflow: volume 1. measurement of stage and discharge: U. S. Geological Survey Water-Supply Paper 2175, 284 p.

The accuracy of the current-meter measurements depends upon choosing good cross-sections with little or no turbulent flow. These are referred to as synoptic streamflow measurements since they were performed on the same day and under the same flow conditions.[20] In some studies, seepage runs are repeated several times over a period of time (using the same measuring sites) to provide an accurate assessment of a stream's gains and losses. Seepage run data may be supplemented by concurrent measurements of specific conductance and temperature, which can aid in the interpretation of the data.

Seepage runs have been used in various stream scenarios to study such parameters as gains to stream base-flow discharge, streamflow losses to the basal lens and coastal sediments, and the impacts of surface water diversions and ground water pumpage.[21] Ideally, prior to conducting a pump test on a well that may affect streamflow, baseline discharge data should be collected along the stream reach most likely to experience impacts. A detailed survey of the stream reach should be conducted before the pump test to determine any obvious changes in flow (gains or losses). Discharge measuring sites should then be established to monitor flow before, during, and after the test. There should be one or more upstream monitoring sites, one or more monitoring sites adjacent to the well, and one or more monitoring sites downstream of the well. Monitoring can be done by direct flow measurements using a flow meter, or by installing temporary weirs and/or partial flumes. Pressure transducers can be used to measure changes in stream stage upstream of the weir or flume before, during, and after the test. Procedures for utilizing seepage run techniques are available from the USGS "Techniques of Water-Resources Investigations Reports" website (https://pubs.usgs.gov/twri/index090905.html) and are discussed in "Techniques of Water-Resources Investigations Reports" Book 4, Chapter B1, Low-flow investigations.[22]

There are situations where direct stream monitoring will not provide definitive results as to the effects of pumping on stream discharge. Observed geohydrological conditions may result from a complex mix of geologic formations, aquifers, and streams. Also, human errors in data collection and/or recording can occur during streamflow measurements using flow meters and stream gages (assumed to be about 5 percent). Natural events, of course, can also affect data quality.

[20] Fontaine, 1996.

[21] Takasaki, K. J., Hirashima, G. T., and Lubke, E. R., 1969, Water resources of windward Oahu, Hawaii: U. S. Geological Survey, Water-Supply Paper 1894, prepared in cooperation with Dept. of Land and Natural Resource, State of Hawaii, 119 p.; Izuka, S. K., 1992, Geology and stream infiltration of North Halawa Valley, Oahu, Hawaii: U. S. Geological Survey Water Resources Investigations Report 91-4197, prepared in cooperation with the Dept. of Transportation, State of Hawaii, 21 p.; Oki, D. S., Wolff, R. H., and Perreault, J. A., 2006, Effects of surface-diversion and ground-water withdrawal on streamflow and habitat, Punaluu Stream, Oahu, Hawaii: U. S. Geological Survey Scientific Investigations Report 2006-5153, prepared in cooperation with the Honolulu Board of Water Supply, 104 p.

[22] Riggs, H.C., 1972, Chapter B1, Low-Flow Investigations, Book 4, Hydrologic Analysis and Interpretation, Techniques of Water Resources Investigations of the U.S. Geological Survey. Available online at http://pubs.usgs.gov/twri/twri4b1/pdf/twri_4-B1_a.pdf.

Rainfall events during pump tests can skew data such that any pumping-induced losses to streamflow are masked by gains to stream discharge caused by runoff and infiltration. Also, the lag time between pumping and the observation of surface water impacts may vary. In some cases, a pump test that lasts for 120 hours (5 days) may not be long enough to show depletions in streamflow, although continued monitoring after the test may display changes in low-flow characteristics.

Indirect Methods for Assessing Ground Water/Surface Water Interaction. Although it is ideal to assess ground water/surface water interaction through the analysis of measurements taken in the field, the logistics and costs associated with direct measurement methods are often prohibitive. Thus, investigators employ various indirect methods to assess the interaction of ground and surface water resources. Indirect assessment methods include numerical ground water models and analytical methods.

Numerical models are generally considered superior to analytical models. However, numerical models require detailed data inputs for multiple variables and such data is not available for most areas of the State. In addition, to date, no numerical models designed for Hawaiʻi aquifers have been designed to account for ground water/surface water interaction. Therefore, ground water/surface water interaction in Hawaiʻi is primarily assessed through the use of analytical models, which are simpler, require fewer data inputs, and are more easily applied than numerical models.

CWRM is primarily concerned with ground water/surface water interaction with respect to potential well impacts on surface water resources. These issues typically arise when a well is proposed near a stream. A variety of methods may be used to estimate the degree to which a proposed well may impact stream flow. Historically, CWRM has used two methods to estimate stream flow impacts: (1) estimating ground water drawdown based on the Theis equation and (2) estimating stream loss utilizing a stream depletion equation based on work by Sophocleous and others. In the first method, the hydraulic conductivity of the aquifer is determined from pump test data. This hydraulic conductivity is then input into the Theis equation to calculate drawdown of the water table at a given distance from the pumping well (e.g. distance to the stream). Potential impacts to the stream are then assessed based on this predicted drawdown. For method two, the hydraulic conductivity of the aquifer is determined from pump test data. This hydraulic conductivity is then input into a stream depletion equation to calculate stream loss, for a given stream reach, as a percentage of the pumping rate of the well.

As a part of the well permit application process, CWRM requires a pump test to be performed for all new wells with a proposed pumping rate greater than 50 GPM. Data from these tests are used for an initial determination on the potential for the well to impact nearby streams, marshes, or other surface water bodies. If it is determined that a new well is likely to adversely impact a surface water body, CWRM may take several actions, including, but not limited to: (1) requiring additional testing and monitoring activities prior to, or as a condition of, permit application approval, (2) submission of an instream flow standard amendment application, (3) approval of the well permit at a reduced pumping rate if it is a requirement of the instream flow standard amendment or if subsequent pumping tests indicate that operation of the well at a lower pump rate will not impact any surface water bodies, or (4) denial of the permit application.

Examples of Ground Water/Surface Water Interaction

Basal Ground Water as Spring Discharge in Pearl Harbor. As mentioned above, many streams are intermittent in their middle reaches and become perennial in their lower reaches due to their intersection of a basal lens. This is particularly the case in Pearl Harbor. Waikele and Waiawa springs are located in the Pearl Harbor Aquifer Sector Area and offer the best examples of surface water where base-flow discharge is dependent upon head.[23]

Oki[24] in the CENCOR numerical model (see **Table F-10**), used the head-discharge relationship at Kalauao Springs in Pearl Harbor to analyze the effects of pumpage to discharge. The base-case was the Visher and Mink[25] condition when agricultural recharge and pumpage was at steady-state or 1950's conditions. For future pumpage scenarios, Oki used the 1967-90 measured head-discharge relationships when agricultural activities ceased as a base-case. The future pumpage scenarios provide an estimate on the loss of basal discharge at one of the Pearl Harbor springs. Future numerical model simulations can calibrate to other Pearl Harbor springs' head-discharge relationships to deduce the amount of discharge reduction throughout the Pearl Harbor area for different pumpage scenarios.

A part of the cooperative agreement between CWRM and the USGS is to directly measure flow and sample the Pearl Harbor springs on a biannual basis. These data can be directly correlated to water levels in monitor wells and correlated to actual pumpage in the region.

Basal Ground Water as Leakage into Marshes. Basal water also discharges through the caprock and from basal and/or caprock springs in low-lying areas forming marshes and anchialine ponds. Basal water leakage is predominant in the Kahuku area where Punamanō and Ki‘i marsh and pond complexes are formed from rainfall, runoff, diffuse leakage of ground water, and from two known springs.[26] In addition there are several flowing artesian wells which

[23] Visher, F. N. and Mink, J. F., 1964, Ground-water resources in Southern Oahu, Hawaii: U. S. Geological Survey Water-Supply Paper 1778, prepared in cooperation with the Division of Land and Water Development, Dept. of Land and Natural Resources, State of Hawaii, 133 p.

[24] Oki, D. S., 1998, Geohydrology of the Central Oahu, Hawaii, ground-water flow system and numerical simulation of the effects of additional pumpage: U. S. Geological Survey Water-Resources Investigations Report 97-4276, prepared in cooperation with the Honolulu Board of Water Supply, 132 p.

[25] Visher and Mink, 1964.

[26] Hunt, C. D., and DeCarlo, E. H., 2000, Hydrology and water and sediment quality at James Campbell National Wildlife Refuge near Kahuku, Island of Oahu, Hawaii: U. S. Geological Survey Water-Resources Investigations Report 99-4171, prepared in cooperation with the U. S. Fish and Wildlife Service, Dept. of Interior, 85 p.

supply water to James Campbell Wildlife Refuge at Kiʻi Marsh. The sediments forming the caprock that underlies the marshes, create a semi-confined Koʻolau basal aquifer. With the basal aquifer having a potentiometric head of about 15 feet above sea level and the elevation of the marsh is only a few feet above sea level, there is ground water leakage through the sediments. Any reduction in the potentiometric head by pumping basal ground water will reduce the amount of leakage through the caprock. The actual amount of leakage cannot be measured directly, but up-gradient increases in basal ground water pumpage will reduce the leakage into the marsh by the same amount.

Kaloko-Honokōhau National Historical Park, located on the Kona coast of the Island of Hawaiʻi, is an example of an area where anchialine ponds are present. However, anchialine ponds with greater biodiversity can be found in other areas of the state.

Development of High-Level Ground Water and Impacts to Streams. The development of ground water resources in Hawaiʻi has historically been driven by municipal and agricultural demands. Horizontal tunnels, large shafts, and traditional wells have been constructed to yield water from both basal aquifers and high-level aquifers. The development of high-level aquifers in some areas has been observed to impact stream flow where surface water discharge was dependent upon dike compartment stores.

Between 1900 and 1950, many high-level water sources were developed to supplement plantation irrigation systems. The plantations drilled horizontal tunnels to tap dike impounded water, which was then gravity-fed to irrigation ditches and distribution systems. Tunnels were developed in mountain areas where high spring and stream discharge provided good surface indicators of ground water accumulated in dike compartments. Spring discharge and streamflow, however, was observed to decrease after tunnel development, as the tunnels effectively captured ground water flows before the water could issue forth from springs and seeps.

An example of an area where tunnels impact surface water resources can be found in Windward Oʻahu, where the Waiāhole Ditch system tunnels capture water from numerous dike-impounded reservoirs. Over time, dike-impounded water was depleted as it discharged through the tunnels. Meanwhile, stream flow diminished as the dike water no longer contributed to flow.

As awareness of surface water impacts increased, water development efforts began to modify tunnel construction. Engineers introduced concrete bulkheads in tunnels to simulate dike boundaries, control water discharge, and to allow ground water to rebuild as storage. The success of bulkheading varies from site to site, and many questions remain as to the effectiveness of such installations in facilitating storage recovery.

Wells have also been used to develop high-level aquifers, and well withdrawals have been observed to impact vicinity surface water resources. In 1963, the Honolulu Board of Water Supply drilled two exploratory wells in Waiheʻe Valley, Oʻahu (T-114 and T-115 wells 2751-02, 03, respectively). A temporary weir was constructed downstream from the wells to measure changes in stream discharge during the five-day well pump testing. Measurements at the weir during testing indicated that well withdrawals resulted in loss of stream flow and that there are also some alluvial contributions to ground water. Pumping of these wells has been restricted by court order[27] such that at least 2.78 MGD of water must be allowed to flow downstream.

Examples Where Surface and Ground Water Do Not Interact. There are cases where pumping wells located near streams have been determined not to affect proximal streamflow. When the streambed is higher than the ground water table, well withdrawals typically do not impact streams. For example, wells (e.g. Mokuhau wells) in Wailuku, Maui, which pump basal ground water from 10 feet above sea level, do not impact the nearby ʻĪao Stream, which is located several hundred feet above sea level. A similar condition exists with the North Waiheʻe Wells located in the neighboring Waiheʻe Aquifer System Area. Water levels are approximately eight feet above sea level and the Waiheʻe River streambed invert elevation is much higher.

Well pumping tends not to impact streams where the streambed is separated from the ground water table by perching members. In the Honolulu area, the Board of Water Supply has drilled wells into the basal aquifer (e.g., Nuʻuanu, Mānoa, and Pālolo) that do not affect vicinity streams. In these instances, streams are not affected by wells because streamflow is dependent upon shallow alluvial aquifers that are not connected to basal ground water aquifers.

Recommendations for Assessing Ground and Surface Water Interaction

The following recommendations are intended to guide future CWRM efforts to improve the assessment of ground and surface water interaction:

- Identify sites statewide where it would be appropriate to conduct seepage runs and incorporate seepage run data collection into the monitoring program.
- Ensure adequate coverage of long-term stream gage sites and identify appropriate low-flow partial record sites.
- Ensure adequate baseline data collection prior to new source development. Coordinate data collection based upon long-range county plans for water development.
- Establish a statewide hydrologic monitoring network which will provide a basis for calibrating and validating numerical models of ground water/surface water interaction.
- Promote and encourage the use of calibrated local-scale numerical model of ground water flow in basal aquifers to assess ground water/surface water interaction as part of the well permitting process. In the modeling area, the ground water head and stream base flow are influenced by the proposed pumping.

[27] Reppun v. Board of Water Supply, 1982, 65 Haw. 531, 656 P.d 57, cert. denied, 471 U.S. 014, 105 S. Ct 2016, 85 L Ed 2d 298 (1985).

F.4.3.3 Assessing Aquifer Sustainable Yield

Natural resources are commonly classified as either renewable: capable of being replenished as rapidly as they are used; or non-renewable: a result of accumulation over a long period of geologic time. Ground water, replenished by rainfall recharge, is universally classified as a renewable resource. However, the amount of ground water that can be developed in any Hawaiʻi aquifer is limited by the amount of natural recharge. Additionally, not all natural recharge an aquifer receives can be developed. Some aquifer outflow or leakage must be maintained to prevent seawater intrusion or to maintain some perennial streamflow. Therefore, the sustainable yield of an aquifer normally represents a percentage of the natural recharge. Ideally, this percentage is determined by considering all relevant aquifer hydrogeologic properties and their effects on temporal and spatial variation in flow, hydraulic head, and storage. However, the State Water Code provides CWRM some flexibility in using other methods to define sustainable yield as provided by HRS §174C-3:

> *"'Sustainable yield' means the maximum rate at which water may be withdrawn from a water source without impairing the utility or quality of the water source as determined by the commission."*

The discretionary and flexible nature of the sustainable yield term allowed CWRM to set chloride limits rather than pumpage limits in the ʻEwa Caprock.

Ground water models are used as tools in ground water management. This section provides a general summary of ground water modeling efforts as they have been applied in Hawaiʻi to evaluate aquifer sustainable yield. As background to support the modeling discussion, a brief explanation of ground water storage and movement parameters is provided.

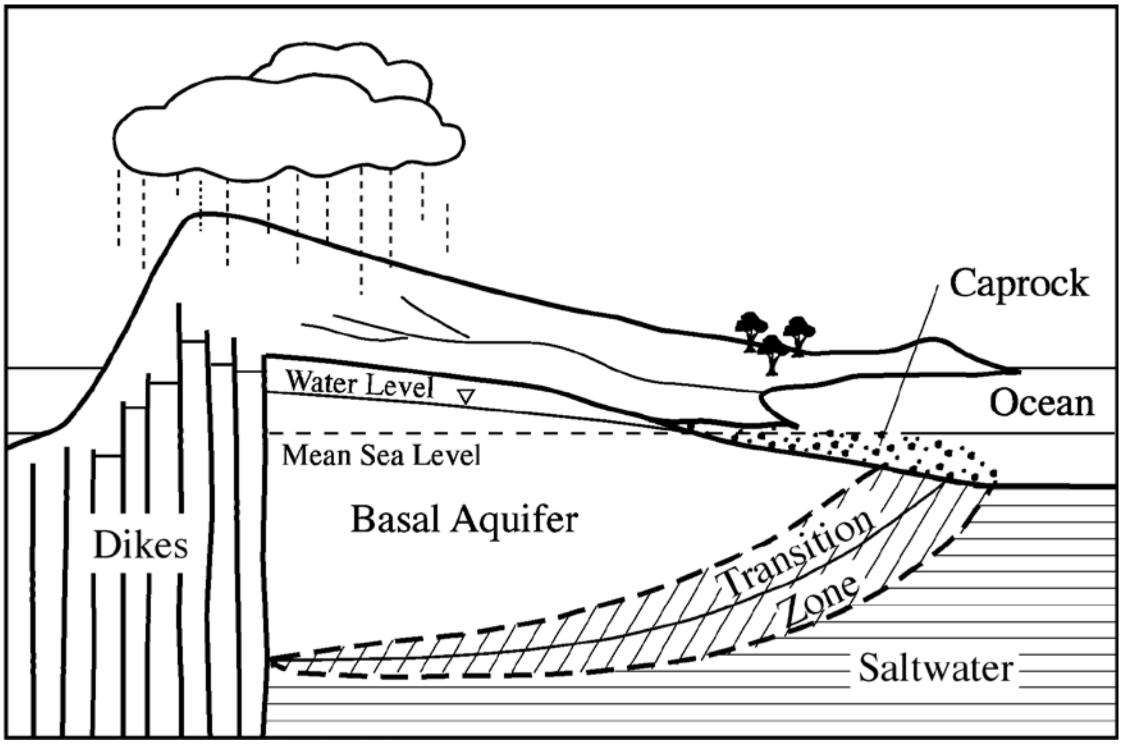
Ground Water Storage and Movement

According to the mass conservation principle, the total storage in an aquifer changes when its inflow is not balanced by its outflow. Under natural conditions, the aquifer is in a hydrologic balance such that the inflow, or the rate of natural rainfall recharge, equals the outflow or the coastal leakage. Thus, the volume of aquifer storage remains constant.

Hydraulic head, or the water level as it relates to water pressure, is an important variable. The spatial distribution of the hydraulic head or gradient determines the speed of water movement. The hydraulic head also determines the storage of an aquifer. The hydraulic head of a basal aquifer is the highest at the inland boundary and gradually reduces toward the coastline. This spatial variation of the hydraulic head induces ground water flow from mountain areas toward the ocean (see **Figure F-12**).

Forced draft or pumping has disrupted the natural balance of Hawaiʻi aquifers. This is evident in the decline of hydraulic head and the reduction of storage. If the rate of forced draft from an aquifer remains constant, the aquifer would eventually reach a new hydrologic balance with a smaller storage. In principle, if the rate of forced draft equals the rate of natural recharge, there will be no leakage outflow and no storage. The hydraulic head or aquifer storage would be reduced to zero. This is not an acceptable scenario. As aquifer storage is reduced, the transition zone would grow to occupy the entire aquifer, gradually replacing all freshwater with brackish or saltwater. Therefore, as a practical matter, it is not possible to create a well network that will capture all recharge.

Figure F-12 Hydrogeologic features of a typical Hawaiian basal aquifer



An aquifer's value as a source of fresh water can be evaluated in terms of hydrogeologic properties that dictate ground water storage and ground water movement. These properties are measured in terms of porosity, storage coefficient, hydraulic conductivity, and transmissivity.

An aquifer's ability to store ground water is determined by porosity and the storage coefficient. Porosity is the ratio of the aquifer's void volume to the total volume of rock material. The void volume of an aquifer is the volume occupied entirely by water. Thus, porosity indicates the maximum amount of water that an aquifer can contain. Generally, only a portion of this water can be developed and extracted for water supply; this is referred to as specific yield. The remaining volume of water is retained as a film on rock surfaces.

The volume of water stored in an aquifer changes in response to hydraulic pressure. The storage coefficient is defined as the volume released from or taken into storage per unit area of the aquifer per unit change in hydraulic head. The typical Hawaiian basal aquifer is unconfined, where the water table comprises the upper boundary (see **Figure F-12**). In an unconfined aquifer, the effective porosity or specific yield is equal to the storage coefficient.

Ground water movement through an aquifer can be measured in terms of hydraulic conductivity or transmissivity. Hydraulic conductivity can be described as the ease with which water moves through the aquifer. Transmissivity is the product of hydraulic conductivity and the depth of flow.

Ground water supplies may be vulnerable to contamination due to human-induced and natural conditions. The impacts of contamination can be amplified and facilitated by ground water movement. Chemical leaching and seawater intrusion are two common sources of contamination. Chemical leaching occurs when residual pesticides, petrochemicals, or other contaminants percolate down from upper soil layers into the freshwater lens. Saltwater intrusion occurs when increasingly brackish water infiltrates into the freshwater lens. This can occur due to (1) improper pumping of a production well, or (2) over pumping of the aquifer, or (3) migration of the transition zone inland and/or vertically upward.

The susceptibility of an aquifer to contamination can be measured by evaluating advection and dispersion. Advection is the transport of contaminants, as water carries impurities in the direction of flow. Dispersion includes: 1) microscopic mechanical mixing due to varying pore spaces through which water flows, and 2) molecular diffusion. Diffusion is defined by Fick's law as the movement of a fluid from an area of higher concentration to an area of lower concentration. Advection and the mechanical mixing portion of dispersion constitutes the majority of contaminant movement within an aquifer while the diffusion component of dispersion usually has much less effect in the spreading of contaminants.

As described earlier, storage and movement of ground water in basal aquifers is also influenced by the Ghyben-Herzberg equilibrium formula. However, though this formula gives satisfactory results where ground water flow is horizontal, in cases where vertical flow is encountered, there may be significant deviation from the 1 to 40 relationship. Vertical flow can be encountered near the coastline and in instances where there is vertical flow in monitoring wells that penetrate differing layers of geologic and aquifer formations.

Laboratory or field tests can be used to assess the parameters described above. Laboratory tests are less reliable, as only a limited portion of the rock matrix can be evaluated. Hawai'i aquifers are highly heterogeneous and, at this time, only statistically describable aquifer parameters can be assigned to Hawai'i aquifers on a large scale.[28] Field tests can provide

[28] Lau, L. Stephen and Mink, J.F., *Hydrology of the Hawaiian Islands*, University of Hawaii Press: Honolulu, 2006.

effective values appropriate for regional studies, however, site-specific pumping tests should be conducted to evaluate local conditions.

Ground Water Management Model Development and Application

Many types of models have been developed and applied in the U.S. and elsewhere for simulating ground water flow and solute transport. These models help to address sustainability issues. The early simulation attempts used analog models such as sand boxes, electrical conductivity sheets, and resistance-capacitance networks. Analytical models such as the Robust Analytical Model (RAM) have been, and continue to be, used in Hawaiʻi with limited ground water data to estimate sustainable yields. More recently, mathematical models have been developed that take full advantage of the rapid advancement of numerical methods and computer technology through what is commonly referred to as numerical models. Finite-difference, finite-element, and other boundary-integral numerical modeling techniques are important tools that should be used to aid in the management of well infrastructure and other ground water management problems where sufficient data and monitoring exist.

Mathematical models of ground water flow are formulated by combining the mass conservation principle and Darcy's law of ground water movement. Darcy's law states that the ground water flow rate can be calculated if the hydraulic head gradient and hydraulic conductivity is known. A conceptual ground water flow model can simulate a basal aquifer when the width of the transition zone is small relative to the thickness of the aquifer. In this case, the freshwater and saltwater are considered to be immiscible fluids separated by a sharp interface. This type of sharp interface model is adequate if the purpose of modeling analysis is to determine the general position, shape, and behavior of the interface; water levels; and flow directions in response to climatic and pumping stresses.

The conceptual sharp interface model may be further divided into two categories: freshwater flow models and coupled freshwater-saltwater flow models. The freshwater flow models are formulated by assuming the saltwater is stationary. The lower boundary of the freshwater model or the sharp interface can then be located by the Ghyben-Herzberg formula.[29] Coupled freshwater-saltwater models are formulated by assuming both freshwater and underlying saltwater are moving. The sharp interface of a coupled freshwater-saltwater flow model can be located based on Hubbert formula.[30]

Mathematical models of ground water solute transport, the movement of solutes in ground water systems, are formulated by combining the mass conservation principle and Fick's law of dispersion. Fick's law states that the mixing of a solute in an aquifer can be calculated if the

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[29] Liu, C.C.K., Lau, L.S. and Mink, J.F., 1983, Groundwater Model for a Thick Freshwater Lens, *Ground Water*, 21(3):293-300.

[30] Liu, et al.1983; Essaid, H. I., 1986, A comparison of the coupled fresh water-salt water flow and the Ghyben-Herzberg sharp interface approaches to modeling of transient behavior in coastal aquifer systems, *Journal of Hydrology,* 86:169–193.

solute concentration gradient and dispersion coefficient are known. For modeling reactive chemicals, additional mathematical terms representing relevant reaction kinetics must also be included in the transport model formulation.

Because the solution of a transport model requires prior knowledge of flow velocity, solute transport modeling must be conducted following a flow simulation. The flow simulation calculates the flow velocity distribution in the aquifer, which is subsequently applied in transport simulation to calculate the salinity distribution. In modeling seawater intrusion, salinity re-distribution may cause appreciable change in water density, which is a flow model variable. Therefore, a comprehensive ground water model must combine both flow and transport simulation. The flow simulation is first conducted to calculate velocity distribution. The velocity distribution is then used by the transport model to calculate salinity distribution. The density change caused by the new salinity distribution is then determined and used to re-calculate the velocity distribution. The process must continue until stable velocity and salinity distributions are established. SUTRA, a numerical ground water model developed by the US Geological Survey, solved coupled flow and solute transport equations.[31]

Formerly, simple analytical ground water models were developed and tested in aquifers with reasonably defined geological structures and hydrology. Mathematical modeling using simple analytical models highlights the relative importance of aquifer hydrogeologic properties. With the increasing power of computers, the accessibility to and use of more complex numerical ground water models and computer codes has become more important. However, before a numerical ground water model can be solely relied upon for prediction and management decisions, a rigorous process of model calibration and verification must be completed. The general procedure in model calibration and verification is to estimate a range of values for the ground water flow and the solute transport parameters, then test the model by comparing the calculated hydraulic head and salinity distribution to the observed values. The results of an adequately-calibrated model will reasonably emulate the observed results of historical events that provide the basis for estimated parameters. Anderson provides a very good detailed explanation of numerical model development.[32] Additionally, CWRM has provided a *Guide for Documentation for Ground Water Modelling Reports* since 1994.

A comprehensive numerical ground water model contains many model parameters. It may also consist of a huge numerical network with up to one million nodes or computational units. In principle, each node may have different model parameters to address the real-world heterogeneity of an aquifer. Therefore, a very close match of calculated and observed head and

[31] Voss, C.J., 1984, A finite-element Simulation Model for Saturated-unsaturated, Fluid-density-dependent Groundwater Flow and Transport Flow with Energy Transport or Chemically Reactive Single-species Solute Transport, *U.S. Geological Survey Water Resources Investigation Report* 84-4369.

[32] Anderson, M.P., Woessner, W.W., 1992, Applied Groundwater Modeling – Simulation of Flow and Advective Transport, 381 p.

salinity distribution data is difficult but may be achieved by the simultaneous manipulation of several model parameters.

Inaccurate model calibrations can be corrected by model verification. A model is considered verified if calculated results can reasonably emulate a historical event, or reasonably predict the behavior of water levels under changing circumstances based on an actual data set. New pumpage distribution patterns or changes in recharge due to reduced irrigation are typical examples of changing circumstances. Ideally, some judgment of the values of model parameters should be practiced. In model calibration and verification, it is advantageous for the investigators who developed the model and those who have gathered field data to participate in the calibration and verification process.

Numerical Ground Water Modeling Efforts in Hawai‘i

Table F-7 is a listing of numerical modeling efforts in Hawai‘i that have been reviewed by CWRM. This is not an exhaustive listing, as there are other private and public reports available that have not been reviewed in depth by CWRM. As reports come to the attention and are reviewed by CWRM these documents are compiled in CWRM’s digital library for public information. In addition, public and private reports exist which have valuable hydrologic information but are not ground water flow models (e.g., recharge studies).

Analytical Ground Water Modeling Efforts in Hawai‘i

Table F-7 also lists analytical modeling efforts that have been reviewed by CWRM. This is not an exhaustive listing as there are other private and public reports available. In addition, public and private reports exist which have valuable hydrologic information but are not ground water flow models (e.g., recharge studies).

An analytical model for a particular ground water system can be formulated using simplifying assumptions for system boundaries, flow, and transport processes. With these simplifying assumptions, theoretical or mathematically derived solutions of the model governing equations can be obtained.

Analytical ground water models are used extensively in ground water management for the following reasons:

- Analytical models are essential for the design of field experiments and subsequent data interpretation to estimate aquifer flow and transport parameters;

- Analytical models are useful modeling tools for preliminary ground water investigations; and

- Analytical models can be used to test comprehensive numerical models through comparison of modeling results for simplified conditions and scenarios.

Table F-7 Summary of Mathematical Ground Water Flow Models Reports in Hawai‘i

YEAR	MODEL	APPLICATION	REFERENCES
1974	GE-TEMPO	Long-term head variability in Palolo aquifer, O‘ahu	Meyers, C.K., Kleinecke, D.C., Todd, D.K., and Ewing, L.E., 1974
1980	Robust Analytical Model (RAM)	Analytical model to assess sustainable yields of Southern O‘ahu	Mink, J.F., WRRC prepared for Honolulu BWS
1981	2-D Flow Model	Ground water head variability in Pearl Harbor aquifer, O‘ahu	Liu, C.C.K., Lau, L.S. and Mink, J.F., WRRC TR 139
Early to Mid-80s	Methods of Characteristics (MOC)	2-D/3-D finite difference model of ground water and chemical transport of pesticide residuals in Pearl Harbor aquifer	Konikow, L.F., and Bredehoeft, J.D., 1978 Orr, Shlomo, and Lau, L.S., 1987
1985	AQUIFEM-Salt	2-D finite element to water systems in Southeast O‘ahu	Eyre, P., Ewart, C., Shade, P. USGS WRIR 85-4270
1990	RAM	Analytical ground water model for estimating sustainable yield values in 1990 WRPP	Mink, J.F. Mink & Yuen, prepared for the Water Commission
1993 to 1994	DYNSYSTEM	3-D finite element to study ‘Ewa marina construction effects on ‘Ewa caprock	Camp Dresser & McKee, 4 Volumes, prepared for HASEKO (‘Ewa) Inc., CCH-OA96-1
1995	AQUIFEM-Salt	2-D finite element to study water level changes due to increased pumping in Hawi, Big Island.	Underwood, M., Meyer, W. Souza, W. USGS WRIR 95-4113
1995	AQUIFEM-Salt	2-D finite element to study water level changes due to increased pumping from Barbers Point Shaft on Waianae Aquifer.	Souza, W., Meyer, W. USGS WRIR 95-4206
1996	Modular Finite Difference Flow (MODFLOW)	2-D finite difference to study the effects of pumpage on water levels for the entire island of Lanai	Hardy, R. CWRM R-1
1996	MODFLOW	2-D finite difference to study connection between caprock and basal aquifers	Willis, R., prepared for The Hawai’i-La’ieikawai Assoc. Inc., CCH-OA96-02
1996	Saturated-Unsaturated Transport (SUTRA)	2-D finite element to study pumpage impacts to water levels on cross-section of ‘Ewa Caprock	Oki, D., Souza, W., Bolke, E. Bauer. G USGS OFR 96-442

Table F-7 (continued)
Summary of Mathematical Ground Water Flow Models Reports in Hawai‘i

YEAR	MODEL	APPLICATION	REFERENCES
1997	AQUIFEM-Salt	2-D finite element to study pumpage impacts to water levels and coastal leakage for entire island of Molokai	Oki, D. USGS WRIR 97-4176
1998	SHARP	Quasi 3-D finite difference to study pumpage impacts to water levels in Central O‘ahu	Oki, D. USGS WRIR 97-4276
1998	SHARP	Quasi 3-D finite difference to study pumpage impacts to water levels in Līhu‘e Kauai	Izuka, S. Gingerich, S. WRIR 98-4031
1998	RAM	Study on sustainable yield for Waipahu, Waiawa and Waimalu Aquifer Systems	Mink, J.F. Mink & Yuen prepared for LURF
1998	RAM	Study on sustainable yield of ‘Ewa-Kunia Aquifer System	Mink, J.F. Mink & Yuen prepared for Estate of James Campbell
1998	FEMWATER	3-D finite element coupled flow and transport to model the ‘Ewa Plain	Woodward Clyde, prepared for C&C of Honolulu
1999	SHARP	Quasi 3-D finite difference to study water levels and coastal leakage at Kaloko-Honokōhau National Park	Oki, D., Tribble, G., Souza, W., Bolke, E. USGS WRIR 99-4073
2001	RAM/SHARP	Comparison between RAM and numerical model results	Oki, D., Meyer. W. USGS WRIR 00-4244
2001	SHARP	Quasi 3-D finite difference to study water levels, transition zone, and surface water impacts in Līhu‘e Basin Kauai	Izuka, S., Oki, D. USGS WRIR 01-4200
2002	AQUIFEM-Salt	2-D finite element ground water flow model to study Hawi area on Big Island	Oki, D. 2002, USGS WRIR 02-4006
2005	3D SUTRA	Simulation of Pearl Harbor variable density flow	Gingerich, S.B, Voss, C.I., Hydrogeol J (2005) 13:436-450
2005	FEFLOW	3-D finite element simulation to study transition zone movement due to pumping on the Honolulu aquifer.	Todd Engineers, prepared for BWS 2005
2005	SUTRA	2-D finite element to simulate effects of Honolulu Valley fills on pumping distribution	Oki D. USGS SIR 2005-5253

Table F-7 (continued)
Summary of Mathematical Ground Water Flow Models Reports in Hawaiʻi

YEAR	MODEL	APPLICATION	REFERENCES
2006	MODFLOW	3-D finite difference study of the Māhukona Aquifer System	Spengler, S., Pacific Hydrogeologic, LLC
2006	AQUIFEM-Salt	2-D finite element simulation to study impacts of future pumpage on water levels and coastal leakage on Molokai	Oki, D. USGS SIR 2006-5177
2006	RAM2	Analytical flow & transport model to estimate sustainable yield of Pearl Harbor	Liu, C.C.K., 2006.WRRC PR-2006-06
2006	MODFLOW	3-D finite difference study for DOH SWAP program to identify well capture zones	Whitttier, R, El-Kadi, A., et. al. WRRC prepared for State of Hawaiʻi DOH
2007	AQUIFEM-Salt	2-D finite element simulation to study impacts of pumpage on water levels and coastal leakage on Kaunakakai Stream Molokai	Oki, D. USGS SIR 2007-5128
2007	RAM2	Modified RAM that includes deep monitor well salinity profile data for estimating sustainable yield values in 2008 WRPP	Liu, C.C.K., 2007.WRRC PR-2008-06
2008	SUTRA	Ground water availability in Wailuku Maui	Gingerich, S.B, USGS SIR 2008-5236
2011	MODFLOW/ SEAWAT	Accessing potential effects of dry wells on Island of Hawaiʻi	Izuka, S.,USGS SIR 2011-5072
2012	SUTRA	Ground water availability in Lahaina Maui	Gingerich, S.B, Engott, J.A., USGS SIR 2012-5010

Analytical Ground Water Flow Model RAM

In Hawaiʻi, the most commonly used analytical ground water model is the robust analytical model (RAM) [33] derived by Mink. Sustainable yield values of Hawaiʻi basal aquifers were estimated by RAM and included in the 1990 WRPP.

[33] Mink, 1980; Mink, J.F., 1981, Determination of Sustainable Yields in Basal Aquifer, in: *Groundwater in Hawaii-A Century of Progress,* Book published by the Water Resources Research Center, University of Hawaii at Mānoa, pp.101-116.

In RAM, a basal aquifer is represented conceptually by two completely stirred tank reactors (CSTRs) separated by a sharp interface (see **Figure F-12**). The fresh water in the upper CSTR flows at a constant rate of $L = I - D$, where L is the coastal leakage; I is the natural rainfall recharge, a constant; and D is the pumping rate, or pumping minus irrigation return flow. The saltwater in the lower CSTR is stationary. RAM calculates the variations over time of the hydraulic head (h) in a basal aquifer in response to pumping stress. The steady-state solution of RAM indicates a simple relationship between the hydraulic head and the pumping rate. This relationship is presented graphically in **Figure F-13**.

Figure F-13 Conceptual formulation of the basal aquifer in the robust analytical model (RAM)

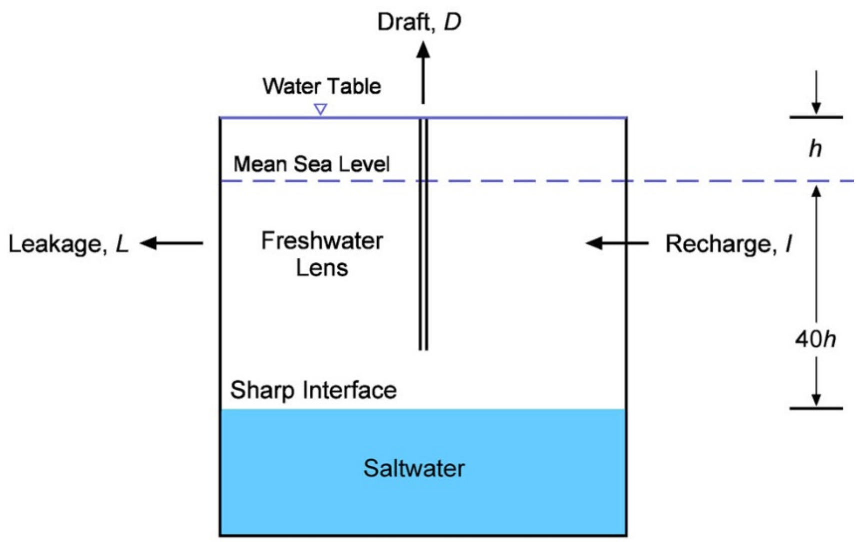
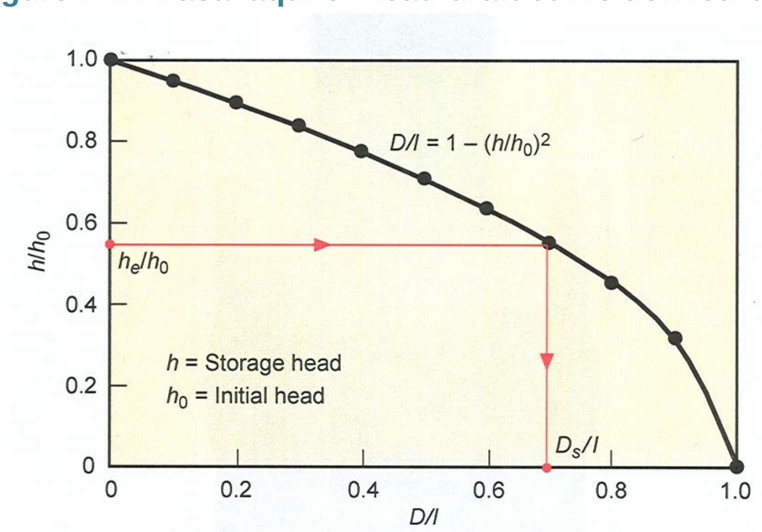


Figure F-14 Basal aquifer head-draft curve derived by RAM.



Based on Mink's $D_s/I = 1-(h_e/h_o)^2$ or $D_s = 1-(h_e/h_o)^2$ or

$$\textit{Sustainable Yield} = \textit{Recharge} \times \left\{ 1 - \left(\frac{\textit{Equilibrium head}}{\textit{Initial head}} \right)^2 \right\}$$

According to RAM, a parabolic relationship of hydraulic head and draft rate exists when a basal aquifer is at a steady state, or when recharge to the aquifer equals leakage plus pumping or forced draft. **Figure** F-14 shows a plot of head vs. draft in terms of dimensionless variables. The ordinate is a dimensionless variable of head, or h/h_0, where h_0 is constant initial head. The abscissa is a dimensionless variable of draft rate, or D/I.

According to RAM, the sustainable yield of a basal aquifer relates directly to its minimum equilibrium head. Mink stated that "the clearest expression of sustainable yield is that of allowable net draft for a selected (minimum) equilibrium head."[34] Sustainable yield, D_s, represents the maximum amount of water that can be withdrawn before a given equilibrium head, h_e, is compromised.

The response of a basal aquifer to pumping stress can be measured in terms of hydraulic head decline and the expansion and upward movement of the transition zone. This expansion and upward movement is a prelude to seawater intrusion. Acceptable source-water salinity in Hawai‘i is 250 mg/L chlorides or less. Seawater intrusion occurs when water with salinity higher than 250 mg/L chlorides reaches the bottom of a pumping well. Therefore, the minimum equilibrium hydraulic head can generally be defined as the hydraulic head that must be maintained to prevent seawater intrusion into a particular well.

The minimum equilibrium head of a well cannot be determined analytically by solving the governing flow equation of RAM as it does not consider saltwater movement or well upconing issues for the spatial distribution of actual wells. Therefore, RAM estimates sustainable yield by establishing a minimum equilibrium head based on selected important well depth within an aquifer or, in the absence of a selected well site, it relies on a relationship for selecting minimum equilibrium head, as suggested by CWRM in the 1990 WRPP (see **Table** F-8**)**. In this WRPP update, CWRM generally used the table to reassess sustainable yields rather than rely on a single important well site.

In short, the ratios of equilibrium heads and percentages of recharge show a precautionary approach to setting sustainable yields for basal aquifers. Basal aquifers where heads show a thin lens are allowed a smaller portion of recharge than thick basal lens. Originally, this was intended to protect well infrastructure from saltwater intrusion due to upconing effects, but an added benefit is that coastal leakage is allowed to continue in significant amounts to the ocean even at sustainable yield estimations. These ratios were not intended for other aquifer types such as perched or high-level dike confined aquifer systems that may predominate an area.

After an equilibrium head (h_e) and thus (h_e/ h_0) is selected, this value is inserted into **Figure** F-13 to obtain the dimensionless variable of draft or D_s/I. Multiplying this value by the known recharge rate gives the sustainable yield.

[34] Mink, 1980.

Table F-8 Relationships between initial head and minimum equilibrium head of Hawai‘i basal aquifers.[35]

The range of initial head, h_0 (ft)	Ratio of minimum equilibrium head and initial head (h_e/h_0)	D_s/I or SY = %of Recharge
4 – 10	0.75	0.44
11 – 15	0.70	0.51
16 – 20	0.65	0.58
21 – 25	0.60	0.64
> 26 and High-Level	0.50	0.75

Key assumptions of RAM include the following:

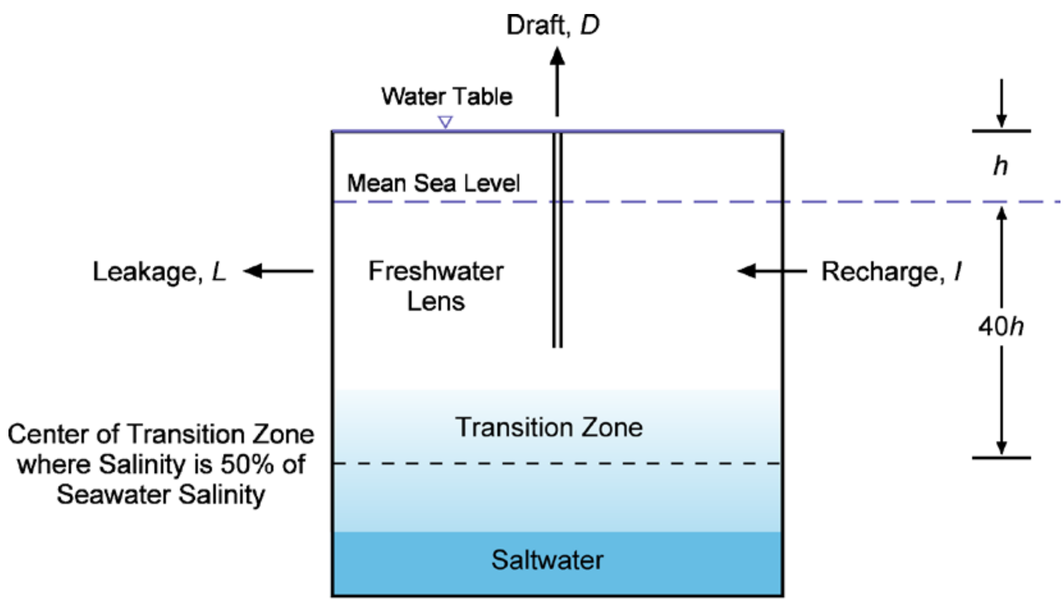
- Freshwater occurs as a basal lens floating on top of sea water;
- A sharp interface exists between the fresh and sea water;
- The aquifer is unconfined, its properties are homogeneous and isotropic, and its thickness is constant;
- Ground water flow is uniform and laminar;
- Head is equivalent to Storage Head; and
- Wells are optimally placed throughout the aquifer system area.
- Important limitations of RAM include the following:
- RAM ignores the spatial distribution of (1) recharge, (2) actual well placement, and (3) actual well pumpage;
- Many of the “initial heads” used in the RAM calculation were estimated due to the absence of pre-development ground water data;
- The “minimum equilibrium head” used in the RAM equation is an estimate based on empirical relationships. It cannot be determined analytically;

[35] State of Hawaii Department of Land and Natural Resources, Commission on Water Resource Management, 1990, *Hawaii Water Plan, Water Resources Protection Plan:* Honolulu, Hawaii.

- RAM does not account for (1) convection and dispersion, (2) variability in the transition zone, (3) flow between aquifer system areas, (4) aquifer system area boundary conditions (such as caprock), and (5) the needs of ground water dependent ecosystems; and
- RAM does not model ground water flow in three-dimensions.

Analytical Ground Water Flow and Transport Model RAM2
The modified RAM (or RAM2,) consists of two submodels. The flow submodel takes the form of RAM. The transport submodel simulates the variation of salinity over time in the transition zone of a basal aquifer in response to pumping stress. In RAM2, a basal aquifer is represented conceptually as two completely stirred tank reactors separated by a transition zone of varying salinity (see **Figure F-15**).

Figure F-15 Conceptual formulation of the basal aquifer model RAM2



Assessing Sustainable Yield of the Hawaiian Basal Aquifers by RAM and RAM2
Ideally, the sustainable yield of a basal aquifer would be determined through a numerical simulation using a comprehensive three-dimensional flow and transport model. However, the application of a comprehensive model for this purpose requires significant time and money to produce and is difficult to use. Comprehensive numerical model parameters are very complex and are difficult to quantify. Simple analytical models such as RAM and RAM2 are currently more readily applied to estimate sustainable yields for water planning purposes, especially given the complexities of estimating recharge alone.

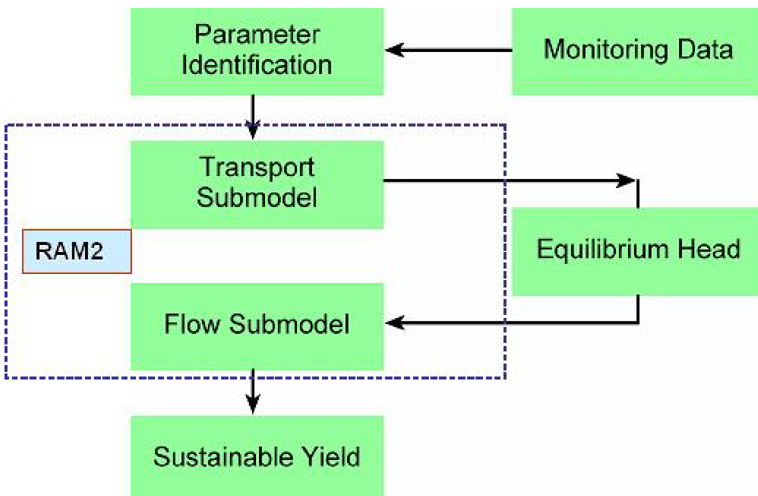
The sustainable yield of Hawai‘i basal aquifers can be determined by the integrated application of both the flow and transport submodels of RAM2. The modeling procedure, as shown in **Figure F-16**, consists of the following steps:

1) Use hydraulic heads and salinity profiles from deep monitoring wells and previous studies to estimate the transport parameter values (i.e., dispersion coefficient and mean hydraulic resident time);

2) Use the transport submodel to calculate the minimum equilibrium hydraulic head; and

3) Use the flow submodel to determine the sustainable yield.

Figure F-16 RAM2 modeling procedure



RAM2 was used by two recent studies[36] to re-evaluate the sustainable yield of a few selected Hawai‘i basal aquifers. **Table F-9** summarizes the results of sustainable yield estimation by both RAM and RAM2.

[36] Liu, 2006; Liu, 2007.

Table F-9 Sustainable yield estimation of selected Hawai‘i basal aquifers

Aquifer	Areas (mi^2)	Natural Recharge (in.)	Estimated Sustainable Yield (MGD) RAM	RAM2
O‘ahu				
‘Ewa-Kunia	28.1	24.0	11.0	19.4
Waipahu-Waiawa	60.7	136.3	102.0	110.3
Waimalu	32.1	59.7	45.0	48.3
Moanalua	10.9	24.0	18.0	15.8
Kalihi	6.3	12.0	9.0	8.7
Beretania	8.6	20.0	15.0	13.9
Kaimukī	14.4	8.7	--	6.5
Maui				
‘Īao	24.7	28.0	20.0	18.5
Moloka‘i				
Kualapu‘u	13.0	9.0	7.0	5.0

Note: According to CWRM, area of Iao is 17.81 mi^2 and area of Kualapuu is 18.2 mi^2

Production Wells in Hawai‘i Basal Aquifers: Operation and Safe Yield

The sustainable yield of Hawai‘i basal aquifers represents the maximum aquifer pumping rate (i.e. allowable draft) assuming optimal placement of wells. In principle, if optimally distributed, each of production well in a basal aquifer can be assigned an allowable draft such that the total draft from the aquifer is equal to or less than the sustainable yield. However, the safe yield of an individual production well is also limited by the localized ground water behavior near the well in response to its pumpage. Specific yields, upconing, and pump intake altitudes can severely limit the safe yield of an individual well while the aquifer as a whole is not threatened. Examples of this are wells drilled too deep, too shallow, or are located in very tight (low permeability) formations. The safe yield of an individual production well may be less than the allowable draft based on any model prediction because of localized operational limitations. Safe yield can be optimized in a production well with proper well design, location, and operation. Further, safe yield of an aquifer based on well infrastructure is best estimated utilizing a calibrated and validated numerical model based on sufficient hydrologic data.

Decline in Specific Capacity

Sustainable yield is evaluated assuming an aquifer is experiencing steady state conditions. It should be noted that this assumption does not account for operational conditions at a given production well. A basal aquifer’s transient response to pumping stress, in the vicinity of a well, may include a decline in specific capacity and/or upconing.

The safe yield of an individual production well is partly controlled by the specific capacity and the available drawdown of that well. When a well is pumped, water is removed from the aquifer surrounding the well, and the water level or hydraulic head is lowered. The drawdown is defined as the vertical distance the water level within the well bore is lowered from the original static (non-pumping) water level. The specific capacity of a production well is its yield per unit drawdown. Available drawdown is the difference between the static head and the lowest practical head, which is normally determined at the time of well construction.

Decline in the specific capacity of a well is measured in terms of operating head. The operating head indicates the transient response of an aquifer to pumping stress. This is usually measured in the field while the aquifer is being pumped. The hydraulic head of a basal aquifer is governed by the Ghyben–Herzberg formula and is called the storage head. The storage head of a large aquifer declines slowly in response to pumping stress. For example, the average decline of the storage head of the Pearl Harbor aquifer was less than 0.25 feet per year during the last 100 years;[37] during the same period, the measured seasonal changes of the operating head near a pumping well in the Pearl Harbor aquifer fluctuated as much as 10 feet. At pumping wells, operating heads are less than storage heads due to turbulent flow into the well. Therefore, operating heads reflect both well inefficiancies and aquifer storage heads.

In Hawaiʻi, the ground water is often pumped from several production wells in a well field. The drawdown at a given well field is equal to the superposition sum of the individual well drawdowns. In general, wells in a well field should be spaced as far apart as possible to minimize well interference. However, economic factors including the cost and availability of land may dictate the implementation of a least-cost well layout, which results in some interference. Both the specific capacity and the available drawdown for each well in a well field must be closely monitored to achieve for satisfactory well operation.

Deterioration in Water Quality (Saltwater intrusion)

When water from a basal aquifer is pumped through a well, pumping stress causes a localized rising of the underlying saltwater. This phenomenon is called upconing.[38] Most past upconing studies and ground water flow models assumed the existence of a sharp interface between freshwater and the underlying saltwater. However, in real-world basal aquifers a gradual transition zone exists between the freshwater and the underlying saltwater (see **Figure F-11**), which appear to differ between aquifer system areas based on deep monitor well data. Also, the nearshore toe of the basal aquifer will shift inland as cumulative pumpage is increased and captures leakage to the ocean. These are significant issues regarding well susceptibility to saltwater intrusion. Mathematical models can and have been used by CWRM to estimate upconing and saltwater intrusion, but the dynamics of the transition zone are not well understood.

[37] Mink, 1980.

[38] Todd, D.K., 1980. Groundwater Hydrology, John Wiley & Sons: New York.

Upconing can be minimized through the proper design and operation of production wells. Generally, wells should have the maximum possible vertical separation from the saltwater zone. This is why in the *Hawaii Well Construction Standards,* all new basal well depths are limited the top ¼ of the thickness of the basal lens encountered during construction. This will reduce the capacity of an individual well but provides a method to optimize the resource and protect future constructed well infrastructure. Wells should also be pumped at a low, uniform rate. The total number of production wells in a well field, well spacing, and pumping rates can be optimized using numerical modeling analyses.

Recommendations for Assessing Sustainable Yield
Ground water can be managed through an understanding of sustainable yield, which is defined as the maximum amount of water that may normally be withdrawn from a source without significantly impairing the source. This definition gives CWRM flexibility to consider and redefine sustainable yields with time and based on case-by-case circumstances. At this time, the sustainable yield of the Hawaiʻi basal aquifers is being evaluated by using analytical ground water models such as the robust analytical model (RAM) and the modified RAM, or RAM2. However, in some areas, including Honolulu, Pearl Harbor, Lanai, Molokaʻi, and (soon) West Maui numerical ground water models have been used to help assess the sustainability of the ground water and refine the uncertainty of analytical ground water models. Additionally, the ʻEwa Caprock area has used a general chloride limit for irrigation wells to establish overall aquifer area sustainable yield.

The most immediate area that requires further investigation is the rate of natural recharge. Reported values of natural recharge vary significantly. These values have been derived from various past studies using differing hydrologic balance analyses. Climate change and data from the last 25 years should also be included into recharge analysis. Recharge should also be standardized such that model studies are comparable. Critical issues for recharge include:

- Estimation of runoff;
- Soil-moisture storage and its relationship to evapotranspiration;
- Assessment of fog drip on precipitation;
- Time steps (daily vs. monthly vs. annual);
- Land use (urban vs. rural vs. agriculture); and
- Results based on CWRM formal aquifer system areas.

A second area that requires further investigation is the interaction between ground water and streamflow. In cases where a stream is hydraulically connected to an aquifer, well withdrawals from the aquifer may cause depletion in the base flow of the stream. This is a concern, as adequate stream flow must be maintained to support instream uses. CWRM must consider ground water/streamflow interactions in its evaluation of sustainable yield and in its review of well-permit applications. Also, numerical models must include the baseflow of streams as part of their calibration analysis.

A third area that requires further study is the salinity transport in the transition zone of basal aquifers. This transport is driven by ground water flow and solute dispersion. Additionally, the effects of bore hole flow in deep monitor wells can introduce complexity in salinity profiles. A recently developed field tracer method by a research team at the University of Hawaiʻi estimates the value of the dispersion coefficient of a basal aquifer by using the salinity profiles observed at deep monitoring wells. The success of this method depends on: how accurately the salinity profile is measured at a deep monitoring well; and how accurately the travel time to the monitoring well is determined. More accurate estimates of the dispersion coefficient can be achieved by establishing ground water monitoring well networks, and by mathematical simulations of the head and velocity distributions.

A fourth area that requires further study is impacts of reducing coastal leakage through pumping and how this might be factored in to sustainable yield estimates. Though §174C-4, HRS of the Water Code states nothing under the chapter of the Code shall apply to coastal waters, this is becoming an increasingly important issue raised through public comments received by CWRM through its processing of other Code responsibilities.

Fifth, more study on spatially detailed analysis of safe yield or well infrastructure along with water use and development plan scenarios is required. Though RAM has its idealized optimization assumptions and RAM2 is formulated by including salinity transport considerations, these models do not simulate the spatial variations of ground water flow and solute transport. Though more spatially detailed analysis can be achieved through monitoring of field data and, if sufficient data exists, numerical ground water models, these approaches must consider clearly defined future land development and pumpage scenarios. Before these comprehensive models can be applied, careful model calibration and verification must be conducted based on adequate field data to ensure that the comprehensive model is a viable management tool. Comprehensive local-scale models may be used for the design and operation of well fields where model parameters can be readily estimated based on sufficient hydrologic data and site-specific field aquifer tests.

Sixth, in the interest of responsible management and protection of water resources and environmental quality, CWRM should expand and improve its hydrologic monitoring network and water use reporting to achieve statewide coverage and to better assess sustainable yields based on actual data.

Lastly, CWRM should consider adaptive management concepts to link the preceding recommendations, which span both science and societal values. CWRM should explore how adaptive management concepts can be applied to the estimation of sustainable yields. CWRM's permit process applies adaptive management concepts and considers other factors, such as rights that affect individual well owners. However, the potential application and incorporation of adaptive management concepts in the estimation of aquifer sustainable yield has yet to be evaluated.

F.4.4 Establishment of the 1990 Sustainable Yield Estimates and Subsequent Updates

In 1980, the Honolulu BWS commissioned hydrologists at the University of Hawaiʻi to develop a model to determine sustainable yields for ground water aquifers in Hawaiʻi. The result was the analytical model known as RAM. Sustainable yield estimates derived via RAM reflect the maximum sustainable average-daily-pumpage rates over an entire aquifer system area, assuming wells are spaced optimally throughout the system. These RAM-derived sustainable yield estimates were incorporated into the 1990 WRPP. In cases where RAM-predicted sustainable yield did not correlate with actual observed conditions in an aquifer system area, CWRM evaluated irrigation practices, historical aquifer pumpage, and other data to refine the RAM estimate. This refined estimate was adopted by CWRM, rather than the strict RAM derived valued. A complete list of the 1990 sustainable yield estimates are presented in **Table F-10**.

In 1993, CWRM adopted an Aquifer System Area approach to organize and manage ground water resources. This superseded the previous method of managing aquifers by larger Sector area boundaries. The Aquifer System Area approach allows for better optimization of well placement and is a better indicator of where water is located within a Sector area. It is the simplest method for optimizing development of the island's ground water resources while ensuring long-term sustainability from the planning and regulatory perspective. As a result of the new management approach, some aquifer system areas were subdivided into multiple systems and others were consolidated into single systems. This resulted in significant changes in the distribution of sustainable yields amongst affected aquifer system areas. Identification of the aquifers systems that were affected and descriptions of the changes that took place are provided in Comment 6 of **Table F-10**.

In 1997, CWRM recognized and adopted the first caprock aquifer sector. The ‘Ewa Caprock Aquifer Sector includes three aquifer system areas. Because the ‘Ewa Caprock Aquifer System Areas overlie basal ground water bodies of other aquifer sectors and systems, and because the dynamics of ground water communication between the caprock and basal aquifers is unclear, CWRM established sustainable yields for the ‘Ewa Caprock Aquifer System Areas based on the chloride content of ground water in individual irrigation wells rather than on average-daily-pumping rates across the aquifer system area, as was done for the basal aquifers. A sustainable yield of 1,000mg/L chloride was adopted for all three ‘Ewa Caprock Aquifer System Areas (see **Table F-12**).

Revisions of individual aquifer system area sustainable yields have also occurred on a case-by-case basis in response to the availability of new data. Sustainable yield estimates have been revised based on recharge studies, ground water models, other hydrogeologic studies, pumpage and deep monitor well data, and the identification of errors in previous models or studies. All revisions to the sustainable yields have taken place in accordance with statutory requirements, and revised sustainable yield estimates adopted by CWRM are official and are used for regulatory and planning purposes.

F.4.4.1 Selection of the 2019 Sustainable Yields

CWRM re-evaluated all sustainable yields for ground water hydrologic units (aka aquifer system areas). The re-evaluation entailed the following steps:

1. Review of sustainable yield calculation models, recharge calculations, deep monitoring well data, historical pumping data, numerical models for predicting infrastructure safe yields, and other hydrogeologic data and studies;

2. Comparison of the previously adopted sustainable yields (those in effect as of August 28, 2008) against those predicted by other models; and

3. Identification of the most appropriate sustainable yield for each aquifer based on conclusions drawn from steps 1 and 2.

CWRM considered four sustainable yield data sets in its evaluation: RAM (1990), RAM (2008), RAM + Updated Recharge, and RAM2 + Updated Recharge. RAM 1990 is the original WRPP 1990 sustainable yield calculations. RAM (2008) is the recalculation of the corrected minimum RAM (2008) values from this 2019 review. The recalculation was conducted when errors were found in the original 1990 calculations. RAM + Updated Recharge consists of sustainable yield estimates resulting from the input of the latest updated recharge estimates into RAM since the 2008 revision and some D/I updates. RAM2 + Updated Recharge consists of sustainable yield estimates predicted by the RAM2 using the original and latest recharge estimates for those few areas with deep monitor well data.

Sustainable yield estimates by models other than RAM or RAM2 were available for some areas; however, because the areas modeled did not match the aquifer system area boundaries, the values could not practically be compared to existing sustainable yield values. Similar issues were encountered with some recharge studies. Therefore, these models and studies were eliminated from consideration. However, some recent recharge studies have been analyzed within CWRM's aquifer hydrologic unit (aquifer system area) approach. Those recharge studies that provided results within this approach are considered in this update.

The sustainable yields for the four data sets considered are listed in **Table F-10**. In addition to these four data sets, CWRM considered the Previously Adopted SY (2007) when the value originated from a CWRM action or a numerical ground water model study. The original uncorrected 1990 RAM sustainable yield numbers are no longer shown in the table for reference since they were not considered in the selection process and are now superseded by the RAM (2008) numbers, which correct known math errors in the original 1990 estimates. The comments in **Table F-10** also provide historical background on changes to aquifer system area boundaries and changes to sustainable yield values.

For a given aquifer system area, the range of sustainable yield estimates shown in **Table F-10** demonstrates that the estimation of aquifer sustainable yields is not an exact science. Insufficient hydrologic, geologic, and meteorological data require the estimation of critical input parameters in any sustainable yield model. Differences in estimates of these input parameters, and in how they are incorporated in a model, can produce a wide range in predicted sustainable yield values for a given aquifer.

Given the range of predicted sustainable yields for each aquifer, and the inherent uncertainty in each prediction, CWRM has applied the *precautionary principle* in selecting sustainable yields for adoption in this update to the WRPP. Application of the precautionary principle is appropriate in light of CWRM's role as a trustee of Hawaiʻi's water resources.

In general, the lowest predicted sustainable yield for an aquifer system area, as shown in **Table F-10**, was selected as the 2019 Sustainable Yield. Exceptions to this rule were recognized on a case-by-case basis and alternative sustainable yields were selected depending on the following:

For Aquifer Systems with predominantly basal resources:

- Presence of an operational deep monitor well and other publicly available hydrogeologic data, such as:
  - Recharge studies that follow the convention of **Section F.4.3.1**;
  - Complete and significant record of historical pumpage, chloride, and water-level data;
  - Numerical model studies for establishing infrastructure safe yields; or
  - Other hydrologic and geologic studies reviewed and accepted by CWRM staff.

- Ground water inputs from adjacent aquifers
- Post-1990 WRPP CWRM actions
- Errors in mathematical calculations
- Clerical errors.

For Aquifer Systems with predominantly high-level resources:

- Presence of an operational ground water-level monitoring network and a stream monitoring network, where applicable, to ensure compliance with instream flow standards, and other publicly available hydrogeologic data, such as:
    - o Recharge studies that follow the convention of **Section F.4.3.1**;
    - o Complete and significant record of historical pumpage, chloride, and water-level data;
    - o Numerical model studies for establishing infrastructure safe yields; or
    - o Other hydrologic and geologic studies reviewed and accepted by CWRM staff.
- Errors in mathematical calculations

For basal aquifer-dominated aquifer system areas, the existence of an operational deep monitor well is critical in determining the location and characteristics of the transition zone and provides an early warning system on the sustainability of the resource. In high-level aquifer dominated aquifer system areas, a robust operational ground water-level monitoring network provides more valuable information than deep monitor wells to assess the sustainability of the resource. In addition, in high-level aquifer systems where existing pumping wells have the potential to impact perennial stream flows, a stream monitoring network provides essential sustainability data.

When monitoring data (well and/or stream), coupled with other scientifically sound, public, and CWRM-vetted aquifer-specific hydrologic, geologic, or other studies strongly suggested that the lowest predicted sustainable yield in **Table F-10** underestimated the sustainable yield, then selection of an alternatively higher sustainable yield was justified. In cases where an alternate sustainable yield was selected, the basis for the selection is called out in **Table F-10** in the Alternate 2019 SY Selection Criteria column and additional information is provided in the table comments.

Table F-11 lists the 2019 sustainable yields for basal and high-level aquifers along with planning comments and aquifer notes. **Table F-12** lists the 2019 sustainable yields for caprock aquifers. Maps illustrating the ground water hydrologic unit boundaries and the 2019 sustainable yield for each aquifer system area are included as **Figure F-17** through **Figure F-22**.

Table F-10 Comparison of Predicted Sustainable Yields Considered by CWRM Sustainable Yield (SY) in Million Gallons Per Day (MGD)

Aquifer Sector	Aquifer System	RAM (1990)	RAM (2008) corrected (1)	RAM + Updated Information (2)	RAM 2 + Updated Information (2)	*SY Range (2019)* (3)	Previously Adopted SY (2008)	Sustainable Yield (2019)	Alternate 2019 SY Selection Criteria
Hawai‘i									
Kohala	Hāwī	27	13	11-29	~	*11-29*	13	**11**	~
Kohala	Waimanu	109	110	122-128	~	*110-128*	110	**110**	~
Kohala	Māhukona	16	17	10-11	~	*10-17*	17	**10**	*(29)*
E. Mauna Kea	Honoka‘a	31	31	29	~	*29-31*	31	**29**	~
E. Mauna Kea	Pa‘auilo	59	60	56	~	*56-60*	60	**56**	~
E. Mauna Kea	Hakalau	150	150	166	~	*150-166*	150	**150**	~
E. Mauna Kea	Onomea	143	147	189	~	*147-189*	147	**147**	~
W. Mauna Kea	Waimea	23	24	16	~	*16-24*	24	**16**	*(29)*
NE. Mauna Loa	Hilo	349	349	379	~	*349-379*	349	**349**	~
NE. Mauna Loa	Kea‘au	395	395	429	~	*395-429*	395	**395**	~
SE. Mauna Loa	‘Ōla‘a	124	125	211	~	*125-211*	125	**125**	~
SE. Mauna Loa	Kapāpala	19	19	53	~	*19-53*	19	**19**	~
SE. Mauna Loa	Nā‘ālehu	117	118	213	~	*118-213*	118	**118**	~
SE. Mauna Loa	Ka Lae	31	31	48	~	*31-48*	31	**31**	~
SW. Mauna Loa	Manukā	42	25	83	~	*25-83*	25	**25**	~
SW. Mauna Loa	Ka‘apuna	50	51	54-97	~	*51-97*	51	**51**	~
SW. Mauna Loa	Kealakekua	38	38	54-88	~	*38-88*	38	**38**	~
NW. Mauna Loa	‘Anaeho‘omalu	30	30	77	~	*30-77*	30	**30**	*(29)*
Kīlauea	Pāhoa	435	437	432	~	*432-437*	437	**432**	~
Kīlauea	Kalapana	157	158	234	~	*158-234*	158	**158**	~
Kīlauea	Hilina	9	9	35	~	*9-35*	9	**20**	*(27)*
Kīlauea	Keaīwa	17	17	45	~	*17-45*	17	**17**	~
Hualālai	Keauhou	38	38	80	~	38-80	38	**38**	~
Hualālai	Kīholo	18	18	40	~	18-40	18	**18**	~

Table F-10 (continued)
Comparison of Predicted Sustainable Yields Considered by CWRM
Sustainable Yield (SY) in Million Gallons Per Day (MGD)

Aquifer Sector	Aquifer System	RAM (1990)	RAM (2008) corrected *(1)*	RAM + Updated Information *(2)*	RAM 2 + Updated Information *(2)*	*SY Range (2019)* (3)	Previously Adopted SY (2008)	Sustainable Yield (2019)	Alternate 2019 SY Selection Criteria
Kauaʻi									
Līhuʻe	Koloa	30	29	33	~	*29-33*	30	**29**	~
Līhuʻe	Hanamāʻulu	40	36	27	~	*27-40*	36	**27**	~
Līhuʻe	Wailua	60	43	51	~	*51-60*	43	**51**	*(28)*
Līhuʻe	Anahola	36	17	21	~	*21-36*	17	**21**	*(28)*
Līhuʻe	Kīlauea	17	5	10	~	*10-17*	5	**10**	*(28)*
Hanalei	Kalihiwai	16	22	16-22	~	*16-22*	11	**16**	*(28)*
Hanalei	Hanalei	35	34	35-47	~	*35-47*	34	**35**	*(28)*
Hanalei	Wainiha	24	24	82	~	*24-82*	24	**24**	~
Hanalei	Nāpali	20	17	28	~	*20-28*	17	**20**	*(28)*
Waimea	Kekaha	12	10	15	~	*10-15*	10	**10**	~
Waimea	Waimea	42	37	48	~	*37-48*	37	**37**	~
Waimea	Makaweli	30	26	43	~	*26-43*	26	**26**	~
Waimea	Hanapēpē	26	22	226	~	*22-26*	22	**22**	~
Lānaʻi									
Central	Windward	3(4)	3	5	~	*3-12*	3	**3**	~
Central	Leeward	3(4)	3	5	~	*3-6*	3	**3**	~
Mahana Sector	Hauola	~	~	3	~	~-3	0	~0	~
Mahana Sector	Maunalei	~	~	2	~	~-2	0	~0	~
Mahana Sector	Paoma	~	~	4	~	~-4	0	~0	~
Kaʻa	Honopū	~	~	4	~	~-4	0	~0	~
Kaʻa	Kaumalapau	~	~	2	~	~-2	0	~0	~
Kanao	Lealia	~	~	1	~	~-1	0	~0	~
Kanao	Manele	~	~	1	~	~-1	0	~0	~

Table F-10 (continued)
Comparison of Predicted Sustainable Yields Considered by CWRM
Sustainable Yield (SY) in Million Gallons Per Day (MGD)

Aquifer Sector	Aquifer System	RAM (1990)	RAM (2008) corrected *(1)*	RAM + Updated Information *(2)*	RAM 2 + Updated Information *(2)*	*SY Range (2019)* *(3)*	Previously Adopted SY (2008)	Sustainable Yield (2019)	Alternate 2019 SY Selection Criteria
Maui									
Wailuku	Waikapu	2	3	6-8	~	*3-8*	3	**3**	~
Wailuku	Iao	20(5)	10	23-28	19-24	*10-28*	20	**20**(15)	*(9a-c, 11)*
Wailuku	Waihee	8	6	15-23	~	*6-23*	8	**8**(16)	*(9a, 9c)*
Wailuku	Kahakuloa	8	5	7-8	~	*5-8*	5	**5**	~
Lahaina	Honokōhau	10	9	14-17	~	*9-17*	9	**9**	~
Lahaina	Honolua	8	8	8-11	~	*8-11*	8	**8**	~
Lahaina	Honokowai	8	6	12-16	~	*6-16*	6	**6**	~
Lahaina	Launiupoko	8	7	13-18	~	*7-18*	7	**7**	~
Lahaina	Olowalu	3	2	6-7	~	*2-7*	2	**2**	~
Lahaina	Ukumehame	3	2	5-6	~	*2-6*	2	**2**	~
Central	Kahului	1	1	1-10	~	*1-10*	1	**1**(32)	~
Central	Paia	8	7	8-33	~	*7-33*	7	**7**(32)	~
Central	Makawao	7	7	20-25	~	*7-25*	7	**7**	~
Central	Kamaole	11	11	11-16	~	*11-16*	11	**11**	~
Koolau	Haiku	31	24	24-27	~	*24-31*	27	**24**	~
Koolau	Honopou	29	16	16-25	~	*16-29*	25	**16**	~
Koolau	Waikamoi	46	37	37-40	~	*37-46*	40	**37**	~
Koolau	Keanae	96	75	75-83	~	*75-96*	83	**75**	~
Hana	Kuhiwa	16	14	14-38	~	*14-38*	16	**14**	~
Hana	Kawaipapa	48	31	31-48	~	*31-48*	48	**31**	~

Table F-10 (continued)
Comparison of Predicted Sustainable Yields Considered by CWRM
Sustainable Yield (SY) in Million Gallons Per Day (MGD)

Aquifer Sector	Aquifer System	RAM (1990)	RAM (2008) corrected (1)	RAM + Updated Information (2)	RAM 2 + Updated Information (2)	*SY Range (2019)* (3)	Previously Adopted SY (2008)	Sustainable Yield (2019)	Alternate 2019 SY Selection Criteria
Maui (continued)									
Hana	Waihoi	20	18	18-24	~	*18-24*	18	**18**	~
Hana	Kipahulu	49	15	15-57	~	*15-57*	42	**15**	~
Kahikinui	Kaupo	18	16	13-17	~	*13-17*	16	**13**	~
Kahikinui	Nakula	7	7	7-15	~	*7-15*	7	**7**	~
Kahikinui	Lualailua	11	11	11	~	*11-15*	11	**11**	~
Molokai									
West	Kaluakoi	2	2	2-4	~	*2-4*	2	**2**	~
West	Punakou	2	2	3	~	*2-3*	2	**2**	~
Central	Hoolehua	2	2	2	~	*2*	2	**2**	~
Central	Pala'au	2	2	3	~	*2-3*	2	**2**	~
Central	Kualapuu	7	4	5-8	5-6	*5-8*	5(6)	**5**(17)	*(9a, 9c-d, 10)*
Southeast	Kamiloloa	3	3	5	~	*3-5*	3	**3**	~
Southeast	Kawela	5	5	10	~	*5-10*	5	**5**	~
Southeast	Ualapue	8	8	8-11	~	*8-11*	8	**8**	~
Southeast	Waialua	8	6	6-8	~	*6-8*	6	**6**	~
Northeast	Kalaupapa	2	2	4	~	*2-4*	2	**2**	~
Northeast	Kahanui	3	3	9	~	*3-9*	3	**3**	~
Northeast	Waikolu	5	5	8	~	*5-8*	5	**5**	~
Northeast	Haupu	2	2	5-6	~	*2-6*	2	**2**	~
Northeast	Pelekunu	9	9	12-14	~	*9-14*	9	**9**	~
Northeast	Wailau	15	15	29	~	*15-29*	15	**15**	~
Northeast	Halawa	8	8	11	~	*8-11*	8	**8**	~

Table F-10 (continued)
Comparison of Predicted Sustainable Yields Considered by CWRM
Sustainable Yield (SY) in Million Gallons Per Day (MGD)

Aquifer Sector	Aquifer System	RAM (1990)	RAM (2008) corrected (1)	RAM + Updated Information (2)	RAM 2 + Updated Information (2)	*SY Range (2019)* (3)	Previously Adopted SY (2008)	Sustainable Yield (2019)	Alternate 2019 SY Selection Criteria
O'ahu									
Honolulu	Pālolo	5	4	4-8	5-6	4-8	5	**5**	(33)
Honolulu	Nu'uanu	15	14	12-19	12-14	12-19	14	**14**	(31)
Honolulu	Kalihi	9	9	7-13	7-9	7-13	9	**9**	(31)
Honolulu	Moanalua	18	17	13-25	13-17	13-25	16	**16**	(31)
Honolulu	Waialae(7a)	3	3	~	~	~	~	~	~
Honolulu	Waialae-West(7a)	~	4	2-3	~	2-3	4(7a)	**2.5**(19)	~
Honolulu	Waialae-East(7a)	~	2	4-10	~	2-10	2(7a)	**2**(18)	~
Pearl Harbor	Waimalu	45	47(20)	42-84	48-50	42-84	45	**45**(20)	*(9a-c)*
Pearl Harbor	Waiawa(7c)	52	See Waipahu-Waiawa	~	~	~	~	~	~
Pearl Harbor	Waipahu(7c)	50	See Waipahu-Waiawa	~	~	~	~	~	~
Pearl Harbor	Waipahu-Waiawa(7c)	~	107	105-180	105-110	105-180	104(8)	**105**(21)	
Pearl Harbor	'Ewa(7d)	3	See 'Ewa-Kunia	~	~	~	~	~	~
Pearl Harbor	Kunia(7d)	8	See 'Ewa-Kunia	~	~	~	~	~	~
Pearl Harbor	'Ewa-Kunia(7d)	~	10	15-20	15-19	*15-20*	16(8)	**16**(22)	*(9a-d, 10, 11)*
Pearl Harbor	Makaīwa(7e)	~	0	<1	~	*<1*	0	**~**	~
Central	Wahiawā (7b)	104	23	141	~	*23-141*	23(7b)	**23**(23)	*(11)*

Table F-10 (continued)
Comparison of Predicted Sustainable Yields Considered by CWRM
Sustainable Yield (SY) in Million Gallons Per Day (MGD)

Aquifer Sector	Aquifer System	RAM (1990)	RAM (2008) corrected *(1)*	RAM + Updated Information *(2)*	RAM 2 + Updated Information *(2)*	*SY Range (2019) (3)*	Previously Adopted SY (2008)	Sustainable Yield (2019)	Alternate 2019 SY Selection Criteria
O‘ahu (continued)									
Wai‘anae	Nānākuli	1	1	1	~	*1-2*	2	1	~
Wai‘anae	Lualualei	4	3	4-9	~	*3-9*	4	3	~
Wai‘anae	Wai‘anae	2	2	3-4	~	*2-4*	3	**3**(24)	***(14a-b,d)***
Wai‘anae	Mākaha	3	3	4-6	~	*3-6*	3	**3**	~
Wai‘anae	Kea‘au	4	4	3-7	~	*3-7*	4	**3**	~
North	Mokulē‘ia	9	8	17-29	~	*8-29*	8	**17***(30)*	***(10)***
North	Waialua	5	4	17-30	~	*4-30*	25(7b)	**17(25)**	(10)
North	Kawailoa	32	29	22-40	~	*22-40*	29	**22**	~
Windward	Ko‘olauloa	42	36	35-41	~	*35-41*	36	**35**	~
Windward	Kahana	15	15	21-23	~	*15-23*	15	**15**	~
Windward	Ko‘olaupoko	30	30	28-46	~	*28-46*	30	**28**	~
Windward	Waimānalo	13	10	9-25	~	*9-25*	10	**9**	~
Waiāhole(26)	Waiāhole(26)	~	15	15	~	*15*	~	**15(26)**	~

Notes:

~	Not Calculated
CWRM	Commission on Water Resource Management
RAM	Robust Analytical Model
SY	Sustainable Yield
WRPP	Water Resources Protection Plan

Table F-10 (continued)
Comparison of Predicted Sustainable Yields Considered by CWRM
Sustainable Yield (SY) in Million Gallons Per Day (MGD)

General Comments & Historical Background on Changes to Aquifer System Boundaries and Sustainable Yield Values
(1) Corrected minimum for 2008 WRPP SY based on 2017 review of RAM D/I, recharge that should have been used in 2008, or mathematical errors)
(2) RAM or RAM 2 methodology using updated best information available for recharge estimates. In cases where multiple valid studies were published ranges of SY are shown.
(3) 2019 SY Range - The bounds of the sustainable yield range were set based on the minimum and maximum estimates resulting from the comparison between the green columns: corrected RAM 2008, RAM + Updated best available Information, and RAM 2 + Updated best available Information.
(4) The Sustainable Yield values for the Windward and Leeward Aquifer System Areas were calculated in 1990 but were accidentally omitted from the Water Resources Protection Plan.
(5) The 20 MGD sustainable yield number is based on a higher recharge value than that reported in the 1990 WRPP. This higher recharge value, along with a slightly modified version of the RAM equation into which it was input, were believed by John F. Mink (developer of the RAM) to more accurately reflect conditions in the Iao Aquifer System Area based on historical behavior. *Reference: Mink, John.F, 1995, Sustainable Yields Maui and Molokai, Letter to the CWRM from Mink & Yuen Inc., dated September 9, 1995.*
(6) In 1993, a mathematical error was discovered in the calculation of the 1990 sustainable yield for the Kualapuu Aquifer System Area. A recalculation of the sutainable yield by John F. Mink in 1995 resulted in a revised recommendation of 5 MGD for the sustainable yield. This number was based on (1) revised estiamtes for direct runoff and evapotranspiration, (2) a modified RAM calculation for sustainable yield, and (3) the presumption of additional recharge to the system from Waikolu Valley. *Reference: Mink, John.F, 1995, Sustainable Yields Maui and Molokai, Letter to the CWRM from Mink & Yuen Inc., dated September 9, 1995.*
(7) In 1993, CWRM adopted an aquifer system areas approach to managing ground water resources in Hawai‘i. This approach is considered the best method for optimizing development of an aquifer while ensuring long-term stability of the water resource. As a result, some aquifer system areas were divided into multiple systems, some aquifer system areas were consolidated into a single system, and new aquifer system areas were created. In addition, revised sustainable yields were proposed for several systems. Specific changes in aquifer system area management and sustainable yields are discussed below: (a) The Waialae Aquifer System Area was subdivided into two separate aquifer system areas due to the presence of a hydrologic boundary at Waialae Iki Ridge. This boundary results in a siginificant hydrologic head difference between the Waialae East and Waialae West Aquifer System Areas. In 2008 the 6 MGD sustainable yield for the original combined aquifer system was redistributed, based on the best available hydrogeologic information, with two-thirds (4MGD) going to Waialae West and one-third (2MGD) going to Waialae East. Subsequent recharge by Engott 2015 updated recharge with lower estimates.

Table F-10 (continued)
Comparison of Predicted Sustainable Yields Considered by CWRM
Sustainable Yield (SY) in Million Gallons Per Day (MGD)

General Comments & Historical Background on Changes to Aquifer System Boundaries and Sustainable Yield Values (cont.)
(7) (b)The Central Aquifer Sector (Wahiawa Aquifer System Area) was separated out from the Pearl Harbor and North Aquifer Sector Areas because the water is high-level rather than basal. The 1993 exisiting pumpage from the system, which totalled 23 MGD, was set as the sustainable yield to maintain spillover of ground water into the Pearl Harbor and North Sectors, thus ensuring sufficient ground water availability in these Sectors to meet demand. The spillover was calculated differently in the 2008 WRPP but has been updated in the 2019 WRPP the following way: • Reviewed all latest recharge updates and used the lowest Waihiawa ASA recharge (Engott 2015 (corrected) - 129.07 MGD). • Subtract the Adjusted Recharge related to the 23 MGD SY (30.67 MGD) from the 129.07 MGD to determine Total Spillover Amount (98.4 MGD) available. • Then split the Total Spillover Amount in half (49.2 MGD), assigning one-half to Pearl Harbor (Waipahu-Waiawa and Ewa-Kunia Aquifer Systems) and one-half to the North (Mokuleia, Waialua, and Kawailoa Aquifer Systems). • For the Pearl Harbor Aquifer Sector Area half of the Total Spillover Amount, assign 85% to the Waipahu-Waiawa Aquifer System Area and 15% to the Ewa-Kunia Aquifer System Area based on the length of their borders with the Wahiawa Aquifer System Area. • For the North Aquifer SectorArea half of the Total Spillover Amount assigns 33% to the Mokuleia Aquifer System Area, 45% to the Waialua Aquifer System Area and 22% to the Kawailoa Aquifer System Area based on the length of their borders with the Wahiawa Aquifer System Area. • Then for all the affected Aquifer System Areas, add the Spillover Amount assigned to each Aquifer System Area Recharge provided in each respective study Using the Revised Recharge multiplied by the D/I for each Aquifer System Area provides the Revised Sustainable Yields. (c) The Waipahu and Waiawa Aquifer System Areas were combined to allow for more flexibility in pumping. The original subdivision of the aquifer system area was not based on hydrogeologic properties. The combined Waipahu-Waiawa Aquifer System Area was assigned the aquifer code (30203). In addition, the sustainable yield for the combined aquifer system area was raised for two reasons. (1) To account for 62 MGD of additional recharge via ground water spillover from the Wahiawa Aquifer System Area (see comment 6b above) and (2) because historic pumping above the 1990 sustainable yields did not adversely affect properly installed wells, indicating that the true sustainable yield of the aquifer system area was greater than that predicted by the RAM. (d) The ‘Ewa & Kunia Aquifer System Areas were combined to manage the aquifer as a whole. The original division of the aquifer was based on the irrigation source (well water versus ditch water) and not hydrologeologic properties. The combined ‘Ewa-Kunia Aquifer System Area was assigned the aquifer code (30204). In addition, the sustainable yield for the combined aquifer system area was raised to account for 14 MGD of additional recharge via ground water spillover from the Wahiawa Aquifer System Area (see comment 6b above).

Table F-10 (continued)
Comparison of Predicted Sustainable Yields Considered by CWRM
Sustainable Yield (SY) in Million Gallons Per Day (MGD)

General Comments & Historical Background on Changes to Aquifer System Boundaries and Sustainable Yield Values (cont.)
(e) The Makaiwa Aquifer System Area was separated out from the Waianae Aquifer System Area due to a difference in ground water behavior in the two aquifer systems. No sustainable yield was established for this system. The Makaiwa Aquifer System Area was assigned the aquifer code (30205), which was previously assigned to the Kunia Aquifer System Area
(8) Sustainable Yield adopted by CWRM in 2000 was based on a review of three ground water models: RAM (analytical), RASA (numerical), CENCOR (numerical). The impetus for the reassessment of the sustainable yields was the demise of large-scale agriculture in the area and the resultant loss of significant volumes of return irrigation recharge to the aquifer systems. The three models assumed significant ground water spillover was occuring from the Central Sector into the Pearl Harbor Sector and reflected various pumping scenarios designed to protect existing infrastructure. The sustainable yield values calculated by the models provided a range of sustainable yield estimates for the ‘Ewa-Kunia and Waipahu-Waiawa Aquifer System Areas *Reference: Hawai‘i Department of Land and Natural Resources - Commission on Water Resource Management, 2000, Commission Meeting Submittal - Request for Approval to Adopt New Sustainable Yields for ‘Ewa-Kunia and Waipahu-Waiawa Aquifer Systems, Pearl Harbor Aquifer Sector, O‘ahu, dated March 15, 2000*.

Table F-10 (continued)
Comparison of Predicted Sustainable Yields Considered by CWRM
Sustainable Yield (SY) in Million Gallons Per Day (MGD)

Alternate Sustainable Yield Selection Criteria
In general, the lowest predicted sustainable yield for an aquifer system area was selected as the 2008 Sustainable Yield. Exceptions to this rule were recognized on a case-by-case basis and alternative sustainable yields were selected based on the following: Basal Ground Water Source (9) - Presence of an operational deep monitor well AND other publicly available hydrogeologic data, such as: 9a - Recharge studies that follow the convention of **Section F.4.3.1** of the WRPP; 9b - Complete and significant record of historical pumpage, chloride, and water-level data; 9c - Numerical model studies for establishing infrastructure safe yields; 9d - Other hydrologic and geologic studies reviewed and accepted by CWRM Staff; or (10) - Ground water inputs from adjacent aquifers; (11) - Post 1990 WRPP CWRM actions; (12) - Errors in mathematical calculations; or (13) – Clerical errors. **High-Level Ground Water Source** (14) - Presence of an operational ground water-level monitoring network and a stream monitoring network, where applicable, to ensure compliance with instream flow standards, AND other publicly available hydrogeologic data, such as: 14a - Recharge studies that follow the convention of **Section F.4.3.1** of the WRPP; 14b - Complete and significant record of historical pumpage, chloride, and water-level data; 14c - Numerical model studies for establishing infrastructure safe yields; 14d - Other hydrologic and geologic studies reviewed and accepted by CWRM Staff

Table F-10 (continued)
Comparison of Predicted Sustainable Yields Considered by CWRM
Sustainable Yield (SY) in Million Gallons Per Day (MGD)

Sustainable Yield (2019) Comments
(15) The sustainable yield for the Iao Aquifer System Area was maintained at 20 MGD as this is believed to be the best estimate to date. This 1995 estimate (see comment 5 above) falls within the range of updated predicted sustainable yields for the system. In addition, numerical models, deep monitor well data, and historical pumpage records all suggest a sustainable yield within the middle of the predicted range. *Reference: Hawai'i Department of Land and Natural Resources - Commission on Water Resource Management, 2002, Waihee Aquifer Systems State Aquifer Codes 60102 and 60103 Ground-Water Management Area Designation Findings of Fact, dated November 11, 2002.*
(16) RAM (2008) revealed an error in the calculation of the original RAM (1990) sustainable yield for the Waihee Aquifer System Area. The 1990 value is 8 MGD. The correct value is 6 MGD. However, based on (1) current ground water demands within the system, (2) the fact that the 8 MGD falls within the predicted range of sustainable yields for the aquifer system, and (3) the presence of a deep monitor well within the system that will allow for long-term monitoring of the transition zone, CWRM elected to maintain the sustainable yield at 8 MGD. Reference: Hawai'i Department of Land and Natural Resources - Commission on Water Resource Management, 2002, Waihee Aquifer Systems State Aquifer Codes 60102 and 60103 Ground-Water Management Area Designation Findings of Fact, dated November 11, 2002. Also, the Maui Department of Water Supply use of their numerical ground water model for the Iao area continues to provide a management tool where CWRM can continue to maintain the sustainable yield at 8 MGD.
(17) The Previously Adopted SY (2007) for the Kualapuu Aquifer System Area dates to a 1996 recalculation of sustainable yield based on a revised recharge number and modified RAM calculation (see comment 5 above). Based on (1) current ground water demands within the system, (2) the fact that the 5 MGD falls within the predicted range of sustainable yields for the aquifer system, (3) the presence of a deep monitor well within the system that will allow for long-term monitoring of the transition zone, and (4) the existence of ground water models for the system, CWRM elected to maintain the sustainable yield at 5 MGD.
(18) Updated recharge data and 2017 review of D/I ratio estimated the ratio as too high suggest a sustainable yield of the Waialae East Aquifer System Area is lower than the Previously Adopted SY (2008).
(19) Updated recharge data suggest that the sustainable yield of the Waialae West Aquifer System Area may be higher than the Previously Adopted SY (2008). However, 2017 review of D/I ratio estimated the ratio as too high and in the absence of a deep monitor well or ground water model, CWRM elected to maintain the sustainable yield at the more conservative number. See comment 7a above. Upon its July 16, 2019 adoption of the updated WRPP, the Commission amended the sustainable yield for Wai'alae-West from 3 to 2.5 mgd, conditioned on the Honolulu Board of Water Supply providing: 1) 100% compliance with their water use reporting requirement (i.e., monthly reporting of water levels, chlorides, and pumpages); and 2) Installation of a new deep monitor well in the Wai'alae-West Aquifer System Area.
(20) RAM (2008) revealed an error in the calculation of the original RAM (1990) sustainable yield for the Waimalu Aquifer System Area. The 1990 value is 45. The correct value is 47 MGD. However, due to exisiting salinity issues in wells in this aquifer system, CWRM elected to maintain the sustainable yield at 45 MGD. A higher sustainable yield may be possible if well placement and pumping are optimized. Waimalu Deep monitor well indicates aquifer is at equilibrium. Red Hill issue suggests keeping status quo for now while at the conclusion of Red Hill review CWRM staff considering moving boundary with Moanalua Aquifer System Area.
(21) The 2019 sustainable yield for the Waipahu-Waiawa Aquifer System Area was calculated using RAM and updated recharges and RAM2 D/I ratio rather than recalibrating the outdated numerical models. Also, see comment 7b above.

(22) The 2019 sustainable yield for the ‘Ewa-Kunia Aquifer System Area was maintained at 16 MGD as this is believed to be the best estimate to date based on historical behavior (See comments 9,10, & 11 above). Also, see comment 7b above.
(23) The sustainable yield for the Wahaiwa Aquifer System Area was held at 23 MGD to ensure sufficient ground water spillover into the Pearl Harbor and North Sectors to meet demands. Also, see Comment 7b above.

Table F-10 (continued)
Comparison of Predicted Sustainable Yields Considered by CWRM
Sustainable Yield (SY) in Million Gallons Per Day (MGD)

Sustainable Yield (2019) Comments (continued)
(24) RAM (2008) revealed an error in the calculation of the original RAM (1990) sustainable yield for the Waianae Aquifer System Area. The 1990 value originally was 3 MGD. The 2008 WRPP corrected the original value to 2 MGD. However, based on (1) current ground water demands within the system, (2) the fact that the 3 MGD falls within the predicted range of sustainable yields for the aquifer system area, (3) the presence of a ground water monitoring network, and (4) a complete and significant record of historical pumpage, chloride, and water-level data, CWRM elected to maintain the sustainable yield at 3 MGD. The importation of water into the area from the Pearl Harbor Aquifer Sector Area provides additional input into the area.
(25) The 2019 sustainable yield for Wailua Aquifer System Area was derived by assuming that 45% of the reserved recharge from the Central Sector Area spills over into the Waialua Aquifer System Area (see comment 7b above). Forty-five percent (45%) of the Pearl Harbor half of Wahiawa ASA spillover recharge was added to the recharge for the Wailua Aquifer System Area and the resulting total recharge value was used for RAM, resulting in the lowerst predicted sustainable yield of 17 MGD.
(26) From Waiahole contested case hearing CCH-OA95-1. Water available for leeward distribution from Waiahole Ditch System (not a true aquifer system area); otherwise, unused portions remain in windward streams.
(27) Based on Mink's qualification of "unreliable" and over 100% change in precipation from 2011 Giambelucca compared to 1990 Mink, the 2008 sustainable yield of 9 was multiplied by 2.25, which is the ratio between the 1990 Mink and the 2011 Giambelluca rainfall data to update the sustainable yield to 20, D/I = 0.44. SY Range 9 (1990 WRPP) - 35 (Engott, 2011) MGD.
(28) SWAP (2008) previously defined minimum of 43 MGD but used the recharge numbers from Shade, 1995 which has been superseded by Izuka & Others, 2015 and is no longer a valid minimum for two main reasons: 1. There was a large overestimation of baseflow that overestimated runoff and underestimated recharge in Shade '95. 2. Recharge in the Shade's old report was based on 1981 and 1998 land-use conditions (Līhu'e Plantation was still open). The estimates in the new report (in the "recent" data set) are for 2010 land use conditions, after the sugar plantations closed and there was a large overestimation of baseflow.
(29) Staff is considering amending the boundaries of the Māhukona, Waimea, and Anaehoomalu Aquifer System Areas based on observed behavior of existing wells within those areas. Changes in boundary conditions amongst these areas will affect and change recharge analysis and quantities; therefore, the SY estimates in this version of the plan are preliminary until further confirmation.
(30) The 2019 sustainable yield for the Mokuleia Aquifer System Area was derived by assuming that 33% of the reserved recharge from the Central Sector Area spills over into the Waialua Aquifer System Area (see comment 7b above). Thirty-three percent (33%) of the North half the Waihiawa ASA recharge spill over was added to the recharge for the Mokuleia Aquifer System Area and the resulting total recharge value was used for RAM, resulting in the lowerst predicted sustainable yield of 17 MGD.
(31) Though the latest recharge estimates from Engott 2015 and changes in D/I ratios from RAM2 created new minimums in the Nuuanu, Kalihi, and Moanalua Aquifer System Areas, and an increase in the Waimalu Aquifer System Area, the sustainable yields will remain the unchanged based on historical pumpage, observation wells & data, and numerical model(s) availability for more analysis. CWRM staff is reviewing BWS monitoring well data and attempting to gather new observation well data away from pumpage sites to further assess the sustainable yields. Also, the shared boundary between the Moanalua & Waimalu Aquifer System Areas may be adjusted as more is learned from the Red Hill Tank investigations, which will affect their areas and, in turn, sustainable yield calculations.

(32) Represents sustainable yield under natural conditions, which ignores significant return irrigation recharge from East Maui. Kahului receives additional return irrigation recharge from Na Wai Eha diversions that is ignored. Upper range of sustainable yields are more likely for current situation.
(33) Lowest minimum of 4 is due to D/I adjustments from RAM2 and resulting rounding to 4 mgd. However, CWRM staff elected to keep the current minimum at 5 mgd while it reviews BWS monitoring well data and attempting to gather new observation well data away from pumpage sites to further assess the sustainable yields.

Table F-10 (continued)
Comparison of Predicted Sustainable Yields Considered by CWRM
Sustainable Yield (SY) in Million Gallons Per Day (MGD)

References	
RAM (1990)	Sustainable Yield Values calculated using the 1990 Robust Analytical Model (RAM). *Source: Hawai'i Department of Land and Natural Resources - Commission on Water Resource Management, 1990, Water Resources Protection Plan, 127pp.*
RAM (2008)	Sustainable Yield Values recalculated by CWRM in 2008 using the 1990 Robust Analytical Model (RAM) and reported original input values. SY values were recalculated after mathematical errors were discovered in calculations for some aquifer systems. RAM (2008) values supercede RAM (1990) values.
RAM + Updated Information	Sustainable Yield Values calculated by inputting updated information from revised RAM D/I values, recharge area corrections to exclude caprock, recharge estimates based on published studies and values into the 1990 Robust Analytical Model. Sources of the update recharge values are provided below by island:
RAM2 + Updated Information	Sustainable Yield Values calculated by inputting updated information from revised RAM D/I values, recharge area corrections to exclude caprock, recharge estimates based on published studies and values into the 2007 Robust Analytical Model 2. Sources of the update recharge values are provided below by island:

Table F-10 (continued)
Comparison of Predicted Sustainable Yields Considered by CWRM
Sustainable Yield (SY) in Million Gallons Per Day (MGD)

References	
Hawai'i	*Izuka, S., Engott, J., Bassiouni, M., Johnson, A., Miller, L., Rotzoll, K., and Mair, A, 2016, Volcanic Aquifers of Hawaii - Hydrogeology, Water budgets, and conceptual models, Scientific Investigations Report 2015-5164, 158pp*
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	Oki, D.S., 2002, Reassessment of ground-water recharge and Simulated ground-water availability for the Hawi Area of North Kohala, Hawai'i: U.S. Geological Survey Water-Resources Investigations Report 02-4006, 62pp. (Hawi)
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	Shade, P.J., 1995, Water Budget for the Kohala Area, Island of Hawaii, Prepared in cooperation with the County of Hawaii Department of Water Supply, U.S. Geological Survey, Water-Resources Investigations Report 95-4114, 24pp.
	Izuka, S., Engott, J., Bassiouni, M., Johnson, A., Miller, L., Rotzoll, K., and Mair, A, 2016, Volcanic Aquifers of Hawaii - Hydrogeology, Water budgets, and conceptual models, Scientific Investigations Report 2015-5164, 158pp (as corrected in print)

Table F-10 (continued)
Comparison of Predicted Sustainable Yields Considered by CWRM
Sustainable Yield (SY) in Million Gallons Per Day (MGD)

References	
Kauaʻi	*Izuka, S., 2006, Effects of Irrigation, Drought, and Ground-Water Withdrawals on Ground-Water Levels in the Southern Līhuʻe Basin, Kauai, Prepared in cooperation with the County of Kauai Department of Water U.S. Geological Survey Water-Resources Scientific Investigations Report 2006-5291, 52pp.*
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	Izuka, Gingerich, 1998, Ground Water in The Southern Līhuʻe Basin, Kauai, Hawaii, Prepared in cooperation with the County of Kauai Department of Water U.S. Geological Survey Water-Resources Scientific Investigations Report 98-4031. 76pp.
	Shade, P.J., 1995, Water Budget for the Island of Kauai, Hawaiʻi: U.S. Geological Survey Water-Resources Investigations Report 95-4128, 25pp.
Lanai	*Hardy, W.R., 1996, A numerical ground-water model for the Island of Lanai, Hawaiʻi: Commission on Water Resource Management, Department of Land and Natural Resources, State of Hawaiʻi, 126pp.*
	Mink, John, 1983, Lanai Water Supply, 62 pp.

Table F-10 (continued)
Comparison of Predicted Sustainable Yields Considered by CWRM
Sustainable Yield (SY) in Million Gallons Per Day (MGD)

References	
Maui	*Izuka, S., Engott, J., Bassiouni, M., Johnson, A., Miller, L., Rotzoll, K., and Mair, A, 2016, Volcanic Aquifers of Hawaii - Hydrogeology, Water budgets, and conceptual models, Scientific Investigations Report 2015-5164, 158pp (as corrected in print)*
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	Shade, P.J., 1999, Water budget of East Maui, Hawaiʻi: U.S. Geological Survey Water-Resources Investigations Report 97-4159, 36pp. (Haiku through Lualailua)
	Shade, P.J., 1997, Water Budget for The Iao Area, Island Of Maui, Hawaii, Prepared in cooperation with the County of Maui Department of Water Supply, U.S. Geologic Survey Water-Resources Investigations Report 97-4244, 29pp
Molokaʻi	*Shade, P.J., 1997, Water budget for the Island of Molokai, Hawaiʻi: U.S. Geologic Survey Water-Resources Investigations Report 97-4155, 20pp.*

Table F-10 (continued)
Comparison of Predicted Sustainable Yields Considered by CWRM
Sustainable Yield (SY) in Million Gallons Per Day (MGD)

References	
O'ahu	*Izuka, S., Engott, J., Bassiouni, M., Johnson, A., Miller, L., Rotzoll, K., and Mair, A, 2016, Volcanic Aquifers of Hawaii - Hydrogeology, Water budgets, and conceptual models, Scientific Investigations Report 2015-5164, 158pp (as corrected in print)*
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	Rotzoll, K. and A.I. El-Kadi, 2007, Numerical Ground-Water Flow Simulation for Red Hill Fuel Storage Facilities, NAVFAC Pacific, Oahu,
	Todd Engineeers, 2005, Development of a Groundwater Management Model, Honolulu Area of the Southern Oahu Groundwater system,
	Shade, P.J., and W.D. Nichols, 1996, Water budget and the effects of land-use changes on ground-water recharge, Oahu, Hawai'i: U.S. Geological Survey Professional Paper 1412-C, 38pp.
	Mink & Yuen Inc., 1998 A Study on The Sustainable Yield of The Ewa-Kunia Aquifer System, prepared for Campbel Estate, 49 pp.
	Mink & Yuen Inc., 1998, A Study on The Pearl Harbor Aquifer System, Waipahu-Waiawa And Waimalu, 54 pp.
	George Yuen & Associates (Mink, J.), 1988, Review and Re-Evaluation of Groundwater Conditions in The Pearl Harbor Groundwater
	Mink, J.F., 1980, State of The Groundwater Resources of Southern Oahu, 83 pp.
RAM 2	Sustainable Yield values calculated using the Robust Analytical Model 2. Sources by Aquifer System are provided below: *Liu, C.C.K., 2006, Analytical Groundwater Flow and Transport Modeling for the Estimation of the Sustainable Yield of Pearl Harbor Aquifer: University of Hawai'i Water Resources Research Center, Project Report PR-2006-06, 53pp. (Waimalu, Waipahu-Waiawa, 'Ewa-Kunia)*
	Liu, C.C.K., 2007, RAM2 Modeling and the Determination of Sustainable Yields of Hawai'i Basal Aquifers: University of Hawai'i Water Resources Research Center, Project Report PR-2008-06, 81pp. (Maui-Iao, Molokai-Kualapuu; Oahu-Palolo, Nuuanu, Kalihi, Moanalua)

Table F-11 Aquifer Notes

Aquifer Sector	Aquifer System	Aquifer Code	Sustainable Yield (2019)	Comments
Kohala	Hāwī	80101	**11**	The recharge value used to calculate the Sustainable Yield INCLUDES return irrigation inputs to ground water. This Aquifer System contains ground water as basal, perched, and high level, with the all reported ground water use pumped from the basal zone.
Kohala	Waimanu	80102	**110**	This Aquifer System contains ground water as basal, perched, and high level, with no reported ground water use.
Kohala	Māhukona	80103	**10**	This Aquifer System contains ground water as basal, perched, and high level. The majority reported ground water is pumped from the high level followed by basal zone. Staff is considering amending the boundary between Waimea and Māhukona Aquifer System Areas based on observed behavior of existing wells within those areas. Changes in boundary conditions amongst these areas will affect and change recharge analysis and quantities; therefore, the SY estimates in this version of the plan are preliminary until further confirmation.
E. Mauna Kea	Honokaʻa	80201	**29**	This Aquifer System contains ground water as basal, perched, and high level. The majority reported ground water is pumped from the high level, followed by basal zone, and with lesser amounts removed from perched.
E. Mauna Kea	Paʻauilo	80202	**56**	This Aquifer System contains ground water as basal, perched, and high level, with the all reported ground water use pumped from the basal zone.
E. Mauna Kea	Hakalau	80203	**150**	This Aquifer System contains ground water as basal, perched, and high level. The majority reported ground water is pumped from the basal zone, followed by perched.
E. Mauna Kea	Onomea	80204	**147**	This Aquifer System contains ground water as basal, perched, and high level, with the all reported ground water use pumped from the basal zone.

Table F-11 Aquifer Notes (continued)

Aquifer Sector	Aquifer System	Aquifer Code	Sustainable Yield (2019)	Comments
W. Mauna Kea	Waimea	80301	**16**	This Aquifer System contains ground water as basal and high level; with the majority reported ground water is pumped from the basal zone, followed by high level. Staff is also considering amending the boundaries between Waimea and Māhukona/Anaehoomalu Aquifer System Areas based on observed behavior of existing wells within those areas. Changes in boundary conditions amongst these areas will affect and change recharge analysis and quantities; therefore, the SY estimates in this version of the plan are preliminary until further confirmation.
NE. Mauna Loa	Hilo	80401	**349**	This Aquifer System contains ground water as basal, perched, and high level. The majority reported ground water is pumped from the basal zone, followed by perched, and with lesser amounts removed from high level.
NE. Mauna Loa	Keaʻau	80402	**395**	This Aquifer System contains ground water as basal, perched, and high level. The majority reported ground water is pumped from the basal zone, followed by perched, and with lesser amounts removed from high level.
SE. Mauna Loa	ʻŌlaʻa	80501	**125**	This Aquifer System contains ground water as predominantly high-level ground water with some perched, with no reported ground water use.
SE. Mauna Loa	Kapāpala	80502	**19**	This Aquifer System contains ground water as predominantly high-level ground water, with some perched. There are no wells located in this Aquifer System.
SE. Mauna Loa	Nāʻālehu	80503	**118**	This Aquifer System contains ground water as basal, perched, and high level. The majority reported ground water is pumped from the basal zone, followed by high level.
SE. Mauna Loa	Ka Lae	80504	**31**	This Aquifer System contains ground water as predominantly basal, with no reported ground water use.
SW. Mauna Loa	Manukā	80601	**25**	This Aquifer System contains ground water as basal and high level, with the all reported ground water use pumped from the basal zone.
SW. Mauna Loa	Kaʻapuna	80602	**51**	This Aquifer System contains ground water as basal and high level, with the all reported ground water use pumped from the basal zone.

Table F-11 Aquifer Notes (continued)

Aquifer Sector	Aquifer System	Aquifer Code	Sustainable Yield (2019)	Comments
SW. Mauna Loa	Kealakekua	80603	**38**	This Aquifer System contains ground water as basal and high level. The majority reported ground water is pumped from the high level, followed by basal zone.
NW. Mauna Loa	Anaehoomalu	80701	**30**	This Aquifer System contains ground water as basal and high level, with the all reported ground water use pumped from the basal zone. Assumes all recharge discharges at the coast between Anaehoomalu and Puako. Possible significant underflow of ground water out of Anaehoomalu into adjacent aquifer system areas was not accounted for in the recharge estimate used to calculate the sustainable yield. Accounting for such underflows may yield a much lower sustainable yield for Anaehoomalu. Staff is also considering amending the boundary between Waimea and Anaehoomalu Aquifer System Areas based on observed behavior of existing wells within those areas. Changes in boundary conditions amongst these areas will affect and change recharge analysis and quantities; therefore, the SY estimates in this version of the plan are preliminary until further confirmation.
Kīlauea	Pahoa	80801	**432**	This Aquifer System contains ground water as basal, perched, and high level, with the all reported ground water use pumped from the basal zone.
Kīlauea	Kalapana	80802	**158**	This Aquifer System contains ground water as basal and high level, with the all reported ground water use pumped from the basal zone.
Kīlauea	Hilina	80803	**20**	This Aquifer System contains ground water as basal and high level, with no reported ground water use.
Kīlauea	Keaiwa	80804	**17**	This Aquifer System contains ground water as predominantly high-level ground water, with some basal All reported ground water use is pumped from the basal zone.

Table F-11 Aquifer Notes (continued)

Aquifer Sector	Aquifer System	Aquifer Code	Sustainable Yield (2019)	Comments
Hualalai	Keauhou	80901	**38**	This Aquifer System contains ground water as basal and high level. The majority reported ground water is pumped from the basal zone, followed by high level. Ongoing and future studies to determine the extent of connection between significant high-level, thin basal, and deep confined freshwater aquifers and impact of ground water pumpage on nearshore ecosystems
Hualalai	Kīholo	80902	**18**	This Aquifer System contains ground water as basal and high level. The majority reported ground water is pumped from the basal zone, followed a minor amount from the high level. Thin basal resources are sensitive to chlorides, while the high-level resrouce is limited
Līhuʻe	Koloa	20101	**29**	This Aquifer System contains ground water as basal, perched and high level, with the majority of reported ground water pumped from the perched zone. (1) Due to the presence of a discontinuous, unmapped confining layer, the nature and extent of the basal ground water lens is not well understood. (2) The recharge value used to calculate the Sustainable Yield INCLUDES return irrigation inputs to ground water.
Līhuʻe	Hanamāʻulu	20102	**27**	This Aquifer System contains ground water as basal, perched and high level. The majority reported ground water is pumped from the perched zone followed by the basal, and with little to no ground water removed from high level. (1) Due to the presence of a discontinuous, unmapped confining layer, the nature and extent of the basal ground water lens is not well understood. (2) The recharge value used to calculate the Sustainable Yield INCLUDES return irrigation inputs to ground water.

Table F-11 Aquifer Notes (continued)

Aquifer Sector	Aquifer System	Aquifer Code	Sustainable Yield (2019)	Comments
Līhuʻe	Wailua	20103	**51**	This Aquifer System contains ground water as basal, perched and high level. The majority reported ground water is pumped from the basal zone followed by high level, and with lesser amounts removed from perched. (1) Predominantly high-level ground water. (2) Due to the presence of a discontinuous, unmapped confining layer, the nature and extent of the basal ground water lens is not well understood. (3) The recharge value used to calculate the Sustainable Yield INCLUDES return irrigation inputs to ground water.
Līhuʻe	Anahola	20104	**21**	This Aquifer System contains ground water as basal, perched and high level. The majority reported ground water is pumped from the high-level zone followed by basal, and with lesser amounts removed from perched. (1) Due to the presence of a discontinuous, unmapped confining layer, the nature and extent of the basal ground water lens is not well understood. (2) The recharge value used to calculate the Sustainable Yield INCLUDES return irrigation inputs to ground water.
Līhuʻe	Kīlauea	20105	**10**	This Aquifer System contains ground water as basal, perched and high level. The majority reported ground water is pumped from the basal zone followed by perched, and with lesser amounts removed from high level. (1) Due to the presence of a discontinuous, unmapped confining layer, the nature and extent of the basal ground water lens is not well understood. (2) The recharge value used to calculate the Sustainable Yield INCLUDES return irrigation inputs to ground water.

Table F-11 Aquifer Notes (continued)

Aquifer Sector	Aquifer System	Aquifer Code	Sustainable Yield (2019)	Comments
Hanalei	Kalihiwai	20201	**16**	This Aquifer System contains ground water as basal and perched, with the all the reported ground water pumped from the basal zone. (1) Due to the presence of a discontinuous, unmapped confining layer, the nature and extent of the basal ground water lens is not well understood. (2) The recharge value used to calculate the Sustainable Yield INCLUDES return irrigation inputs to ground water.
Hanalei	Hanalei	20202	**35**	This Aquifer System contains ground water as basal, perched and high level. The majority reported ground water is pumped from the basal zone followed by perched. There are no wells located in the high-level zone. (1) Due to the presence of a discontinuous, unmapped confining layer, the nature and extent of the basal ground water lens is not well understood. (2) The recharge value used to calculate the Sustainable Yield INCLUDES return irrigation inputs to ground water.
Hanalei	Wainiha	20203	**24**	This Aquifer System contains ground water as basal and high level, with all the reported ground water pumped from the basal zone. Due to the presence of a discontinuous, unmapped confining layer, the nature and extent of the basal ground water lens is not well understood.
Hanalei	Napali	20204	**20**	There are two wells located in the high-level zone, with no reported pumped quantities. (1) Due to the presence of a discontinuous, unmapped confining layer, the nature and extent of the basal ground water lens is not well understood. (2) Predominantly Basal Ground Water. (3) The recharge value used to calculate the Sustainable Yield INCLUDES return irrigation inputs to ground water.

Table F-11 Aquifer Notes (continued)

Aquifer Sector	Aquifer System	Aquifer Code	Sustainable Yield (2019)	Comments
Waimea	Kekaha	20301	**10**	This Aquifer System contains ground water as basal. The basal lens is protected by a thick sedimentary caprock along the coast; however, no wells utilize the caprock.
Waimea	Waimea	20302	**37**	This Aquifer System contains ground water as basal and high level, with all the reported ground water pumped from the perched zone. There are no wells located in the high-level zone.
Waimea	Makaweli	20303	**26**	This Aquifer System contains ground water as basal and perched, with the all reported ground water pumped from the perched zone.
Waimea	Hanapēpē	20304	**22**	This Aquifer System contains ground water as basal and perched; although there is very likely high-level water located in the higher elevation it is currently not utilized. The majority of reported ground water pumped from the basal zone.
Central	Windward	50101	**3**	Only high-level ground water.
Central	Leeward	50102	**3**	(1) Only high-level ground water. (2) Ground water may be brackish in the PaLāwaʻi Basin area.
Mahana Sector	Hauola	50201	**~**	(1) Ground water is brackish
Mahana Sector	Maunalei	50202	**~**	(1) Ground water is brackish
Mahana Sector	Paoma	50203	**~**	(1) Ground water is brackish
Kaa	Honopū	50301	**~**	(1) Ground water is brackish
Kaa	Kaumalapau	50302	**~**	(1) Ground water is brackish

Table F-11 Aquifer Notes (continued)

Aquifer Sector	Aquifer System	Aquifer Code	Sustainable Yield (2019)	Comments
Kanao	Lealia	50401	~	(1) Ground water is brackish
Kanao	Manele	50402	~	(1) Ground water is brackish
Wailuku	Waikapu	60101	**3**	This Aquifer System contains ground water as basal and high level; with all of reported ground water use pumped from the basal zone.
Wailuku	Iao	60102	**20**	This Aquifer System contains ground water as basal, alluvial, caprock, and high level, with the majority reported ground water use pumped from the basal zone, followed by high level, with lesser amounts removed from alluvial and caprock wells.
Wailuku	Waihee	60103	**8**	This Aquifer System contains ground water as basal, perched, and high level, with all reported ground water use pumped from the basal zone.
Wailuku	Kahakuloa	60104	**5**	This Aquifer System contains ground water as basal, perched, and high level. There are no wells located in this Aquifer System.
Lahaina	Honokōhau	60201	**9**	This Aquifer System contains ground water as basal, perched, and high level, with no reported ground water use.
Lahaina	Honolua	60202	**8**	This Aquifer System contains ground water as basal and high level, with all reported ground water use pumped from the basal zone.
Lahaina	Honokowai	60203	**6**	This Aquifer System contains ground water as basal and high level, with all reported ground water use pumped from the basal zone.
Lahaina	Launiupoko	60204	**7**	This Aquifer System contains ground water as basal and high level, with all reported ground water use pumped from the basal zone.
Lahaina	Olowalu	60205	**2**	This Aquifer System contains ground water as basal and high level, with all reported ground water use pumped from the basal zone.
Lahaina	Ukumehame	60206	**2**	This Aquifer System contains ground water as basal and high level, with all reported ground water use pumped from the basal zone.

Table F-11 Aquifer Notes (continued)

Aquifer Sector	Aquifer System	Aquifer Code	Sustainable Yield (2019)	Comments
Central	Kahului	60301	**1**	(This Aquifer System contains ground water as basal and caprock. Sustainable Yield ignores significant importation of surface water (return irrigation) into Kahului from outside the aquifer system area. This explains the ability to withdraw freshwater from the aquifer at significantly higher rates than the sustainable yield without apparent negative impacts (i.e. rising chloride concentrations or decreasing water levels). The majority of reported ground water use pumped from the basal zone.
Central	Paia	60302	**7**	This Aquifer System contains ground water only as basal ground water. The sustainable Yield ignores significant importation of surface water into Paia from outside the aquifer system area. This explains the ability to withdraw freshwater from the aquifer at significantly higher rates than the sustainable yield without apparent negative impacts (i.e. rising chloride concentrations or decreasing water levels). All reported ground water use pumped from the basal zone.
Central	Makawao	60303	**7**	This Aquifer System contains ground water as basal and high level, with the majority of reported ground water use pumped from the basal zone.
Central	Kamaole	60304	**11**	This Aquifer System contains ground water as basal, perched, and high level. The majority reported ground water use is pumped from the basal zone and with lesser amounts removed from perched.
Koolau	Haiku	60401	**24**	This Aquifer System contains ground water as basal, perched, and high level with the majority reported ground water use pumped from the basal zone, with lesser amount removed from high level wells.
Koolau	Honopou	60402	**16**	This Aquifer System contains ground water as basal, perched, and high level, with the all reported ground water use pumped from the basal zone.
Koolau	Waikamoi	60403	**37**	This Aquifer System contains ground water as basal, perched, and high level, with no reported ground water use.

Table F-11 Aquifer Notes (continued)

Aquifer Sector	Aquifer System	Aquifer Code	Sustainable Yield (2019)	Comments
Koolau	Keanae	60404	**75**	This Aquifer System contains ground water as basal, perched, and high level, with the all reported ground water use pumped from the basal zone.
Hana	Kuhiwa	60501	**14**	This Aquifer System contains ground water as basal and high level, with no reported ground water use.
Hana	Kawaipapa	60502	**31**	This Aquifer System contains ground water as basal and high level, with the all reported ground water use pumped from the basal zone.
Hana	Waihoi	60503	**18**	This Aquifer System contains ground water as basal, perched, and high level, with no reported ground water use.
Hana	Kipahulu	60504	**15**	This Aquifer System contains ground water as basal, perched, and high level, with the all reported ground water use pumped from the perched zone.
Kahikinui	Kaupo	60601	**13**	This Aquifer System contains ground water as basal and high level, with the all reported ground water use pumped from the basal zone.
Kahikinui	Nakula	60602	**7**	This Aquifer System contains ground water as basal and high level, with no reported ground water use.
Kahikinui	Lualailua	60603	**11**	This Aquifer System contains ground water as basal, with a small area of high level located in the farthest interior. All reported ground water use pumped from the basal zone.
West	Kaluakoi	40101	**2**	This Aquifer System contains ground water as basal which is brackish, with no reported ground water use.
West	Punakou	40102	**2**	This Aquifer System contains ground water as basal which is brackish, with no reported ground water use.
Central	Hoolehua	40201	**2**	This Aquifer System contains ground water as basal which is brackish, with no reported ground water use.
Central	Palaau	40202	**2**	This Aquifer System contains ground water as basal, and there is partially effective caprock. Reported ground water use is pumped mainly from the basal zone, with lesser quantities from the caprock.
Central	Kualapuu	40203	**5**	This Aquifer System contains ground water as basal and high level, with the all reported ground water pumped from the basal zone.

Table F-11 Aquifer Notes (continued)

Aquifer Sector	Aquifer System	Aquifer Code	Sustainable Yield (2019)	Comments
Southeast	Kamiloloa	40301	**3**	This Aquifer System contains ground water as basal, with a small area of high level near the crest of the mountains. All the reported ground water usage is from the basal zone.
Southeast	Kawela	40302	**5**	This Aquifer System contains ground water as basal, with an area of high level. All the reported ground water usage is pumped from the basal zone.
Southeast	Ualapue	40303	**8**	This Aquifer System contains ground water as basal, caprock, and a small area of high level. Reported ground water use is pumped mainly from the basal zone, with lesser quantity from the caprock.
Southeast	Waialua	40304	**6**	This Aquifer System contains ground water as basal and a small area of high level. All reported ground water use is pumped from the basal zone.
Northeast	Kalaupapa	40401	**2**	Ground water occurs predominantly as high-level ground water with minor amounts of basal. There are no wells located in this Aquifer System.
Northeast	Kahanui	40402	**3**	Ground water occurs predominantly as high-level ground water. All reported ground water use is pumped from the high-level zone.
Northeast	Waikolu	40403	**5**	Ground water occurs predominantly as high-level ground water. All reported ground water use is pumped from the high-level zone.
Northeast	Haupu	40404	**2**	Ground water occurs predominantly as high-level ground water. There are no wells located in this Aquifer System.
Northeast	Pelekunu	40405	**9**	Ground water occurs predominantly as high-level ground water with some basal along the coast. There are no wells located in this Aquifer System.
Northeast	Wailau	40406	**15**	Ground water occurs predominantly as high-level ground water. There are no wells located in this Aquifer System.
Northeast	Halawa	40407	**8**	This Aquifer System contains ground water as basal, perched and high level. There are no wells located in this Aquifer System.
Honolulu	Palolo	30101	**5**	This Aquifer System contains ground water as basal, perched and high level in addition there is a thick effective caprock. The majority reported ground water use is pumped from the caprock followed by the basal zone and with lesser amounts removed from the high level.

Table F-11 Aquifer Notes (continued)

Aquifer Sector	Aquifer System	Aquifer Code	Sustainable Yield (2019)	Comments
Honolulu	Nuuanu	30102	**14**	This Aquifer System contains ground water as basal, perched and high level in addition there is a thick effective caprock. The majority reported ground water use is pumped from the basal followed by the caprock and with lesser amounts removed from the high level.
Honolulu	Kalihi	30103	**9**	This Aquifer System contains ground water as basal, perched and high level in addition there is a thick effective caprock. All reported ground water use is pumped from the basal zone.
Honolulu	Moanalua	30104	**16**	This Aquifer System contains ground water as basal, perched and high level in addition there is a thick effective caprock. All reported ground water use is pumped from the basal zone.
Honolulu	Waialae-West	30105	**2.5**	This Aquifer System contains ground water as basal, perched and high level in addition there is a thick effective caprock. All reported ground water use is pumped from the basal zone.
Honolulu	Waialae-East	30106	**2**	This Aquifer System contains ground water as basal, perched and high level in addition there is a thick effective caprock. The majority reported ground water use is pumped from the caprock followed by the basal zone.
Pearl Harbor	Waimalu	30201	**45**	This Aquifer System contains predominately ground water as basal and high level in addition there is a caprock. All reported ground water use is pumped from the basal zone and high level. The lowest model-predicted sustainable yield is 47 MGD. However, due to exisiting salinity issues in wells in this aquifer system, CWRM elected to maintain the sustainable yield at 45 MGD. A higher sustainable yield may be possible if well placement and pumping are optimized.
Pearl Harbor	Waipahu-Waiawa	30203	**105**	This Aquifer System contains predominately ground water as basal in addition there is a caprock. All reported ground water use is pumped from the basal zone. The recharge value used in the Sustainable Yield calculation includes spillover of ground water from the Wahiawa Aquifer System area.

Table F-11 Aquifer Notes (continued)

Aquifer Sector	Aquifer System	Aquifer Code	Sustainable Yield (2019)	Comments
Pearl Harbor	ʻEwa-Kunia	30204	**16**	This Aquifer System contains predominately ground water as basal in addition there is a caprock. All reported ground water use is pumped from the basal zone. The recharge value used in the Sustainable Yield calculation includes spillover of ground water from the Wahiawa Aquifer System area.
Pearl Harbor	Makaiwa	30205	**~**	This Aquifer System contains predominately ground water as basal in addition there is a caprock. All reported ground water use is pumped from the basal zone.
Central	Wahiawā	30501	**23**	This Aquifer System contains ground water entirely of high level. Spillover from this Aquifer Sector supplements the Mokuleia, Wailua, Kawailoa, Ewa-Kunia, and Waipahu-Waiawa Aquifer Systems.
Waianae	Nānākuli	30301	**1**	This Aquifer System contains ground water as basal and high level in addition there is a caprock, with no reported ground water use.
Waianae	Lualualei	30302	**3**	This Aquifer System contains ground water as basal and high level, in addition there is a caprock. The reported ground water use is pumped from the caprock and basal zones.
Waianae	Waiʻanae	30303	**3**	This Aquifer System contains ground water as basal, alluvial, and high level, in addition there is a caprock. The reported ground water use is pumped from the high level and basal zones.
Waianae	Mākaha	30304	**3**	This Aquifer System contains ground water as basal, perched, alluvial, and high level, in addition there is a caprock. The majority reported ground water use is pumped from the high level, followed by the perched, alluvial, and cap rock.
Waianae	Keaʻau	30305	**3**	This Aquifer System contains ground water as basal and high level, in addition there is a caprock. All reported ground water use is pumped from the basal zone.

Table F-11 Aquifer Notes (continued)

Aquifer Sector	Aquifer System	Aquifer Code	Sustainable Yield (2019)	Comments
North	Mokulēʻia	30401	**17**	This Aquifer System contains ground water as basal, in addition there is a thick effective caprock. All reported ground water use is pumped from the basal zone. The recharge value used in the Sustainable Yield calculation includes spillover of ground water from the Wahiawa Aquifer System area.
North	Waialua	30402	**17**	This Aquifer System contains ground water as basal, in addition there is a thick effective caprock. All reported ground water use is pumped from the basal zone. The recharge value used in the Sustainable Yield calculation includes spillover of ground water from the Wahiawa Aquifer System area.
North	Kawailoa	30403	**22**	This Aquifer System contains ground water as basal and perched but lacks an effective caprock. The majority of reported ground water use is pumped from the basal zone. The recharge value used in the Sustainable Yield calculation includes spillover of ground water from the Wahiawa Aquifer System area.
Windward	Koʻolauloa	30601	**35**	This Aquifer System is predominantly basal ground water.
Windward	Kahana	30602	**15**	This Aquifer System contains ground water as basal, alluvial, and high level, in addition there is a caprock. All reported ground water use is pumped from high level.
Windward	Koʻolaupoko	30603	**28**	This Aquifer System contains ground water as basal and high level, in addition there is a caprock. The majority reported ground water use is pumped from high level. Ground water removed from the aquifer system area by the Waiāhole Tunnel was subtracted from the total recharge value used to calculate sustainable yield.
Windward	Waimānalo	30604	**9**	This Aquifer System contains ground water as basal and high level, in addition there is a caprock. All reported ground water use is pumped from high level.
Waiahole Ditch	Waiahole Ditch	30701	**15**	From Waiahole contested case hearing CCH-OA95-1. Water available for leeward distribution from Waiahole Ditch System (not a true aquifer system area); otherwise, unused portions remain in windward streams.

Table F-12 Sustainable Yield Values for Hawai‘i Caprock Aquifers

Sustainable Yield = Miligrams Per Liter (mg/L) Sodium

Aquifer Sector Area	Aquifer System Area	Code	Sustainable Yield
O‘ahu			
‘Ewa Caprock	Malakole	30207	NA
‘Ewa Caprock	Kapolei	30208	1000
‘Ewa Caprock	Puuloa	30209	1000

F.4.4.2 Future Sustainable Yield Selection Criteria

As the WRPP is a living document, sustainable yields will be re-estimated continually based on the best information available as new information is acquired with time. In general, the best information that is scientifically sound and CWRM-vetted for aquifer-specific hydrologic, geologic, or other data will be used for future sustainable yield revisions on case-by-case basis. Revisions shall be consistent with the following criteria:

For Aquifer Systems with predominantly basal resources:

- Presence of an operational deep monitor well and other publicly available hydrogeologic data, such as:
  - Recharge studies that follow the convention of **Section F.4.3.1**;
  - Complete and significant record of historical pumpage, chloride, and water-level data;
  - Numerical model studies for establishing infrastructure safe yields; or
  - Other hydrologic and geologic studies reviewed and accepted by CWRM staff.

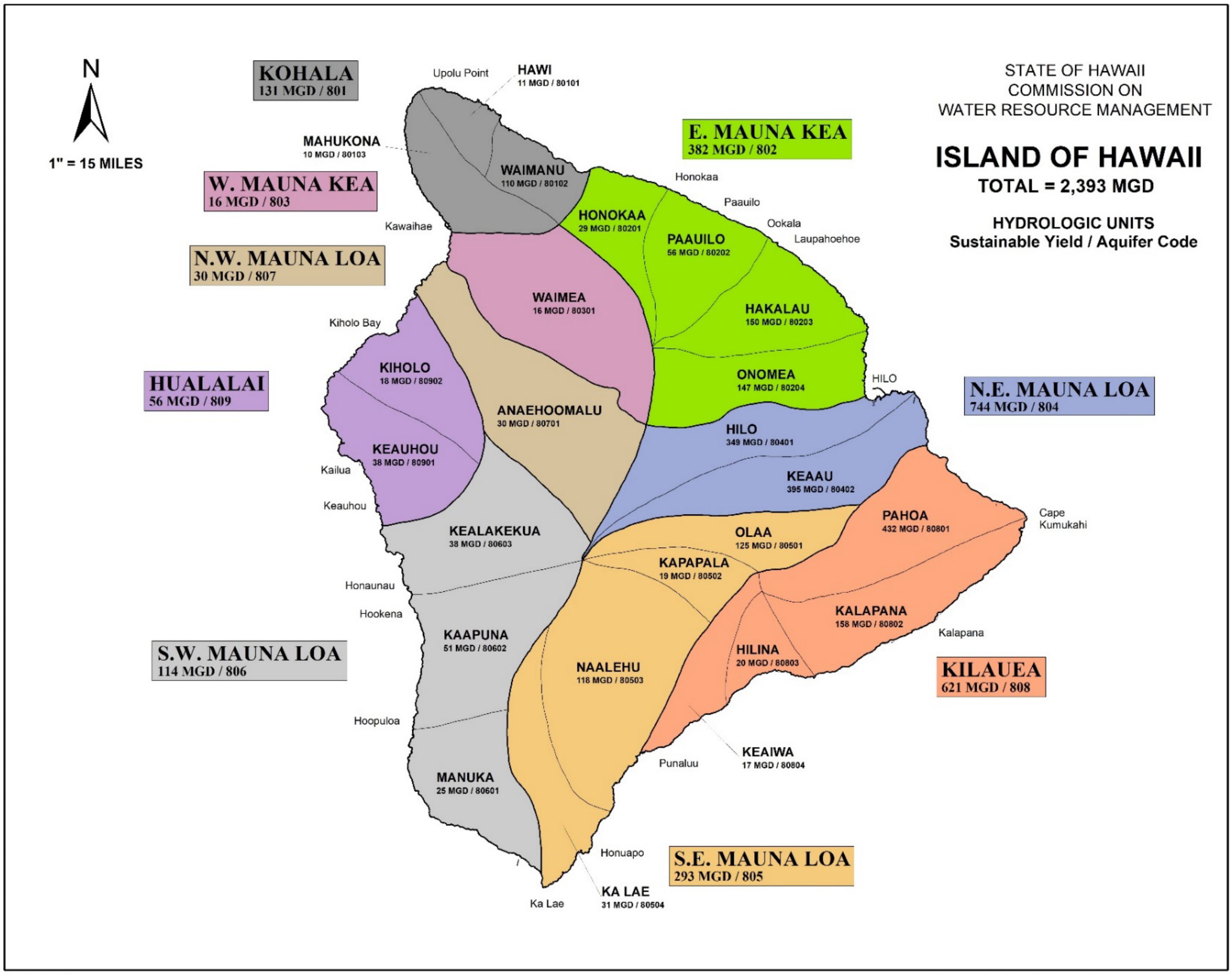
- Ground water inputs from adjacent aquifers.

For Aquifer Systems with predominantly high-level resources:

- Presence of an operational ground water-level monitoring network and a stream monitoring network, where applicable, to ensure compliance with instream flow standards and other publicly available hydrogeologic data, such as:
  - Recharge studies that follow the convention of **Section F.4.3.1**;
  - Complete and significant record of historical pumpage, chloride, and water-level data;
  - Numerical model studies for establishing infrastructure safe yields; or
  - Other hydrologic and geologic studies reviewed and accepted by CWRM staff.

- Ground water spill-over from adjacent aquifers.

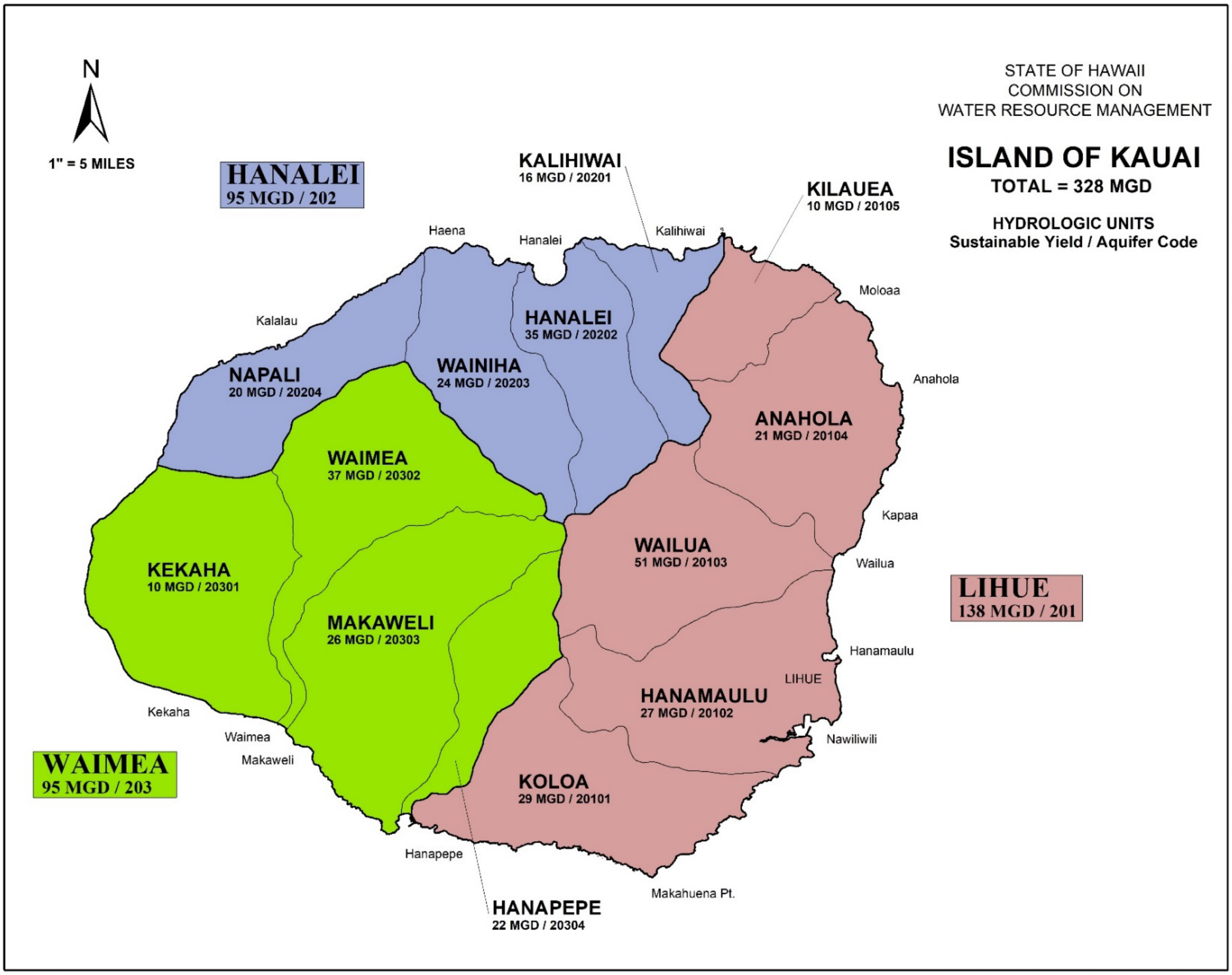
Figure F-17 Island of Hawai‘i Ground Water Hydrologic Units and 2019 Sustainable Yields



06/20/2018

Map Projection: Universal Transverse Mercator

Figure F-18 Island of Kaua‘i Ground Water Hydrologic Units and 2019 Sustainable Yields



06/20/2018

Map Projection: Universal Transverse Mercator

Figure F-19 Island of Lānaʻi Ground Water Hydrologic Units and 2019 Sustainable Yields

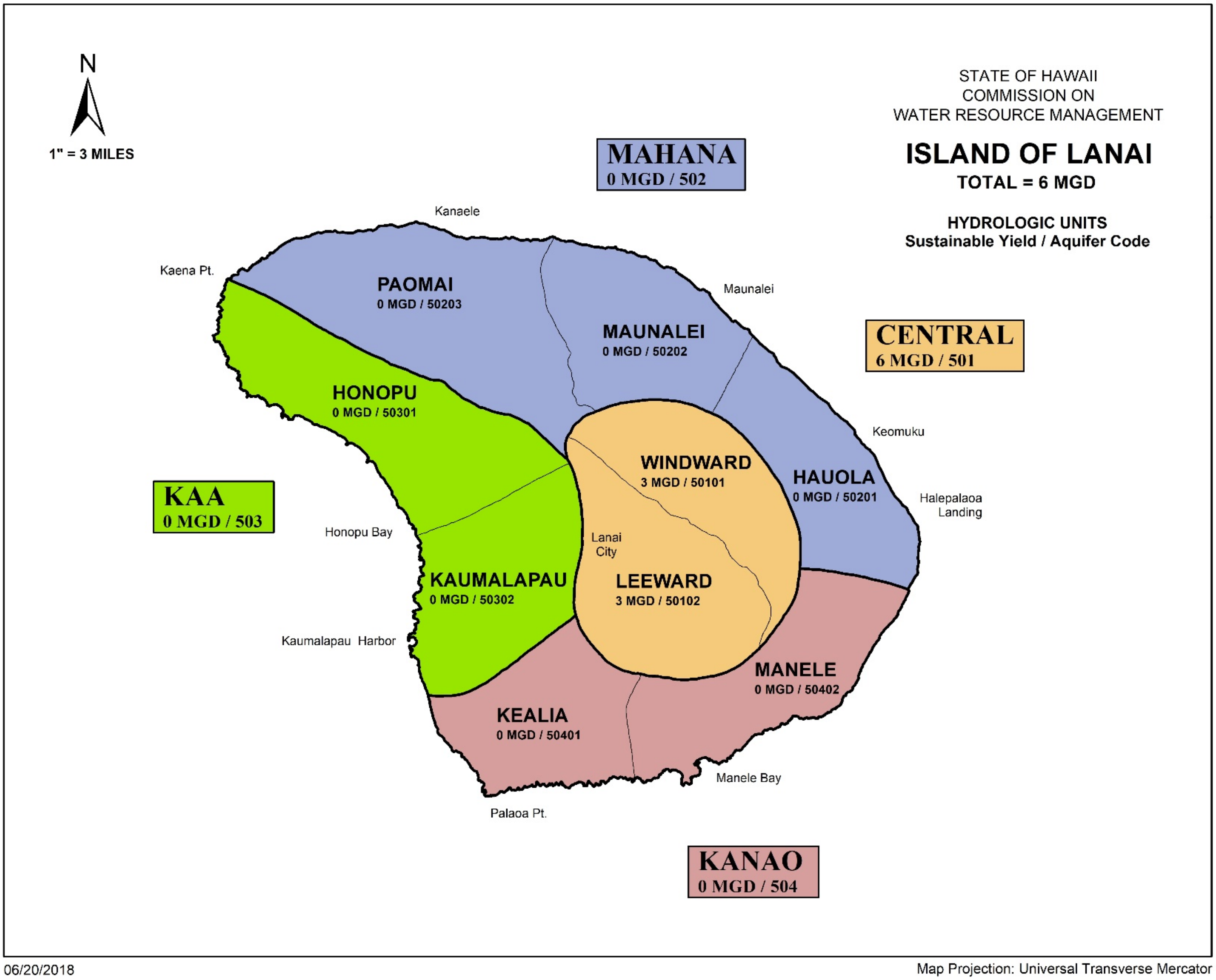
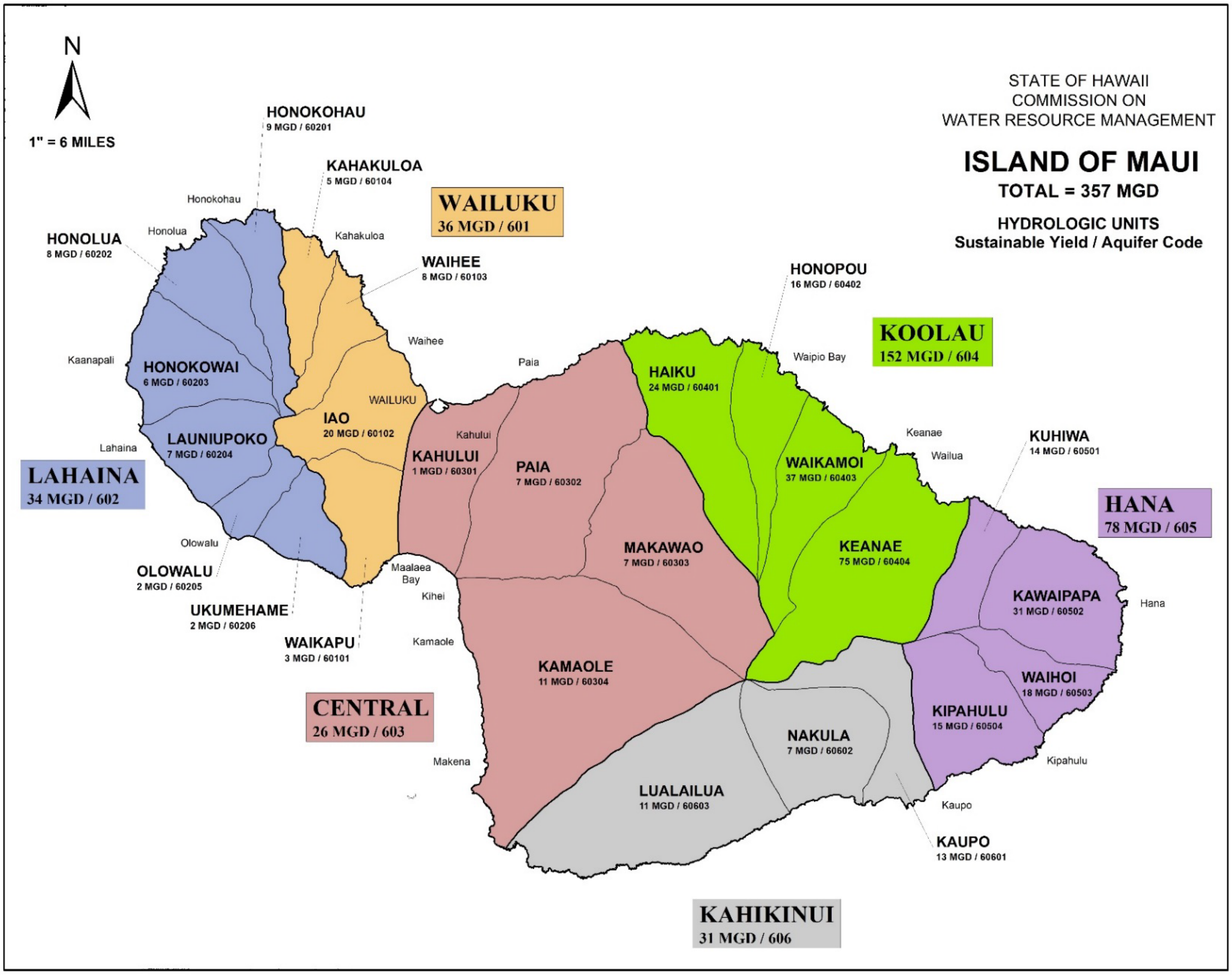


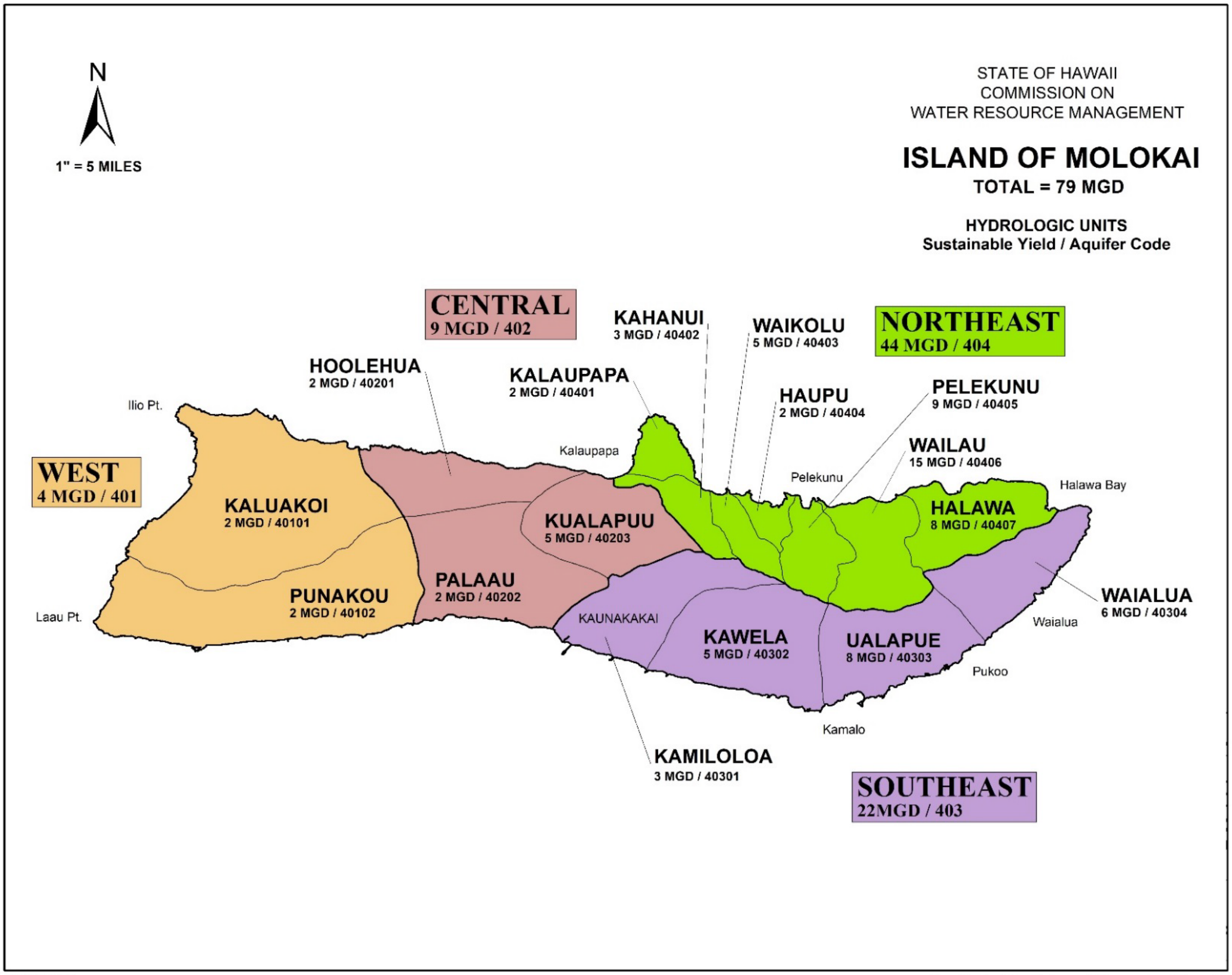
Figure F-20 Island of Maui Ground Water Hydrologic Units and 2019 Sustainable Yields



06/20/2018

Map Projection: Universal Transverse Mercator

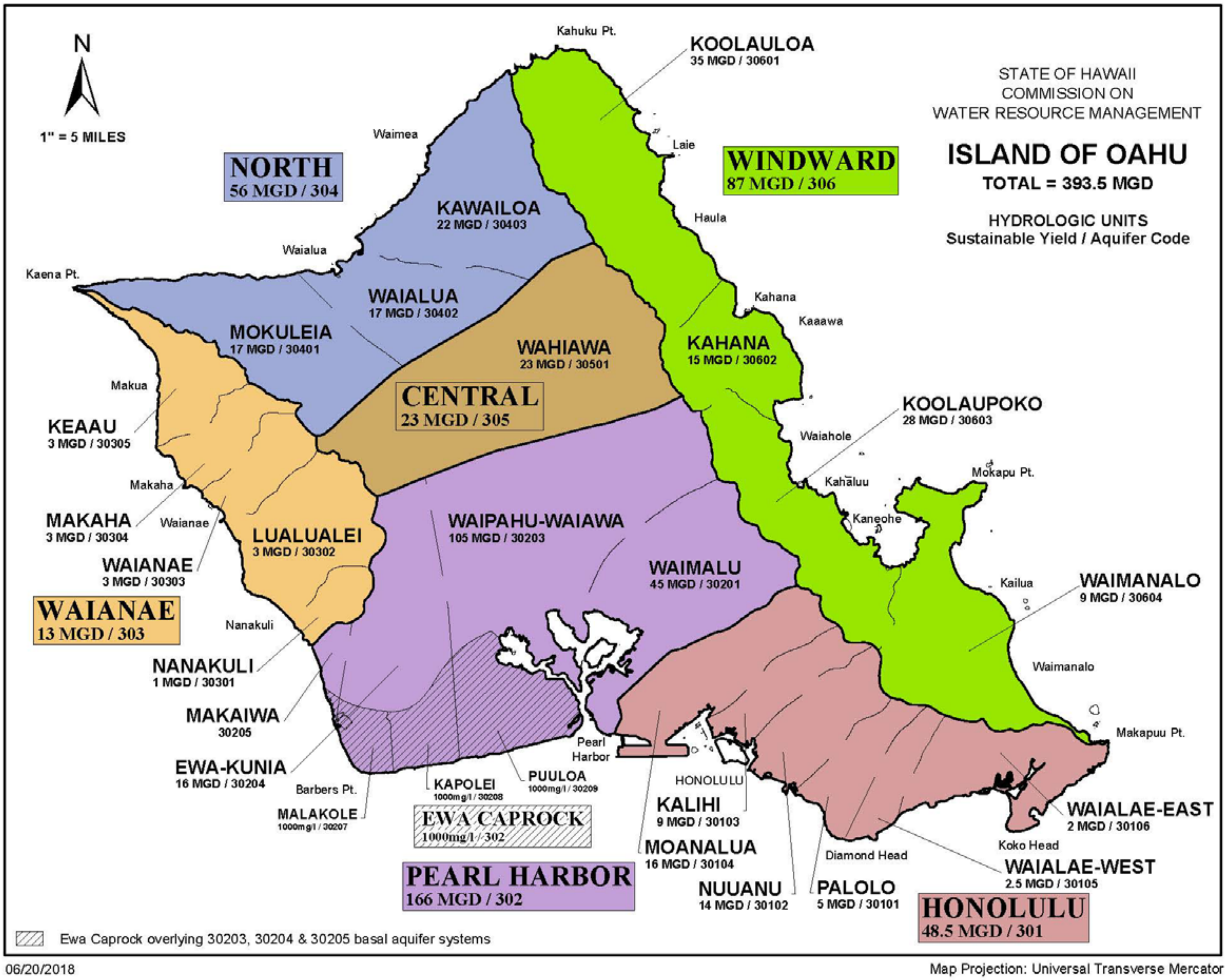
Figure F-21 Island of Moloka‘i Ground Water Hydrologic Units and 2019 Sustainable Yields



06/20/2018

Map Projection: Universal Transverse Mercator

Figure F-22 Island of Oʻahu Ground Water Hydrologic Units and 2019 Sustainable Yields



F.5 Nature and Occurrence of Surface Water

Early in its history, CWRM recognized the need for a broad-based collection of existing information on Hawai‘i’s surface water resources to enable sensible water management and decision making. As a result, CWRM and the U.S. National Park Service (USNPS) undertook a cooperative project that produced the 1990 document entitled *Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii’s Stream Resources* (HSA). This document continues to serve as a key reference for stream-related research in Hawai‘i. To provide the general public with an introduction to Hawai‘i’s surface water resources, CWRM and the USGS cooperated to develop the *Surface Water in Hawaii* information brochure published in 2003. The brochure includes information on basic surface water characteristics, system components and behavior, and natural and human-related impacts. The information in this section adapts CWRM’s collaborative work with the USNPS and the USGS to provide a basic overview of the nature and occurrence of surface water in Hawai‘i and implications for surface water management through instream flow standards.

F.5.1 Surface Water Occurrence

The State Water Code defines surface water as consisting of both contained surface water and diffused surface water. Contained surface water exists upon the surface of the earth in naturally or artificially created water bodies such as streams, man-made watercourses, lakes, reservoirs, and coastal waters. Diffused surface water includes all other waters on the surface of the earth that are not contained within waterbodies.

Surface water occurs in areas that, due to topographic slope, contribute to surface water drainage systems that typically manifest as streams or rivers. These drainage areas are confined by topographic divides and are generally referred to as watersheds. Watersheds are sometimes called drainage basins or catchments. Hawai‘i watersheds are consistently small in comparison to mainland systems, however, watershed profiles vary widely across the main islands. For example, watersheds on the geologically young island of Hawai‘i tend to be short in length, have fairly shallow channels, exhibit simple stream networks with few tributaries, and may sometimes terminate in a waterfall at the ocean. On the older island of Kauai, watershed systems exhibit eroded features, such as deeper incised channels, complex stream networks with many tributary branches, and large riverine estuaries at the ocean interface.

Watersheds are influenced by human alterations to natural stream systems that affect both surface water hydrology, stream biota, and water quality. Infrastructure significantly changes the path and flow of water. Ditches and canals, even storm drain systems, are built to convey water from one area to another, while reservoirs are used to store water on and off stream systems. Stream channel alterations also influence watershed processes. Channel alterations may include hardened channel linings and embankments, retention basins, culverts, drainage inlets and outlets, and channel realignments.

Within a watershed, surface water resources occur in various settings, both natural and altered. Streams, springs, ditches and canals, and reservoirs are the most common surface water settings in Hawaiʻi. These are described in the sections below.

F.5.1.1 Streams

Streams originating in mauka rainfall belts are the principle drainage features of Hawaiʻi watersheds. The USGS defines the term "stream" as follows:

> *Stream – a general term for a body of flowing water; natural water course containing water at least part of the year. In hydrology, it is generally applied to the water flowing in a natural channel as distinct from a canal.*

Streamflow consists of five components: 1) Direct runoff of rainfall in the form of overland flow and subsurface flow, which rapidly returns infiltrated water to the stream; 2) Water returned from bank storage; 3) Ground water discharge in the form of base flow, where the stream intersects the water table; 4) Rain that falls directly on streams; and 5) any additional water, including excess irrigation water, discharged to the stream by humans.[39]

Direct runoff occurs during and immediately following a period of rainfall when the capacity of the soil to accept and store water is exceeded, causing water to run off in a sheet of overland flow. Water may also enter the stream as subsurface flow when rainfall infiltrates the ground surface and moves laterally in the near-surface soils. Subsurface flow is generally slower and may continue for days after a rainfall event but may also occur quickly if water is able to move through preferential pathways. Similarly, during a period of high rainfall, water may be absorbed into the banks of the stream as bank storage. This water can be returned to the stream to contribute to total streamflow.

Water that infiltrates the ground surface may also recharge ground water bodies such as perched aquifers or dike compartments, which subsequently discharge water to streams. This ground water discharge to the stream, referred to as base flow, may occur during extended dry periods as well as during rainfall events. Base flow contributions occur where the stream intersects the ground water table and where the ground water body is above the water level in the stream. Since ground water levels vary with time, base flow also varies with time. However, variations in base flow are much smaller than variations in direct runoff.

Perennial Streams: A perennial stream is defined as a stream which flows continuously throughout the year. Some streams flow perennially throughout their entire course, while others flow perennially over parts of their course. Streams in Hawaiʻi are commonly perennial in mountainous interior areas, where streams gain water from dike-impounded ground water systems and where rainfall is persistent. Perennial flow is also common in lower stream reaches

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[39] Oki, D.S., 2004, Trends in Streamflow Characteristics in Hawaii, 1913-2003: U.S. Geological Survey Fact Sheet 2004-3104, 4 p.

near the coast where streams gain water from freshwater-lens systems. Where a vertically extensive freshwater-lens system exists, streams may gain water and flow perennially at higher altitudes inland from the coast.[40]

The HSA provided a listing of 376 perennial streams which were defined using data from various sources. The authors acknowledged that, although over one third of the streams on the list did not flow continuously from their headwaters to the ocean, these streams have perennial sections. This list of streams is used by CWRM to make preliminary determinations in regulatory permitting, though streams must often be assessed on a case-by-case basis.

Intermittent Streams: A stream or part of a stream is considered intermittent when it only flows at certain times of the year. Flow generally occurs for several weeks or months in response to seasonal precipitation and subsequent ground water discharge. An intermittent stream may also exist where a perched ground water body contributes to streamflow during certain times of the year. Intermittent streams are often able to support small communities of native freshwater species, either due to upstream or downstream perennial reaches or the persistence of pool habitats between flowing stream segments.

Ephemeral Streams: Ephemeral streams usually manifest in dry gulches on the leeward side of mountain ranges, where there is little or no ground water influence. Ephemeral streams only flow in direct response to rainfall, which indicates that the stream channel is not in contact with the water table. In general, flows last but a few hours or days following a single storm event.

F.5.1.2 Springs

Springs occur where ground water discharges naturally from the ground surface at a more or less continuous rate. Springs are largely dependent upon the permeability of rock layers, the position of the water table, and surface topography.

F.5.1.3 Ditches and Canals

The ditches and canals that traverse the Hawaiian landscape are largely a result of the sugar industry's need to transport water for cane cultivation in the late 1800s. By 1884, there were a total of 90 sugar planters, plantations, and mills. Extensive irrigation systems often consisted of concrete-lined or unlined channels, tunnels, and flumes that moved water from wet, windward areas to arable plains in dry, leeward areas. By 1920, an estimated 800 million gallons of surface water, in addition to almost 400 million gallons of pumped ground water, was consumed by the sugar industry daily.

[40] Izuka, S.K., and Gingerich, S.B., 1998, Ground water in the southern Lihue basin, Kauai, Hawaii: U.S. Geological Survey Water-Resources Investigations Report 98-4031, 71 p.

The demise of the sugar industry towards the end of the 20th Century brought the closure of large-scale plantations and the conversion of plantation fields to diversified agriculture. Associated changes also occurred in irrigation practices and agricultural water consumption. Many of the irrigation systems that once served plantation agriculture still continue to divert water, however, most systems do not function as efficiently as they once did. System maintenance, which was executed by the plantations, is no longer coordinated and many new owners of former plantation lands do not have the means or desire to carry out refurbishment and repair projects. These irrigation systems are significant in that, not only do they contribute to the viability of agriculture, they impact the surface water hydrology of diverted streams; they impact the hydrology of the streams they pass via leakage, overflows, and controlled releases (for maintenance); and they impact the ground water hydrology of the area receiving irrigation.

F.5.1.4 Reservoirs

A reservoir is generally an artificial basin created for the purpose of collecting, storing, and regulating water. Reservoirs are usually created by damming the downstream end of a drainage basin. In Hawaiʻi, there are very few natural lakes, so these man-made reservoirs often serve as recreational boating and fishing lakes. Many of the reservoirs that dot the landscape were constructed to serve the sugar and pineapple industries, while others were built for flood control or as impoundment reservoirs for drinking water prior to treatment. Reservoirs can influence local climatological patterns, habitat conditions for stream organisms, water quality, and ground water infiltration. **Appendix J Resource Conservation and Augmentation** contains additional discussion on dams and reservoirs.

F.5.2 Surface Water Hydrologic Units

Surface water hydrologic units have been established by CWRM to provide a consistent basis for managing surface water resources. A surface water hydrologic unit coding system is used to reference and describe the units delineated by CWRM. This section describes the coding system and lists all surface water hydrologic units by island. Maps illustrating the hydrologic unit boundaries are included in **Section F.5.2.3 Surface Water Hydrologic Coding System**.

F.5.2.1 Purpose of Surface Water Hydrologic Unit Coding

As described earlier in **Section F.5.1**, surface water occurs in variable settings throughout Hawaiʻi. The surface water hydrologic unit coding system described herein was established to provide a consistent method by which to reference and describe surface water resources and to assist in various water planning efforts. The coding system is an important first-step towards improving the organization and management of surface water information that CWRM collects and maintains.

The primary goal of the coding system is to provide standard surface water hydrologic unit delineations for the coordination of data, information, and resource management practices. Key objectives of CWRM Surface Water Hydrologic Units include the following:

- Define and delineate unique units that can accommodate the relational requirements in a database environment, while providing a system that can be easily understood by the general public;
- Develop an information management system which utilizes a coding system to relate surface water permits and other resource information to a given unit;
- Define hydrologic units to be considered in the analysis and development of instream flow standards;
- Provide a reference system that promotes better information management of other resource inventories;
- Promote the sharing and collection of surface water resource data between government agencies, the public, private entities, and community organizations; and
- Improve the overall coordination of monitoring, data collection, and field investigation efforts.

F.5.2.2 Basis for Surface Water Hydrologic Unit Delineations

The State Water Code mandates that the WRPP shall include:

> *"…Hydrologic units and their characteristics, including the quantity and quality of available resource, requirements for beneficial instream uses and environmental protection, desirable uses worthy of preservation by permit, and undesirable uses for which permits may be denied."*[41]

The State Water Code defines a hydrologic unit as "[a] surface drainage area or a ground water basin or a combination of the two."[42]

Ground water hydrologic units were established by CWRM under the 1990 WRPP. For surface water units, however, the 1990 WRPP only suggests a complex classification scheme.

In 2005, CWRM adopted surface water hydrologic units and the coding system described below. In developing CWRM Surface Water Hydrologic Units, it was necessary to review the HSA, *State Delineation of Watersheds* (1994), and *Refinement of Hawaii Watershed Delineations* (1999) reports to arrive at a coding system that could meet the requirements for organizing and managing surface water information.

[41] HRS §174C-31(d)(2).

[42] HRS §174C-3.

The naming convention for surface water hydrologic units indicates regional and sub-regional divisions as follows:

Island division = Island
Regional division = Surface Water Hydrologic Unit

F.5.2.3 Surface Water Hydrologic Unit Coding System

The surface water hydrologic unit code is a unique combination of four digits. In the *State Definition and Delineation of Watersheds* report, a watershed unit is defined as follows:

> *"A watershed unit is comprised of a drainage basin (or basins) which include both stream and overland flow, whose runoff either enters the ocean along an identified segment of coastline (coastal segment) or enters an internal, landlocked drainage basin. The watershed units for an island are defined so that all segments of coastline are assigned to a unique watershed unit and so that all areas of an island are assigned to one, and only one, watershed unit."*

The surface water hydrologic unit coding system is based on a hierarchy in which the island is the largest component and the surface water hydrologic unit is the regional component. The island is identified by a single-digit number. Each surface water hydrologic unit is identified by a three-digit number and a Hawaiian geographic name or local geographic term.

Therefore, surface water hydrologic units are assigned a unique code in the four-digit format as follows:

0	**000**
Island	Surface Water Hydrologic Unit

The individual components of the coding system are described below.

ISLAND: <u>0</u>000

The first digit represents the eight main Hawaiian Islands using a unique number assigned by CWRM. The Island Code is the same 1-digit number used in the Hawaii Stream Assessment. The islands of Niihau, Kahoolawe and Lanai did not appear in the HSA database because these islands do not have perennial streams, however they have been included in the coding system as part of a more comprehensive surface water management scheme.

SURFACE WATER HYDROLOGIC UNIT SYSTEM: 0**<u>000</u>**

The last three digits are sequentially assigned, generally beginning in the north and continuing around each island in a clockwise manner. This method is similar to previous coding efforts.

There are a total of 558 Surface Water Hydrologic Units statewide. **Table F-13** to **Table F-20** below list all units by island and are accompanied by maps showing the unit boundaries (see **Figure F-23** to **Figure F-30**). For the majority of hydrologic units, unit boundaries closely match drainage basin boundaries. Individual stream systems are contained entirely within the hydrologic unit boundaries (from the headwater to the mouth). However, in a few instances, streams were found to cross hydrologic unit boundaries, and in these cases, drainage basins were refined to more accurately determine the natural flow of water based on elevation gradients. In these instances, the hydrologic unit boundaries were evaluated together with the drainage basin and redrawn through on-screen digitizing using ArcGIS software.

Table F-13 Niʻihau (1) Surface Water Hydrologic Units

1001	Kaaukuu	1008	Mauuloa
1002	Kooeaukani	1009	Nonopapa
1003	Kaʻailana	1010	Puuwai
1004	Nomilu	1011	Kaumuhonu
1005	Kalaoa	1012	Keanauhi
1006	Honuaula	1013	Keawanui
1007	Halaii		

Table F-14 Kauaʻi (2) Surface Water Hydrologic Units

2001	Awaʻawapuhi	2038	Moikeha
2002	Honopū	2039	Waikaea
2003	Nakeikionaiwi	2040	Wailua
2004	Kalalau	2041	Kawailoa
2005	Pōhakuao	2042	Hanamāʻulu
2006	Waiolaa	2043	Līhuʻe Airport
2007	Hanakoa	2044	Nāwiliwili
2008	Waiahuakua	2045	Puali
2009	Hoʻolulu	2046	Huleia
2010	Hanakāpīʻai	2047	Kipu Kai
2011	Maunapuluo	2048	Mahaulepu
2012	Limahuli	2049	Waikomo
2013	Mānoa	2050	Aepo
2014	Wainiha	2051	Lāwaʻi
2015	Lumahaʻi	2052	Kalāheo
2016	Waikoko	2053	Wahiawa
2017	Waipā	2054	Hanapēpē
2018	Waiʻoli	2055	Kukamahu
2019	Hanalei	2056	Kaumakani
2020	Waileia	2057	Mahinauli
2021	ʻAnini	2058	Aʻakukui
2022	Kalihikai West	2059	Waipao
2023	Kalihikai Center	2060	Waimea
2024	Kalihikai East	2061	Kapilimao
2025	Kalihiwai	2062	Paua
2026	Puʻukumu	2063	Hoea
2027	Kauapea	2064	Niu
2028	Kīlauea	2065	Kaawaloa
2029	Kulihaili	2066	Nahomalu
2030	Pīlaʻa	2067	Kaulaula
2031	Waipake	2068	Haeleele
2032	Moloaʻa	2069	Hikimoe
2033	Pāpaʻa	2070	Kaaweiki
2034	Aliomanu	2071	Kauhao
2035	Anahola	2072	Makaha
2036	Kumukumu	2073	Milolii
2037	Kapaʻa	2074	Nualolo

Table F-15 Oʻahu (3) Surface Water Hydrologic Units

3001	Kālunawaikaʻala	3045	Niu
3002	Pakulena	3046	Wailupe
3003	Paumalu	3047	Waialaenui
3004	Kawela	3048	Diamond Head
3005	Oio	3049	Ala Wai
3006	Malaekahana	3050	Nuuanu
3007	Kahawainui	3051	Kapalama
3008	Wailele	3052	Kalihi
3009	Koloa	3053	Moanalua
3010	Kaipapau	3054	Keehi
3011	Maakua	3055	Manuwai
3012	Waipuhi	3056	Salt Lake
3013	Kaluanui	3057	Halawa
3014	Papaʻakoko	3058	Aiea
3015	Halehaa	3059	Kalauao
3016	Punaluu	3060	Waimalu
3017	Kahana	3061	Waiawa
3018	Makaua	3062	Waipio
3019	Kaʻaʻawa	3063	Kapakahi
3020	Kualoa	3064	Waikele
3021	Hakipuʻu	3065	Honouliuli
3022	Waikane	3066	Kaloi
3023	Waianu	3067	Makaiwa
3024	Waiāhole	3068	Nanakuli
3025	Kaʻalaea	3069	Ulehawa
3026	Haiamoa	3070	Mailiili
3027	Kahaluu	3071	Kaupuni
3028	Heʻeia	3072	Kamaileunu
3029	Keaʻahala	3073	Makaha
3030	Kāneʻohe	3074	Keaau
3031	Kawa	3075	Makua
3032	Puu Hawaiiloa	3076	Kaluakauila
3033	Kawainui	3077	MʻAnini
3034	Kaelepulu	3078	Kawaihapai
3035	Waimanalo	3079	Pahole
3036	Kahawai	3080	Makaleha
3037	Makapuu	3081	Waialua
3038	Koko Crater	3082	Kiikii
3039	Hanauma	3083	Paukauila
3040	Portlock	3084	Anahulu
3041	Kamiloiki	3085	Loko Ea
3042	Kamilonui	3086	Keamanea
3043	Hahaione	3087	Waimea
3044	Kuliouou		

Table F-16 Moloka‘i (4) Surface Water Hydrologic Units

4001	Waihanau	4026	Honouliwai
4002	Waialeia	4027	Waialua
4003	Waikolu	4028	Kainalu
4004	Wainene	4029	Honomūni
4005	Anapuhi	4030	Ahaino
4006	Waiohookalo	4031	Mapulehu
4007	Keawanui	4032	Kalua‘aha
4008	Kailiili	4033	Kahananui
4009	Pelekunu	4034	Ohia
4010	Waipu	4035	Wawaia
4011	Haloku	4036	Kamalo
4012	Oloupena	4037	Kawela
4013	Puukaoku	4038	Kamiloloa
4014	Wailele	4039	Kaunakakai
4015	Wailau	4040	Kalamaula
4016	Kalaemilo	4041	Manawainui
4017	Waiahookalo	4042	Kaluapeelua
4018	Kahiwa	4043	Waiahewahewa
4019	Kawainui	4044	Kolo
4020	Pipiwai	4045	Hakina
4021	Halawa	4046	Kaunala
4022	Papio	4047	Papohaku
4023	Honowewe	4048	Kaa
4024	Pohakupili	4049	Mo‘omomi
4025	Honoulimaloo	4050	Maneopapa

Table F-17 Lana‘i (5) Surface Water Hydrologic Units

5001	Puumaiekahi	5017	Awehi
5002	Lapaiki	5018	Kapua
5003	Hawaiilanui	5019	Naha
5004	Kahua	5020	Kapoho
5005	Kuahua	5021	Kawaiu
5006	Poaiwa	5022	Mahanalua
5007	Halulu	5023	Manele
5008	Maunalei	5024	Anapuka
5009	Wahane	5025	PaLāwa‘i Basin
5010	Hauola	5026	Ulaula
5011	Nahoko	5027	Kaumalapau
5012	Kaa	5028	Kalamanui
5013	Haua	5029	Kalamaiki
5014	Waiopa	5030	Paliamano
5015	Kahea	5031	Honopū
5016	Lopa	5032	Kaapahu

Table F-18 Maui (6) Surface Water Hydrologic Units

6001	Waikapu	6050	Punalau
6002	Pohakea	6051	Honomanu
6003	Papalaua	6052	Nuaailua
6004	Ukumehame	6053	Piinaau
6005	Olowalu	6054	Ohia
6006	Launiupoko	6055	Waiokamilo
6007	Kauaula	6056	Wailuanui
6008	Kahoma	6057	West Wailuaiki
6009	Wahikuli	6058	East Wailuaiki
6010	Honokowai	6059	Kopiliula
6011	Kahana	6060	Waiohue
6012	Honokahua	6061	Paakea
6013	Honolua	6062	Waiaaka
6014	Honokōhau	6063	Kapaula
6015	Anakaluahine	6064	Hanawi
6016	Poelua	6065	Makapipi
6017	Honanana	6066	Kuhiwa
6018	Kahakuloa	6067	Waihole
6019	Waipili	6068	Manawaikeae
6020	Waiolai	6069	Kahawaihapapa
6021	Makamakaole	6070	Keaaiki
6022	Waihee	6071	Waioni
6023	Waiehu	6072	Lanikele
6024	Iao	6073	Heleleikeoha
6025	Kalialinui	6074	Kawakoe
6026	Kailua Gulch	6075	Honomaele
6027	Maliko	6076	Kawaipapa
6028	Kuiaha	6077	Moomoonui
6029	Kaupakulua	6078	Haneoo
6030	Manawaiiao	6079	Kapia
6031	Uaoa	6080	Waiohonu
6032	Kealii	6081	Papahawahawa
6033	Kakipi	6082	Alaalaula
6034	Honopou	6083	Wailua
6035	Hoolawa	6084	Honolewa
6036	Waipio	6085	Waieli
6037	Hanehoi	6086	Kakiweka
6038	Hoalua	6087	Hahalawe
6039	Hanawana	6088	Puaaluu
6040	Kailua	6089	Oheo
6041	Nailiilihaele	6090	Kalena
6042	Puehu	6091	Koukouai
6043	Oopuola	6092	Opelu
6044	Kaaiea	6093	Kukuiula
6045	Punaluu	6094	Kaapahu

Table F-18 Maui (6) Surface Water Hydrologic Units (continued)

6046	Kolea	6095	Lelekea
6047	Waikamoi	6096	Alelele
6048	Puohokamoa	6097	Kalepa
6049	Haipuaena	6098	Nuanuaaloa
6099	Manawainui	6106	Kipapa
6100	Kaupo	6107	Kanaio
6101	Nuu	6108	Ahihi Kinau
6102	Pahihi	6109	Mooloa
6103	Waiopai	6110	Wailea
6104	Poopoo	6111	Hapapa
6105	Manawainui Gulch	6112	Waiakoa

Table F-19 Kahoolawe (7) Surface Water Hydrologic Units

7001	Lae Paki	7013	Waaiki
7002	Honokoa	7014	Kealia Luna
7003	Makaakae	7015	Hakioawa
7004	Ahupuiki	7016	Oawawahie
7005	Ahupu	7017	Pali o Kalapakea
7006	Kaukamoku	7018	Kaukamaka
7007	Moaulaiki	7019	Lae o Kaka
7008	Olohia	7020	Kamohio
7009	Kuheeia	7021	Kanaloa
7010	Kaulana	7022	Waikahalulu
7011	Papakanui	7023	Honokanaia
7012	Papakaiki	7024	Wai Honu

Table F-20 Hawai‘i (8) Surface Water Hydrologic Units

8001	Kealahewa	8050	Malanahae
8002	Hualua	8051	Honokaia
8003	Kumakua	8052	Kawela
8004	Kapua	8053	Keaakaukau
8005	Ohanaula	8054	Kainapahoa
8006	Hanaula	8055	Nienie
8007	Hapahapai	8056	Papuaa
8008	Pali Akamoa	8057	Ouhi
8009	Wainaia	8058	Kahaupu
8010	Halelua	8059	Kahawailiili
8011	Halawa	8060	Keahua
8012	Aamakao	8061	Kalopa
8013	Niulii	8062	Waikaalulu
8014	Waikama	8063	Kukuilamalamahii
8015	Pololu	8064	Alilipali
8016	Honokane Nui	8065	Kaumoali
8017	Honokane Iki	8066	Pohakuhaku
8018	Kalele	8067	Waipunahina
8019	Waipahi	8068	Waipunalau
8020	Honokea	8069	Paauilo
8021	Kailikaula	8070	Aamanu
8022	Honopūe	8071	Koholalele
8023	Kolealiilii	8072	Kalapahapuu
8024	Ohiahuea	8073	Kukaiau
8025	Nakooko	8074	Puumaile
8026	Waiapuka	8075	Kekualele
8027	Waikaloa	8076	Kaala
8028	Waimaile	8077	Kealakaha
8029	Kukui	8078	Keehia
8030	Paopao	8079	Kupapaulua
8031	Waiaalala	8080	Kaiwiki
8032	Punalulu	8081	Kaula
8033	Kaimu	8082	Kaohaoha
8034	Pae	8083	Kaawalii
8035	Waimanu	8084	Waipunalei
8036	Pukoa	8085	Laupahoehoe
8037	Manuwaikaalio	8086	Kilau
8038	Naluea	8087	Manowaiopae

Table F-20 Hawai‘i (8) Surface Water Hydrologic Units (continued)

8039	Kahoopuu	8088	Kuwaikahi
8040	Waipāhoehoe	8089	Kihalani
8041	Wailoa/Waipio	8090	Kaiwilahilahi
8042	Kaluahine Falls	8091	Haakoa
8043	Waiulili	8092	Pahale
8044	Waikoekoe	8093	Kapehu Camp
8045	Waipunahoe	8094	Paeohe
8046	Waialeale	8095	Maulua
8047	Waikoloa	8096	Pohakupuka
8048	Kapulena	8097	Kulanakii
8049	Kawaikalia	8098	Ahole
8099	Poupou	8133	Paukaa
8100	Manoloa	8134	Honolii
8101	Ninole	8135	Maili
8102	Kaaheiki	8136	Wainaku
8103	Waikolu	8137	Pukihae
8104	Waikaumalo	8138	Wailuku
8105	Waiehu	8139	Wailoa
8106	Nanue	8140	Kaahakini
8107	Opea	8141	Kīlauea
8108	Peleau	8142	Keauhou Point
8109	Umauma	8143	Kīlauea Crater
8110	Hakalau	8144	Kapāpala
8111	Kolekole	8145	Pahala
8112	Paheehee	8146	Hīlea
8113	Honomū	8147	Nā’ālehu
8114	Laimi	8148	Kiolaka‘a
8115	Kapehu	8149	South Point
8116	Makea	8150	Kauna
8117	Alia	8151	Ki‘ilae
8118	Makahanaloa	8152	Kealakekua
8119	Waimaauou	8153	Wai‘aha
8120	Waiaama	8154	Honokōhau
8121	Kawainui	8155	Keahole
8122	Onomea	8156	Kīholo
8123	Alakahi	8157	Pōhakuloa
8124	Hanawi	8158	Kamakoa
8125	Kalaoa	8159	Hāloa
8126	Aleamai	8160	Lamimaumau
8127	Kaieie	8161	Waikoloa
8128	Puuokalepa	8162	Kawaihae
8129	Kaapoko	8163	Honokoa
8130	Papaikou	8164	Keawanui
8131	Kapue	8165	Lapakahi
8132	Pahoehoe	8166	Māhukona

Figure F-23 Niihau Surface Water Hydrologic Units, Unit Codes 1001 to 1013

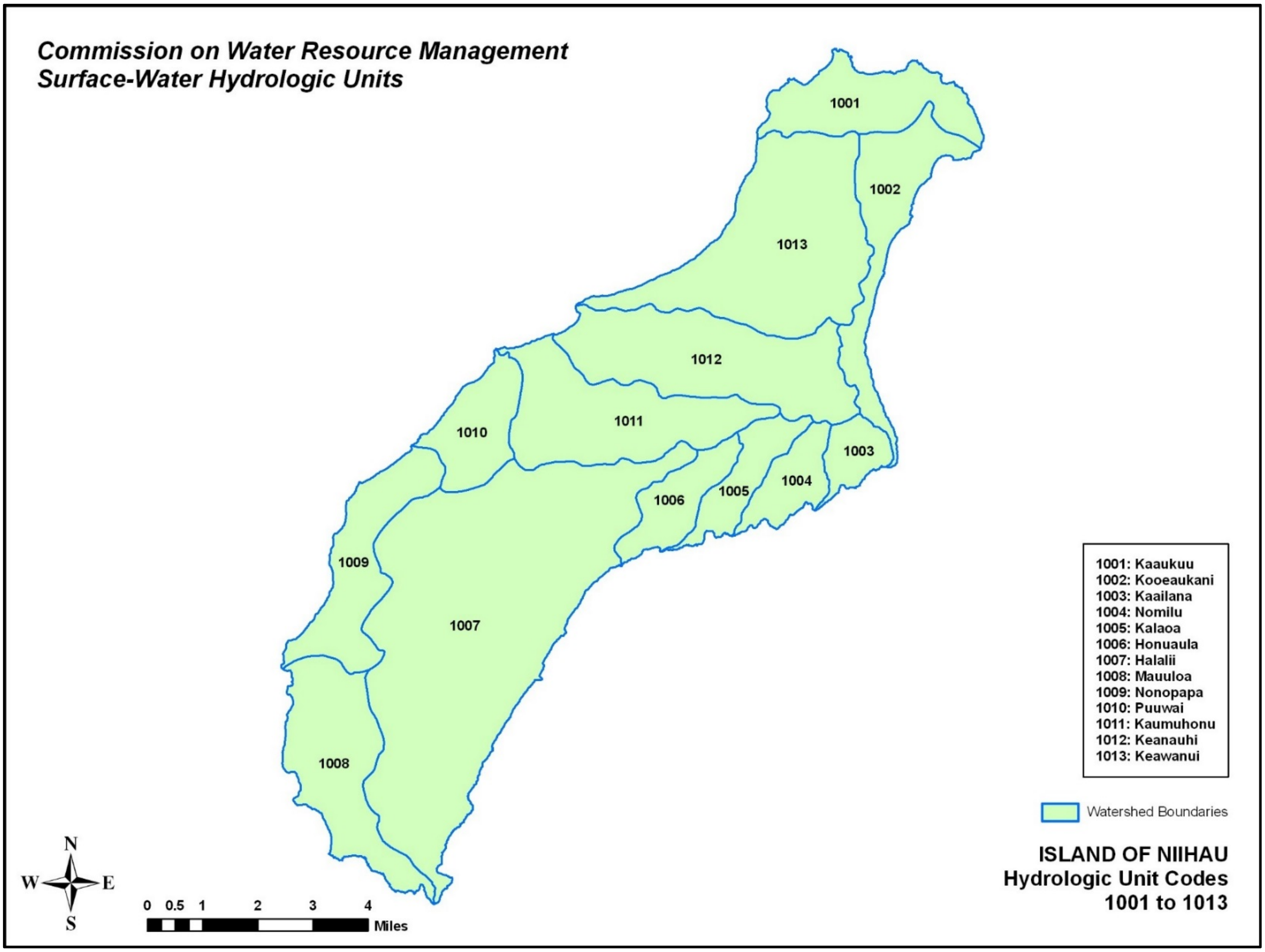


Figure F-24 Kaua‘i Surface Water Hydrologic Units, Unit Codes 2001 to 2074

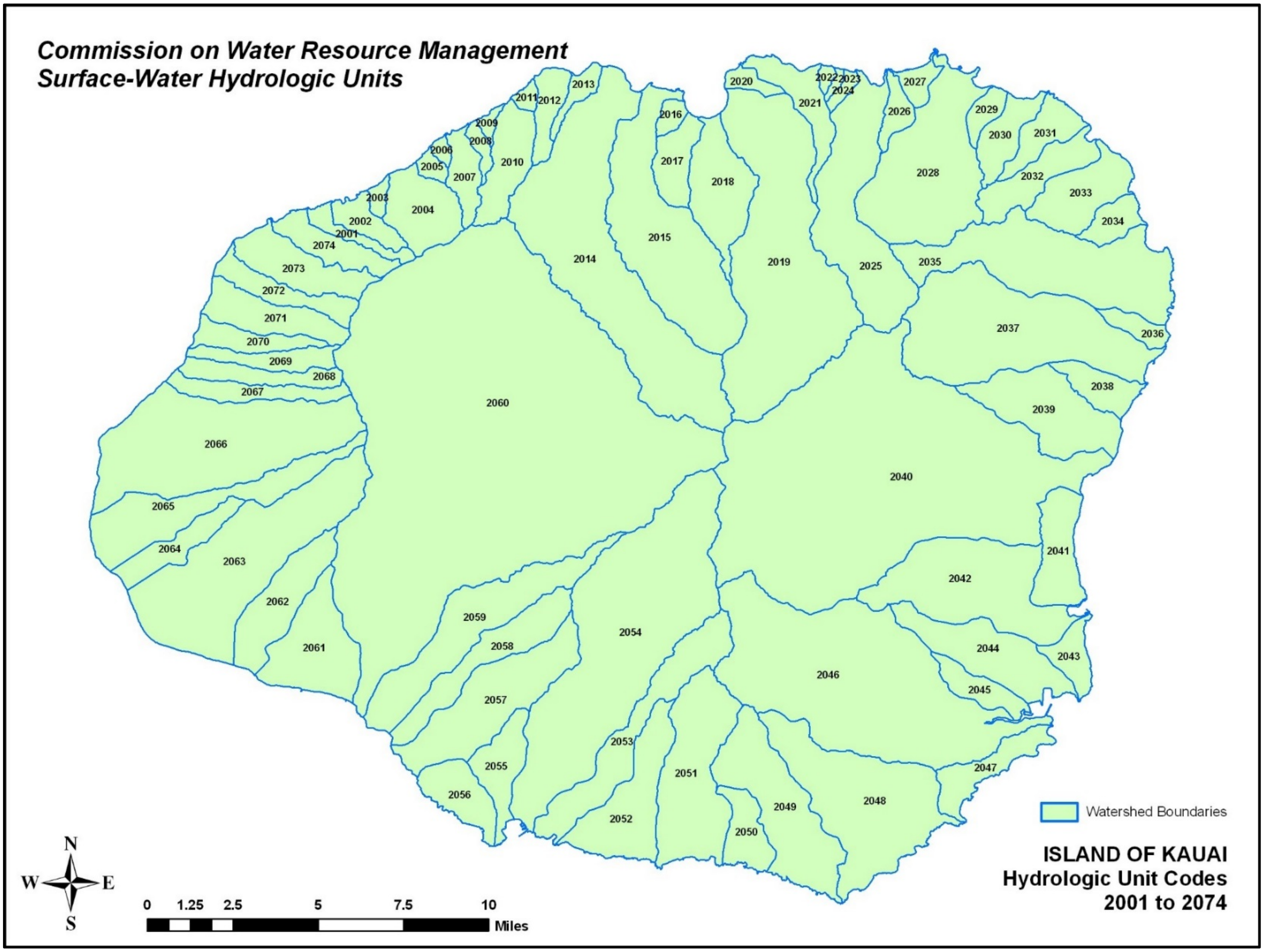


Figure F-24A Kauaʻi Surface Water Hydrologic Units, Unit Codes 2001 to 2013

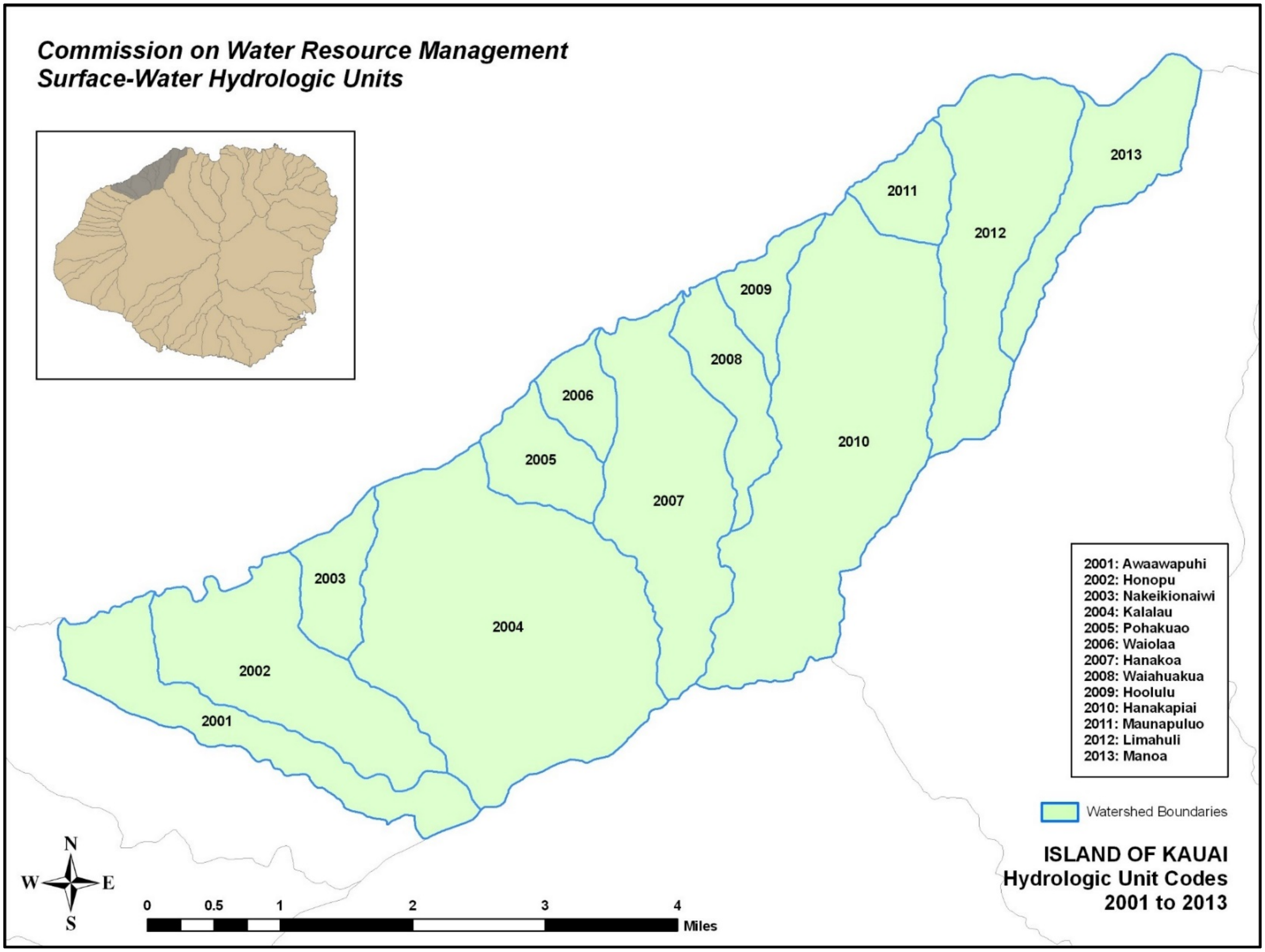


Figure F-24B Kaua'i Surface Water Hydrologic Units, Unit Codes 2014 to 2026

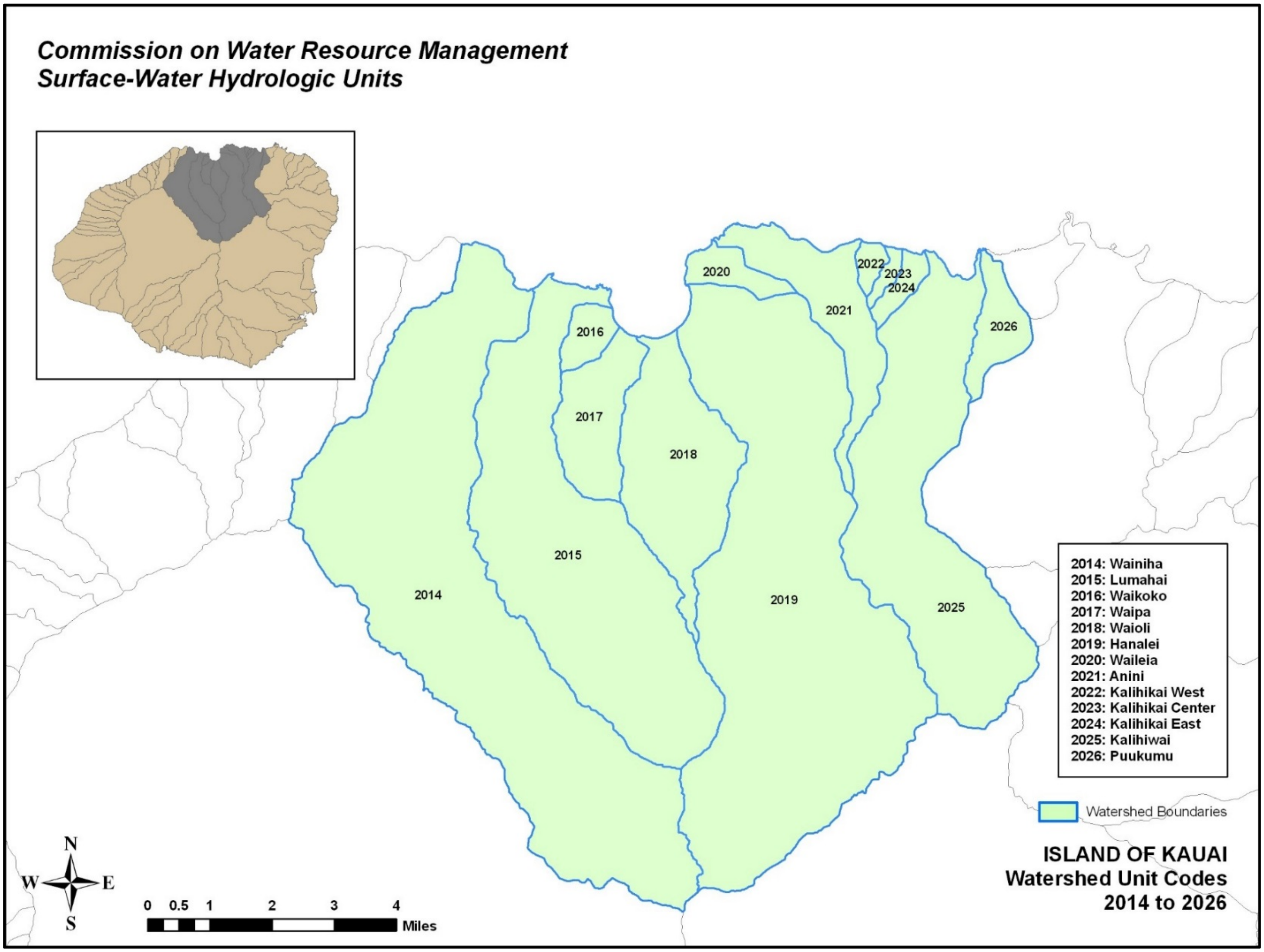


Figure F-24C Kaua'i Surface Water Hydrologic Units, Unit Codes 2027 to 2039

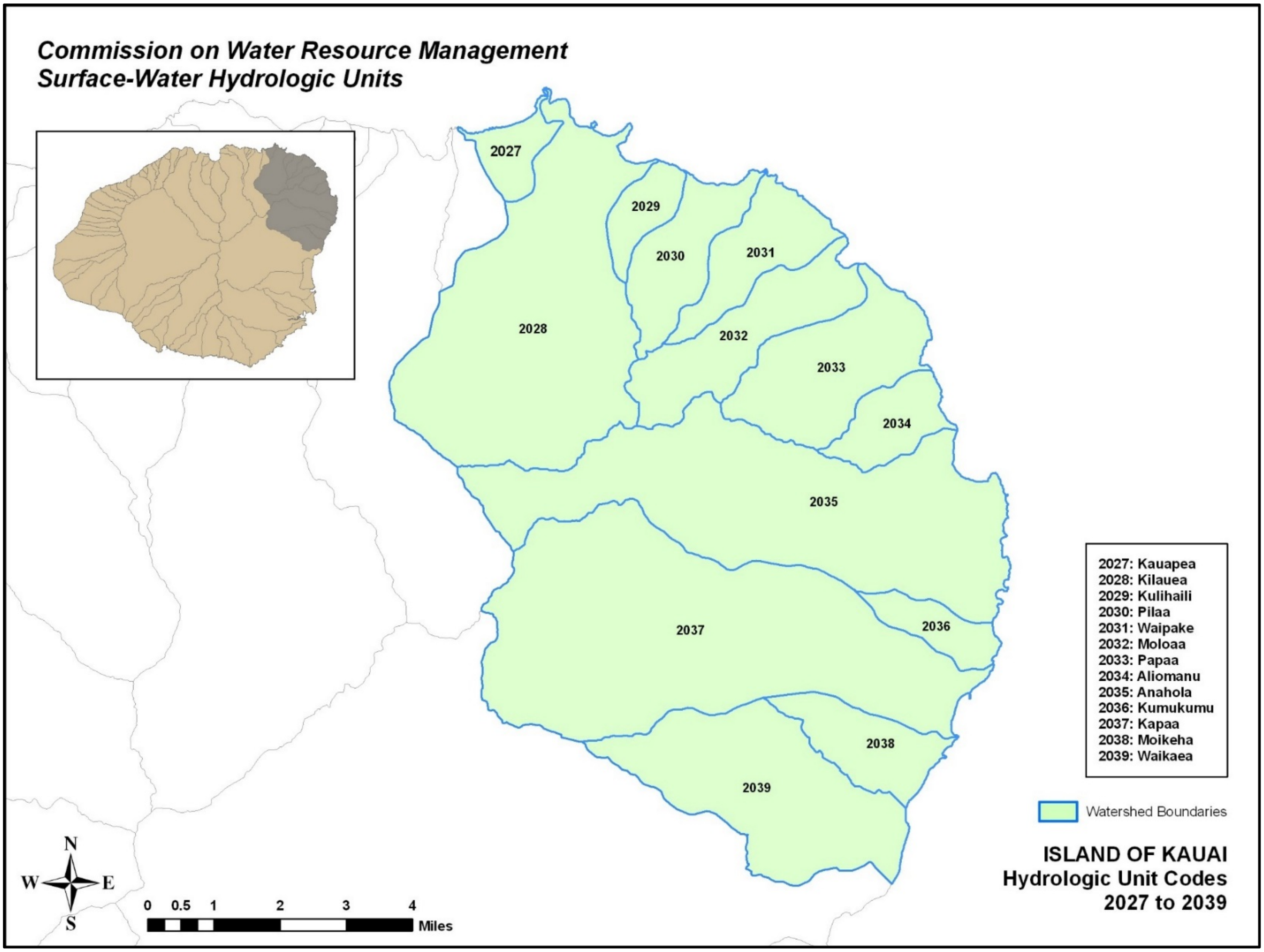


Figure F-24D Kauaʻi Surface Water Hydrologic Units, Unit Codes 2040 to 2052

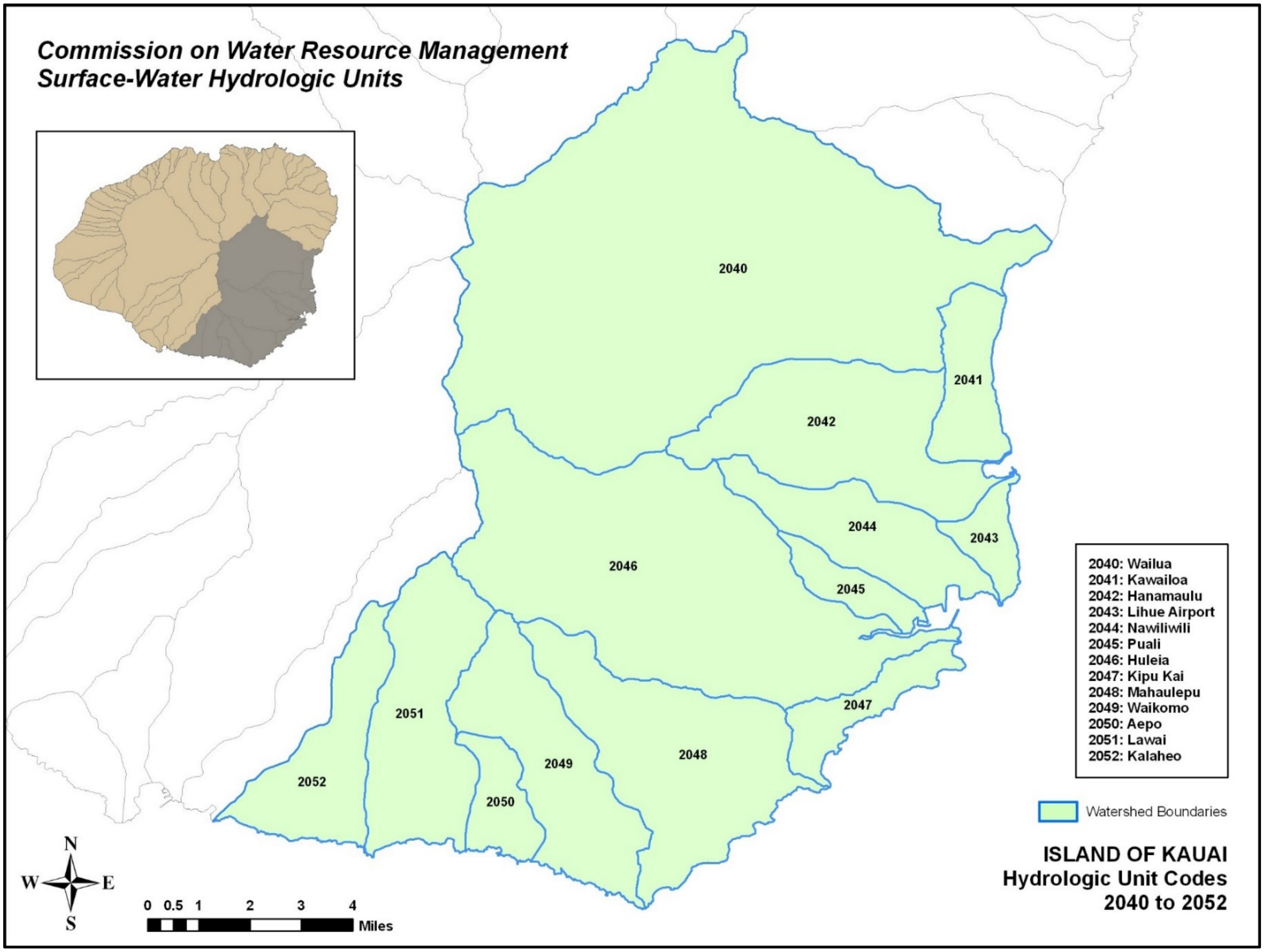


Figure F-24E Kaua'i Surface Water Hydrologic Units, Unit Codes 2053 to 2060

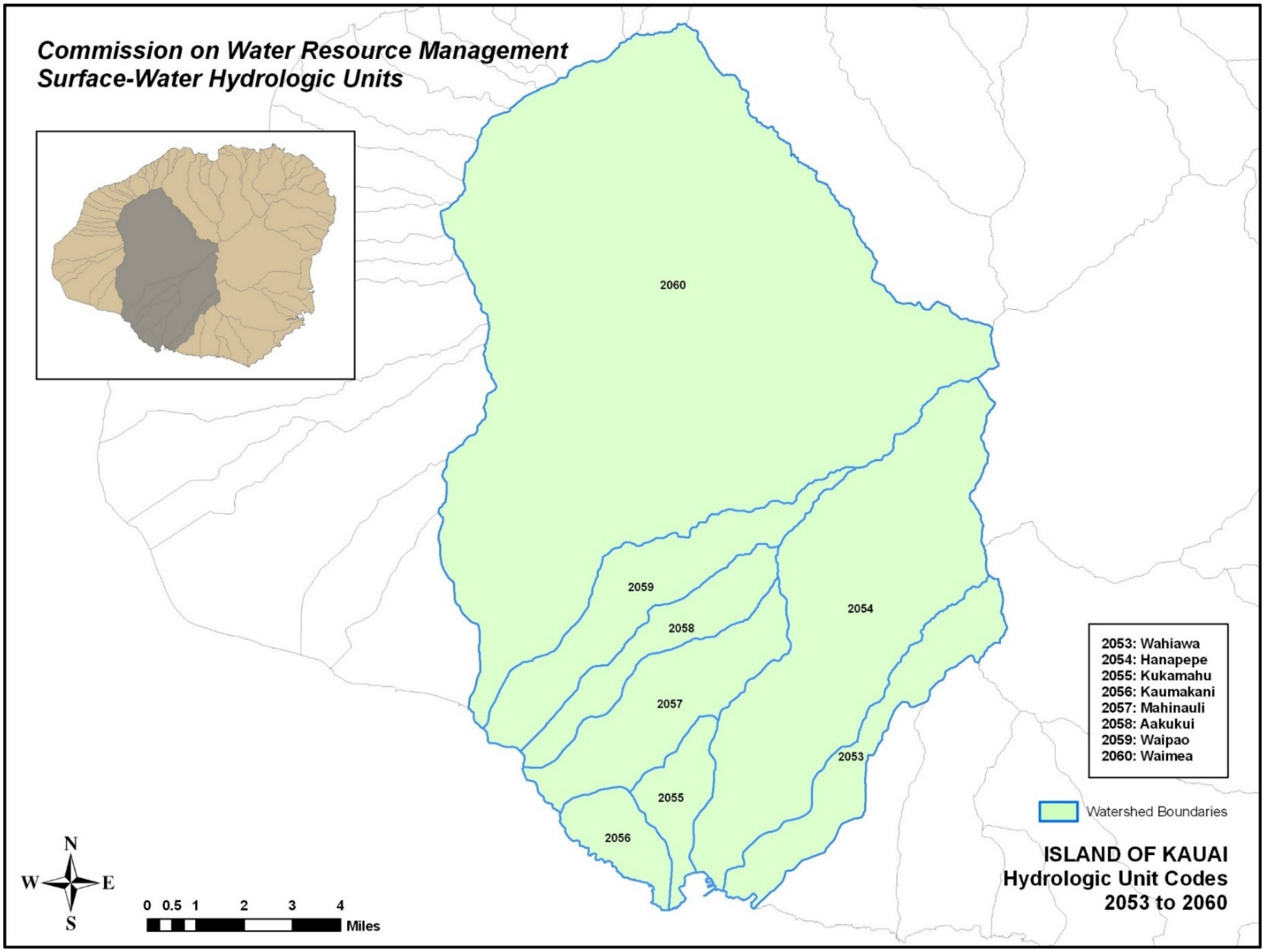


Figure F-24F Kauaʻi Surface Water Hydrologic Units, Unit Codes 2061 to 2074

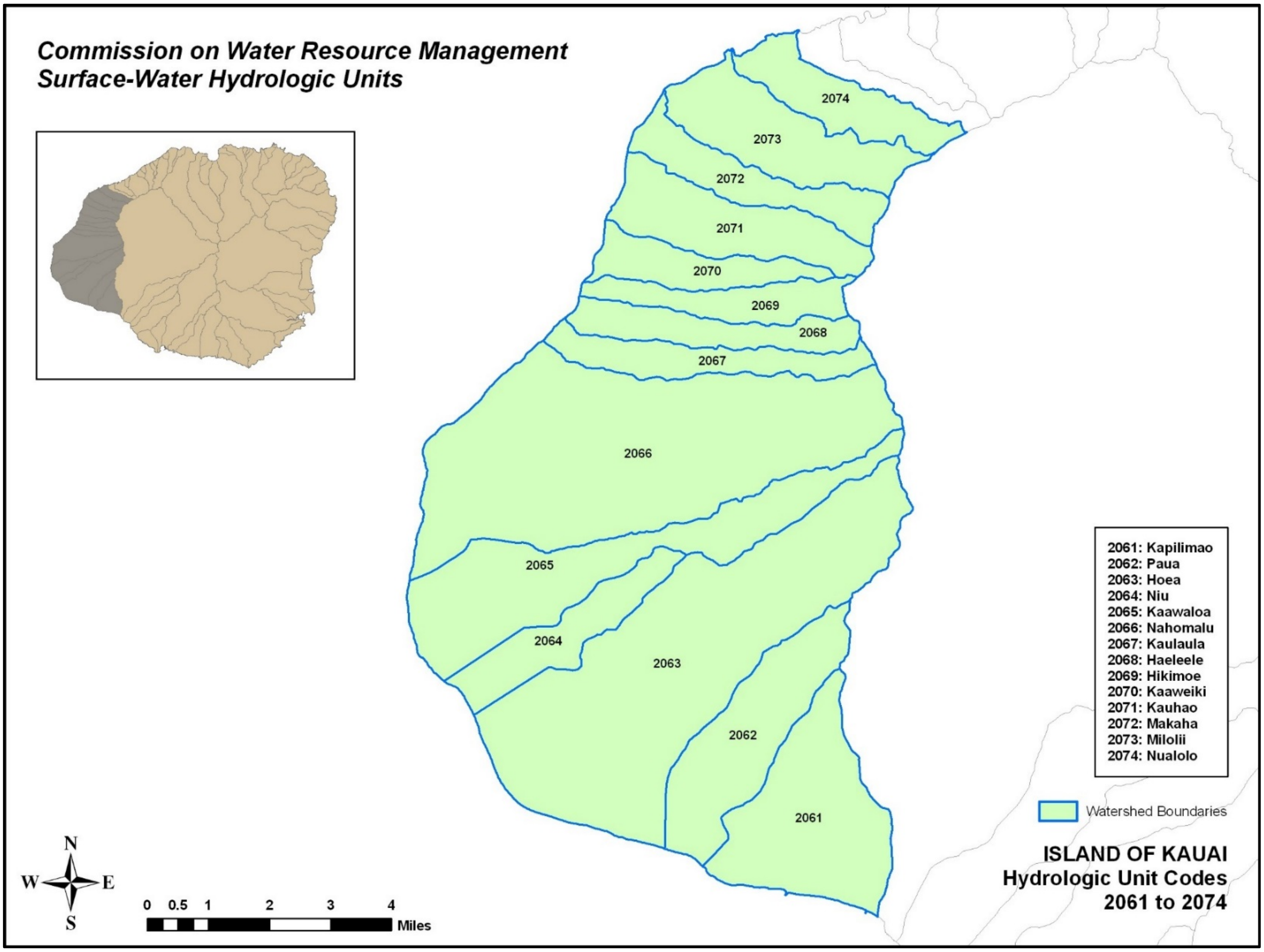


Figure F-25 O‘ahu Surface Water Hydrologic Units, Unit Codes 3001 to 3087

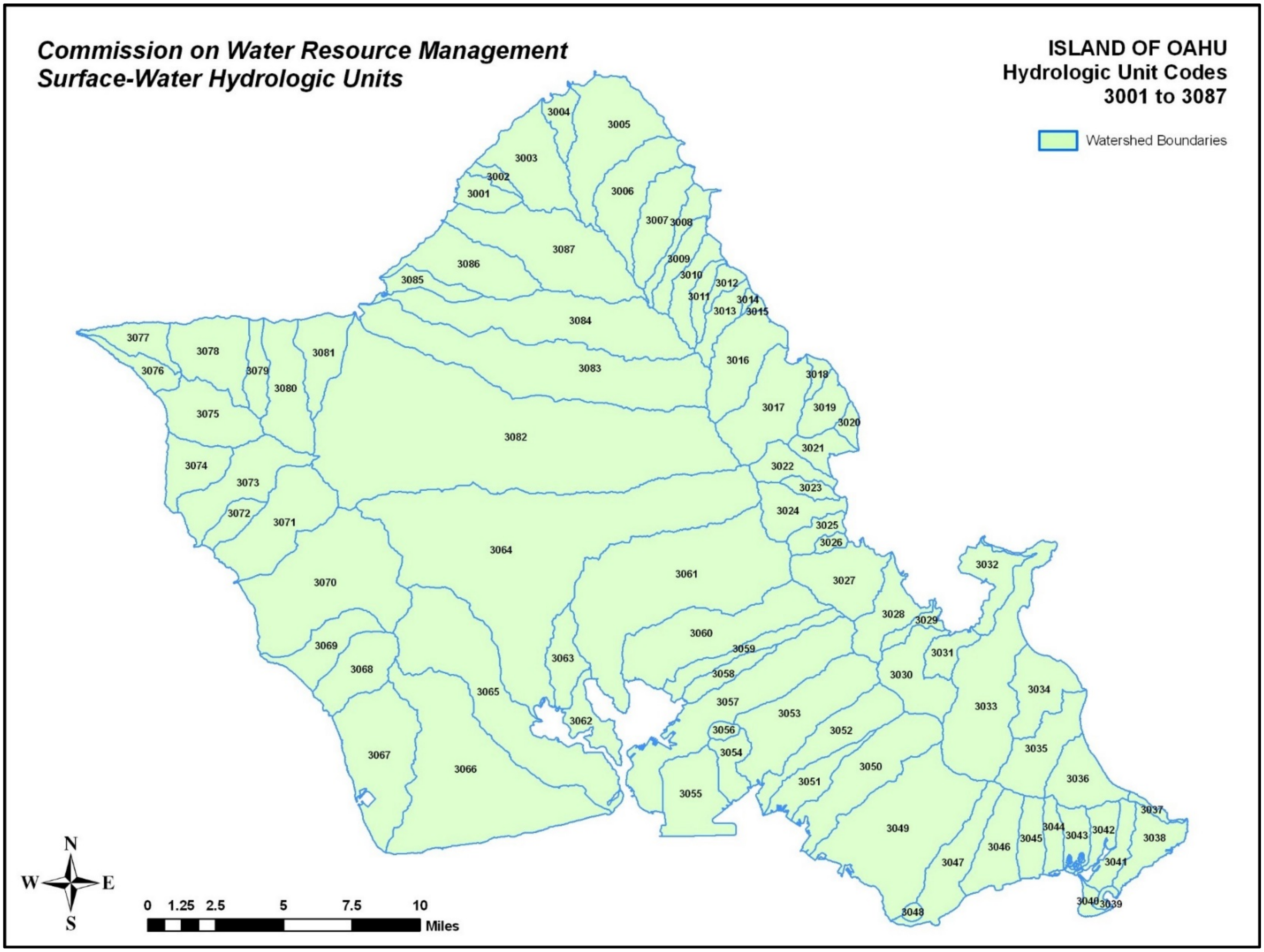


Figure F-25A O‘ahu Surface Water Hydrologic Units, Unit Codes 3001 to 3026

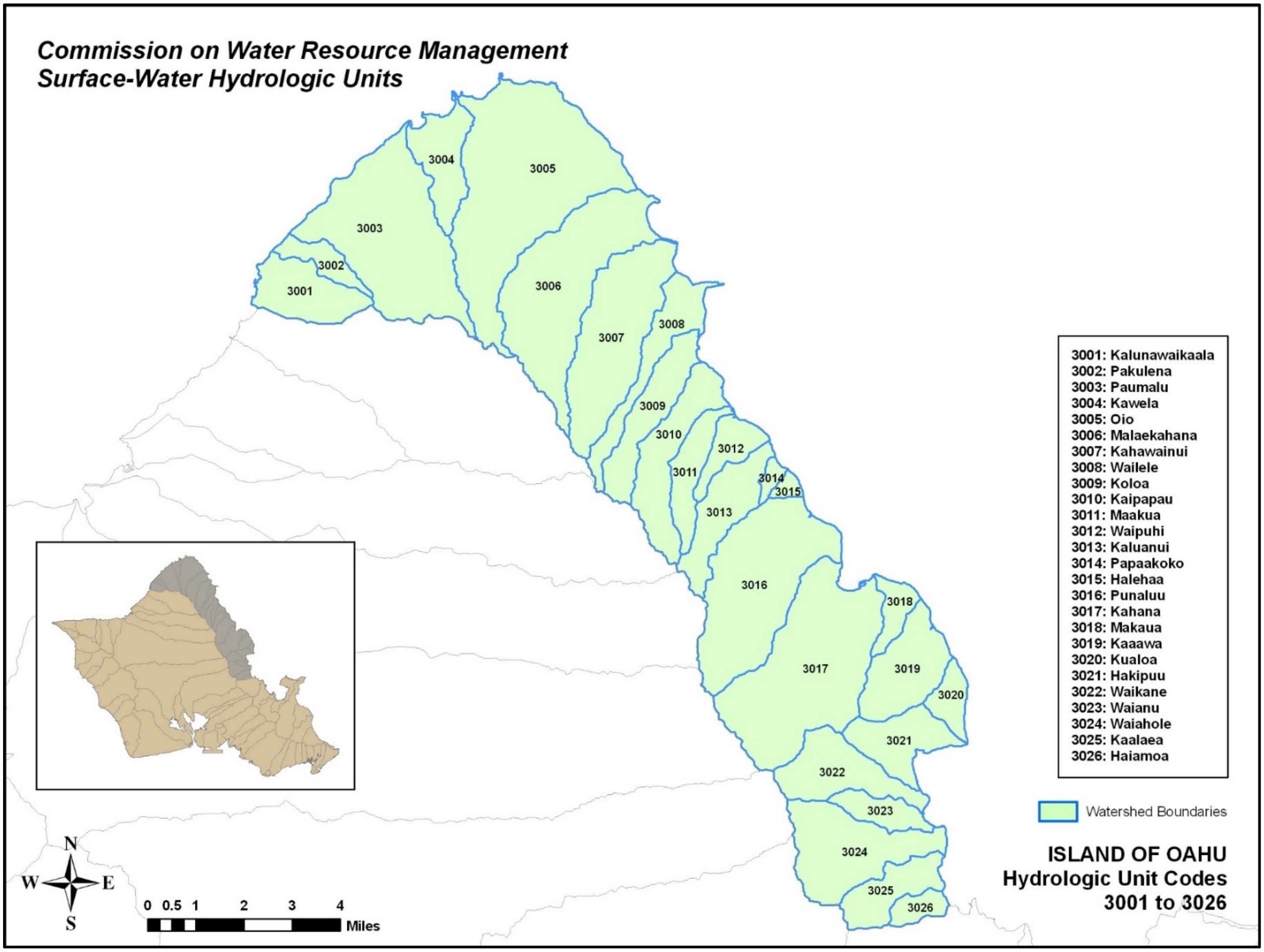


Figure F-25B Oʻahu Surface Water Hydrologic Units, Unit Codes 3027 to 3046

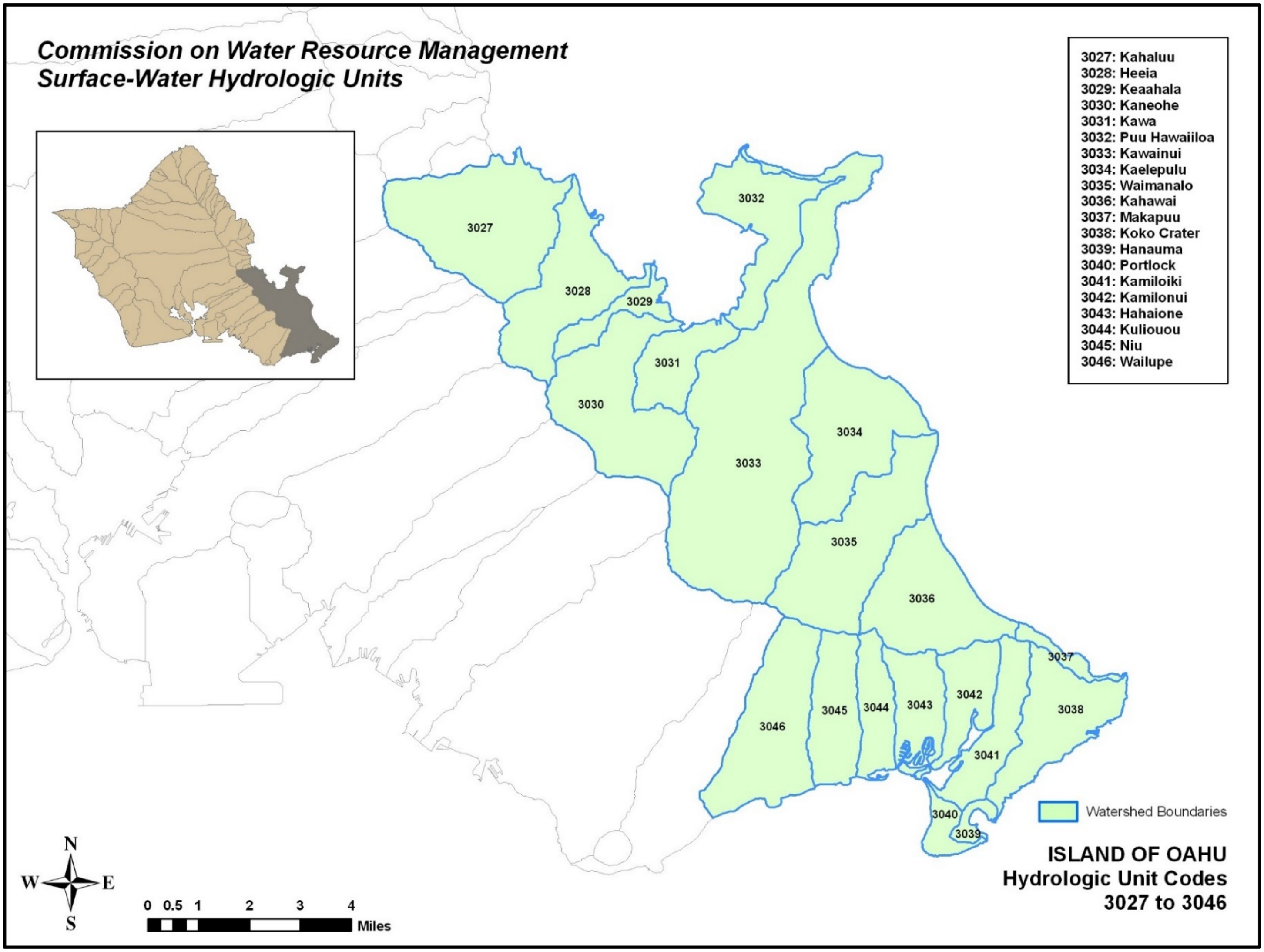


Figure F-25C O‘ahu Surface Water Hydrologic Units, Unit Codes 3047 to 3061

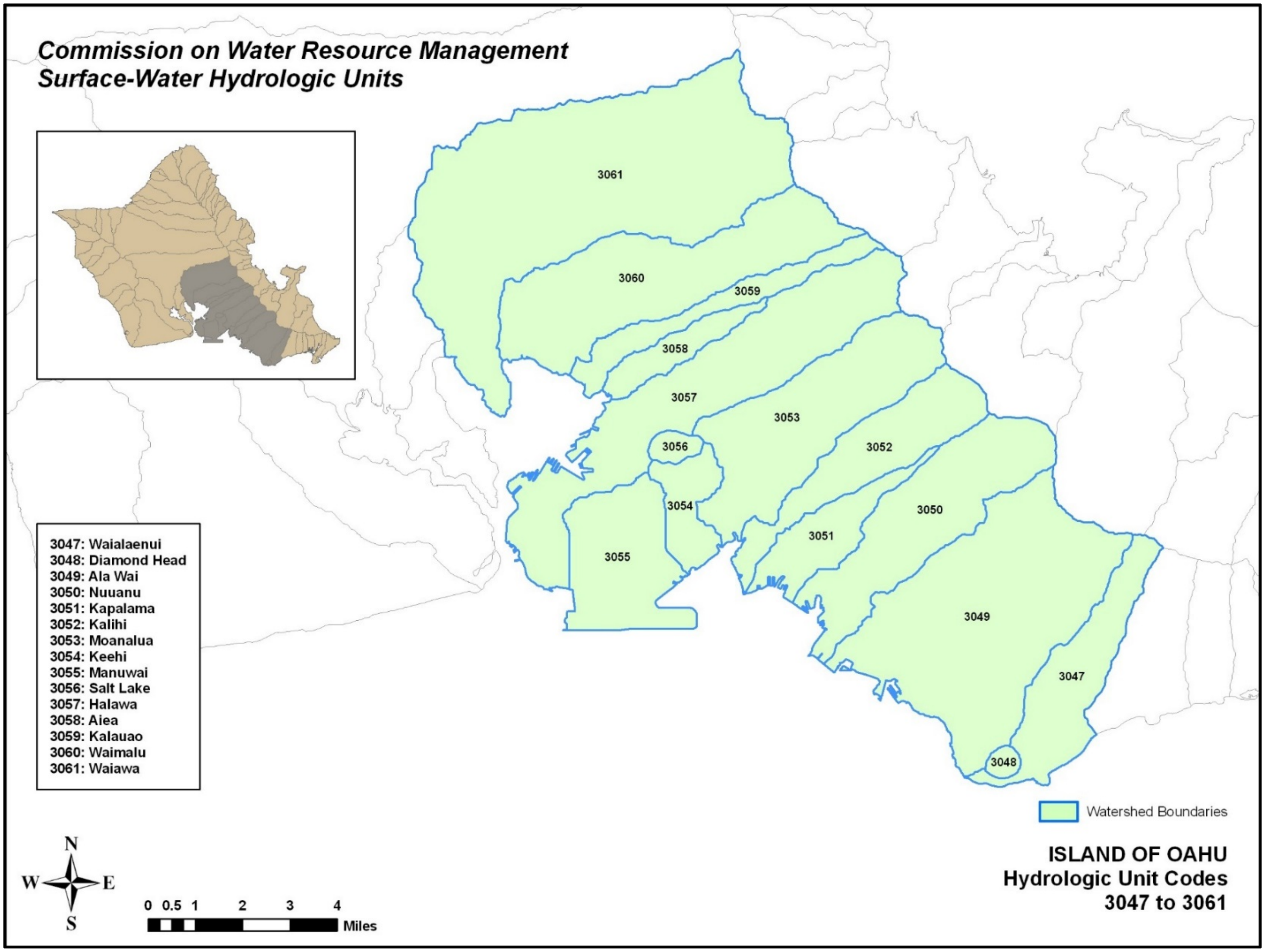


Figure F-25D O‘ahu Surface Water Hydrologic Units, Unit Codes 3062 to 3070

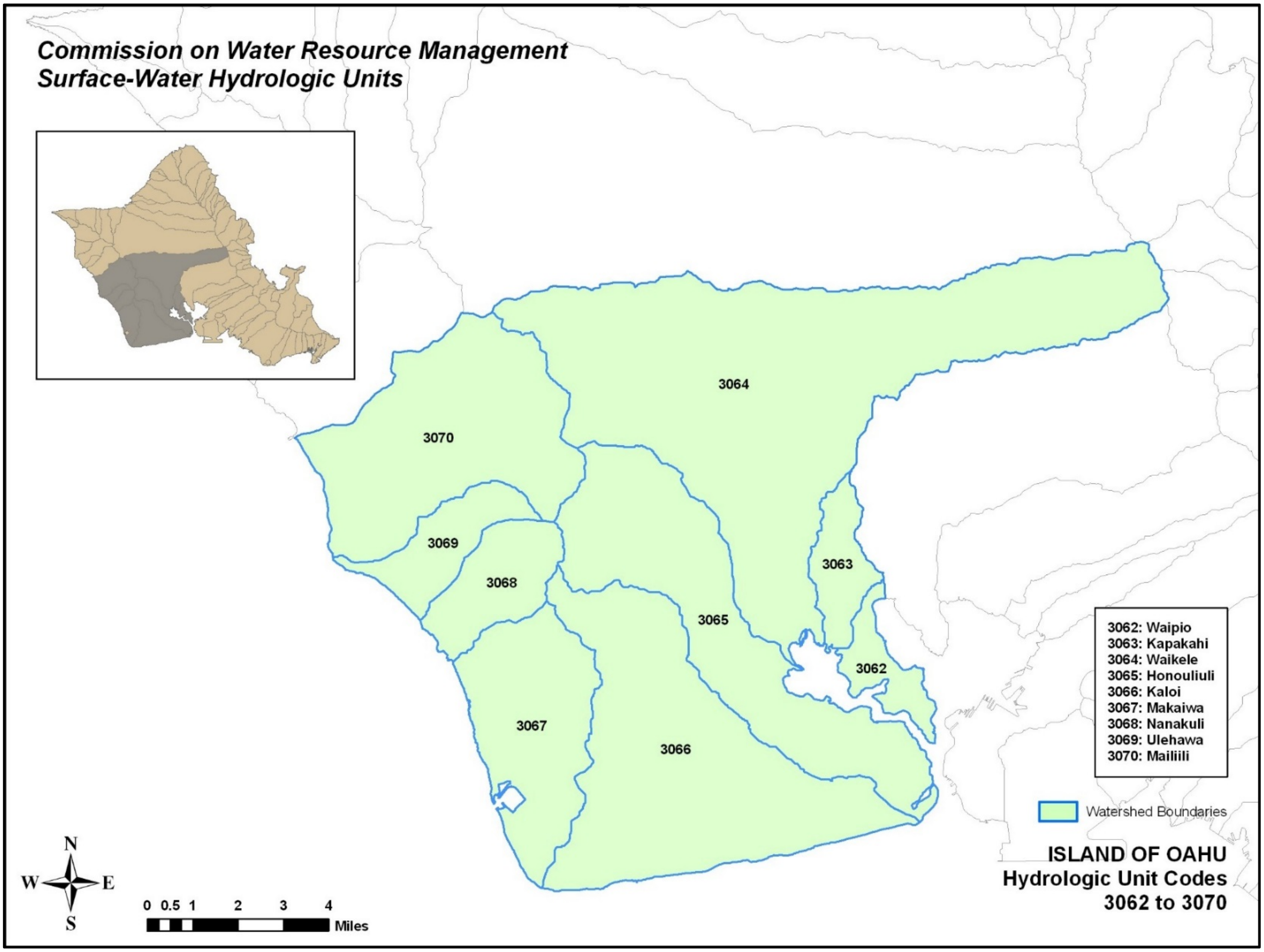


Figure F-25E O‘ahu Surface Water Hydrologic Units, Unit Codes 3071 to 3081

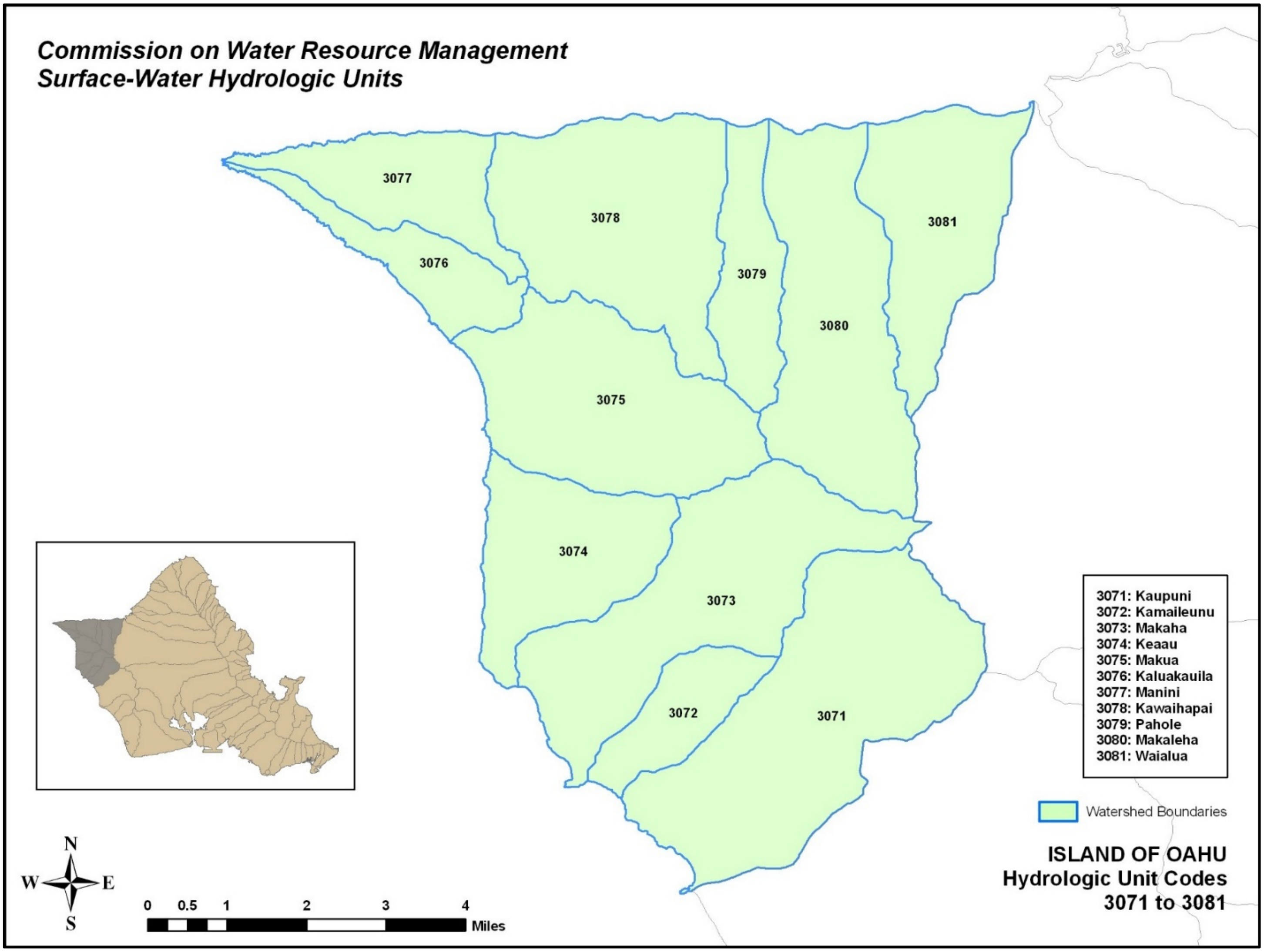


Figure F-25F O‘ahu Surface Water Hydrologic Units, Unit Codes 3082 to 3087

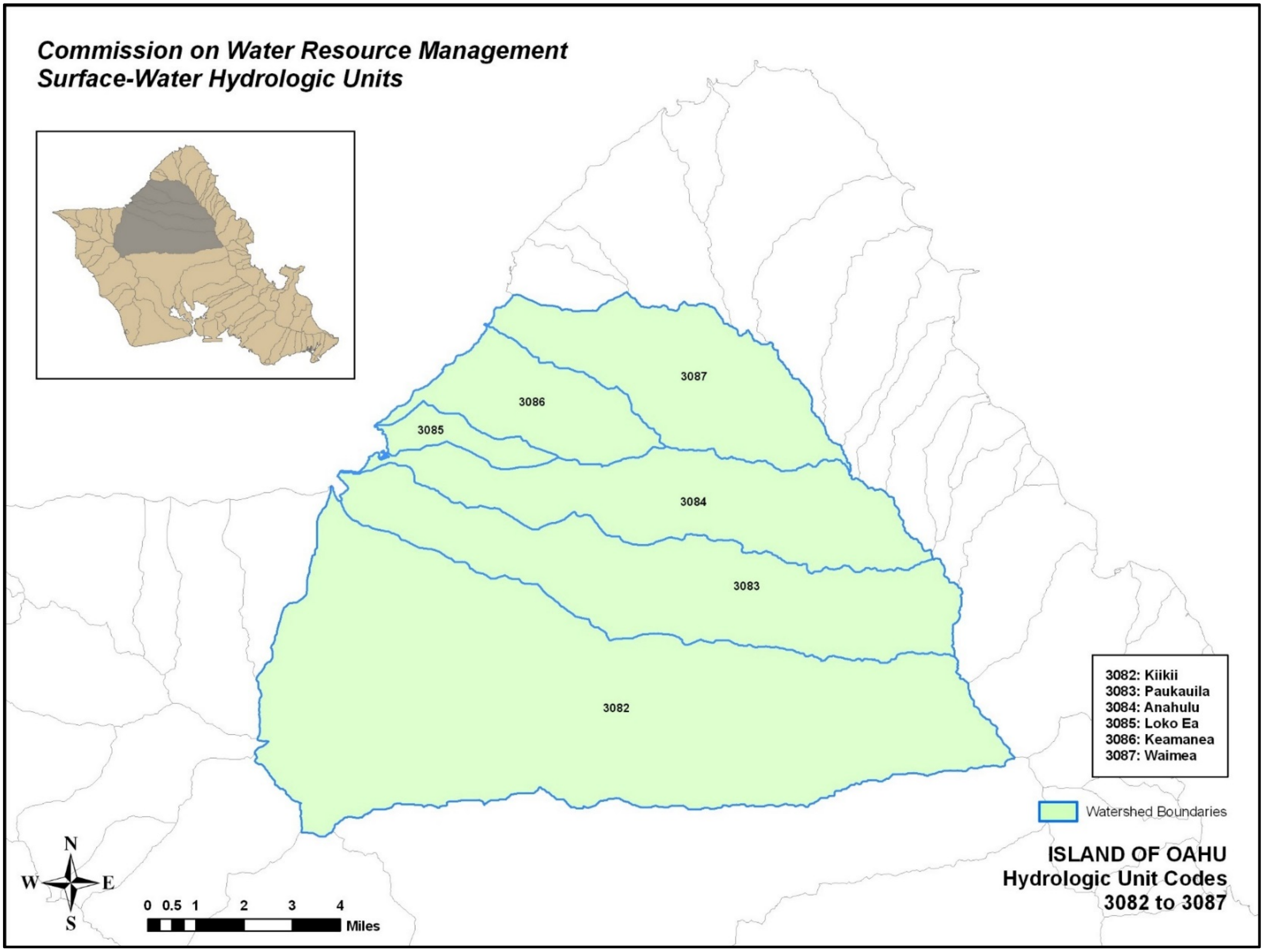


Figure F-26 Moloka‘i Surface Water Hydrologic Units, Unit Codes 4001 to 4050

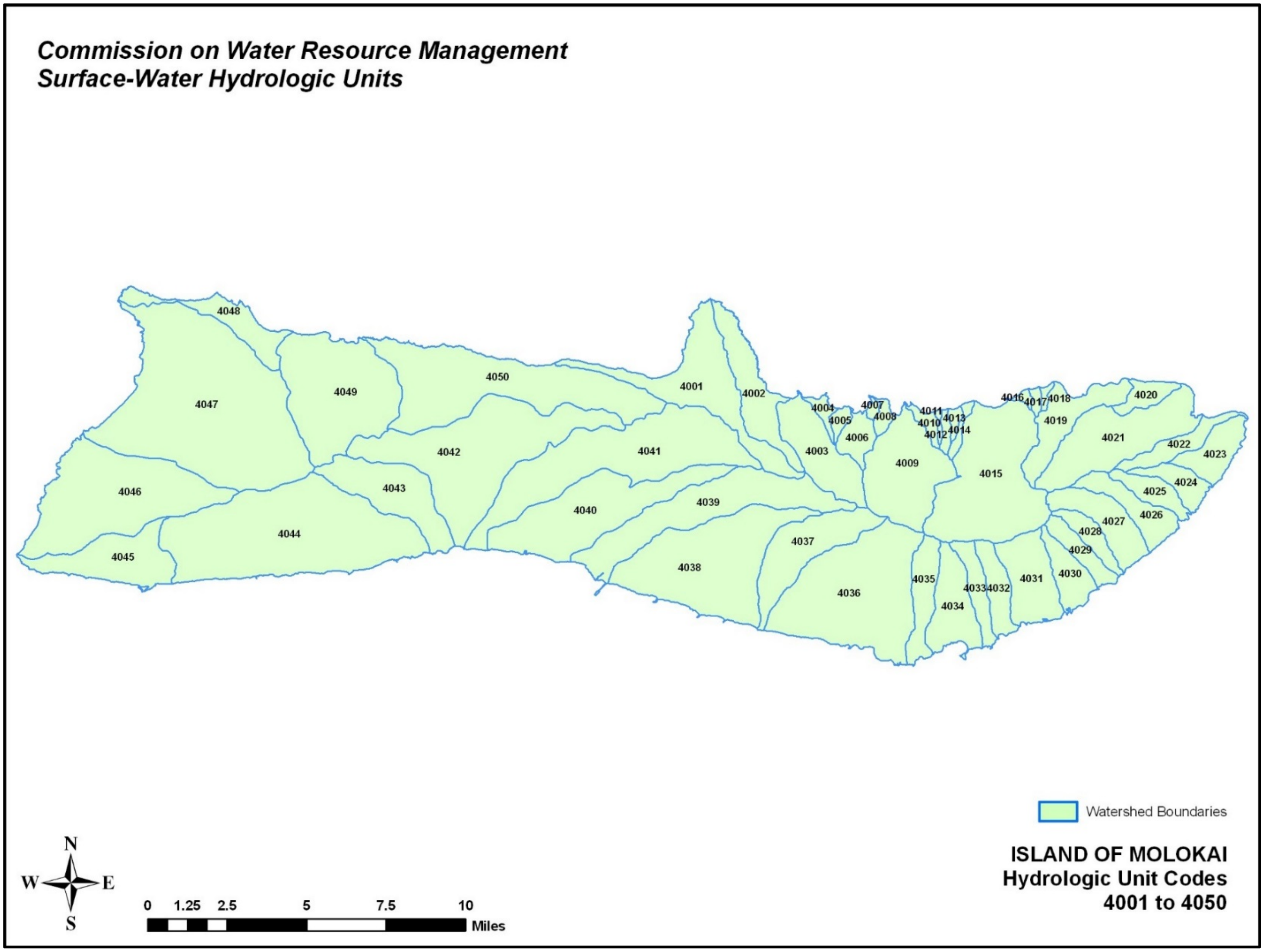


Figure F-26A Moloka‘i Surface Water Hydrologic Units, Unit Codes 4001 to 4009

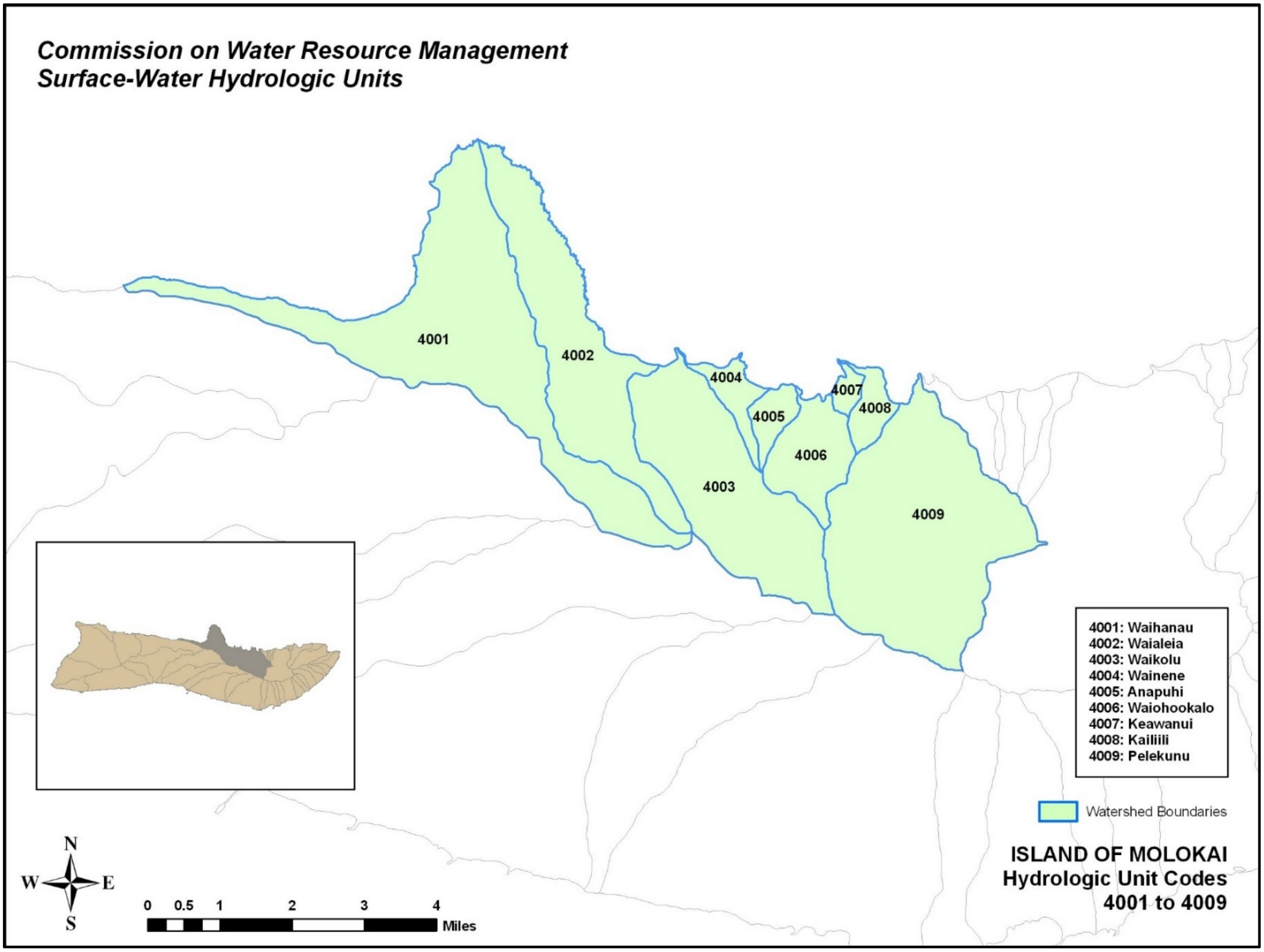


Figure F-26B Moloka'i Surface Water Hydrologic Units, Unit Codes 4010 to 4035

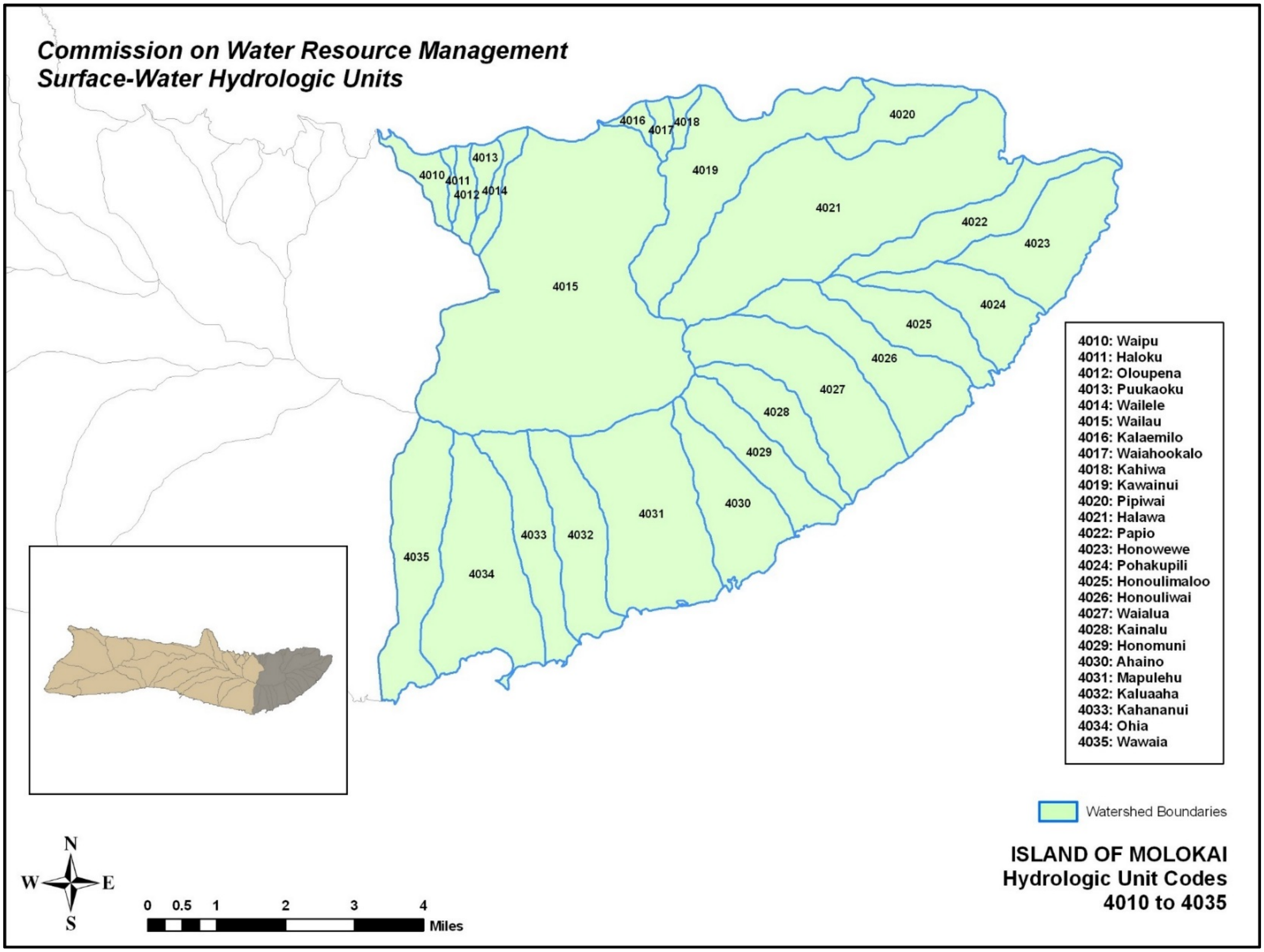


Figure F-26C Moloka‘i Surface Water Hydrologic Units, Unit Codes 4036 to 4041

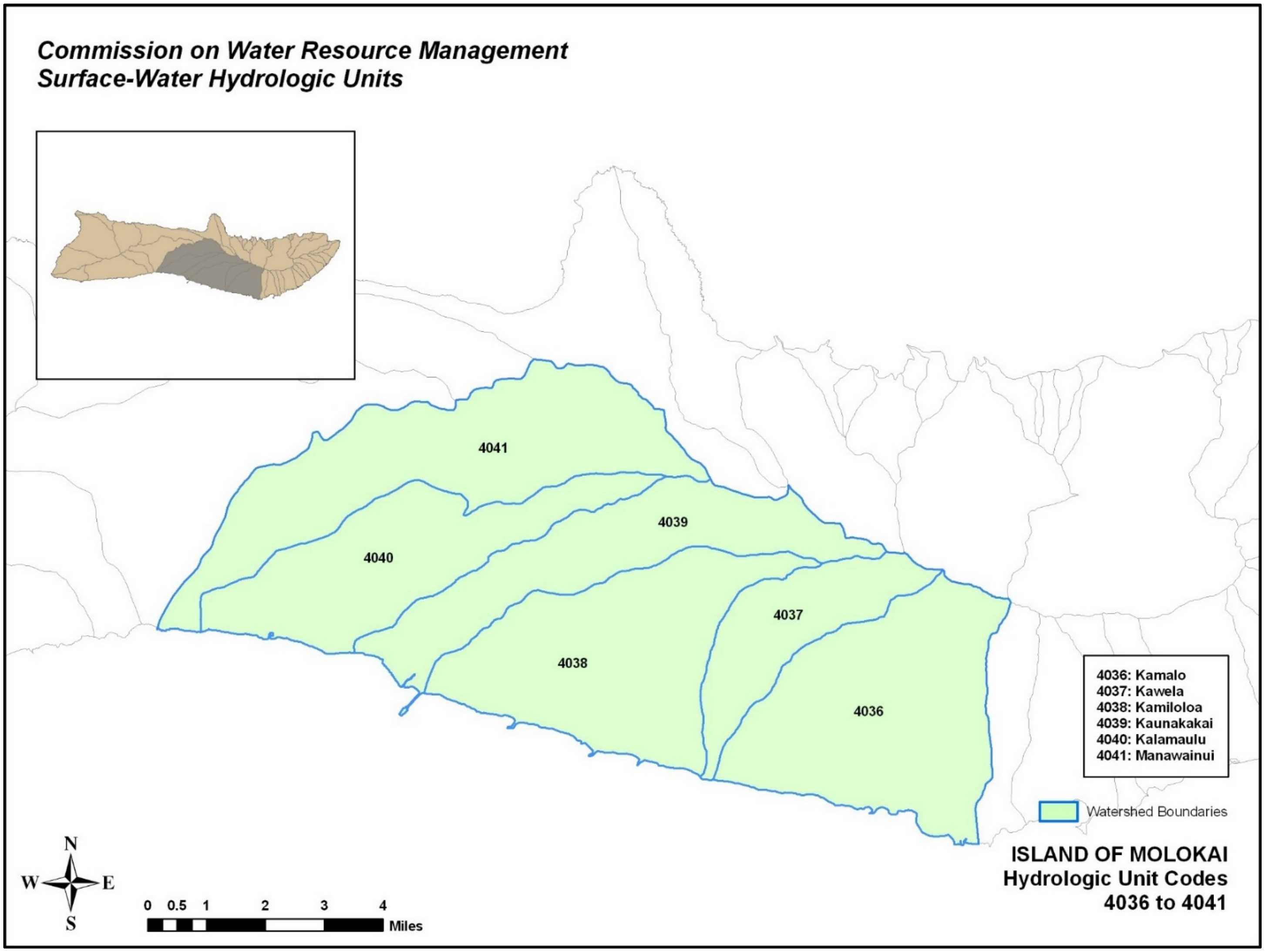


Figure F-26D Molokaʻi Surface Water Hydrologic Units, Unit Codes 4042 to 4050

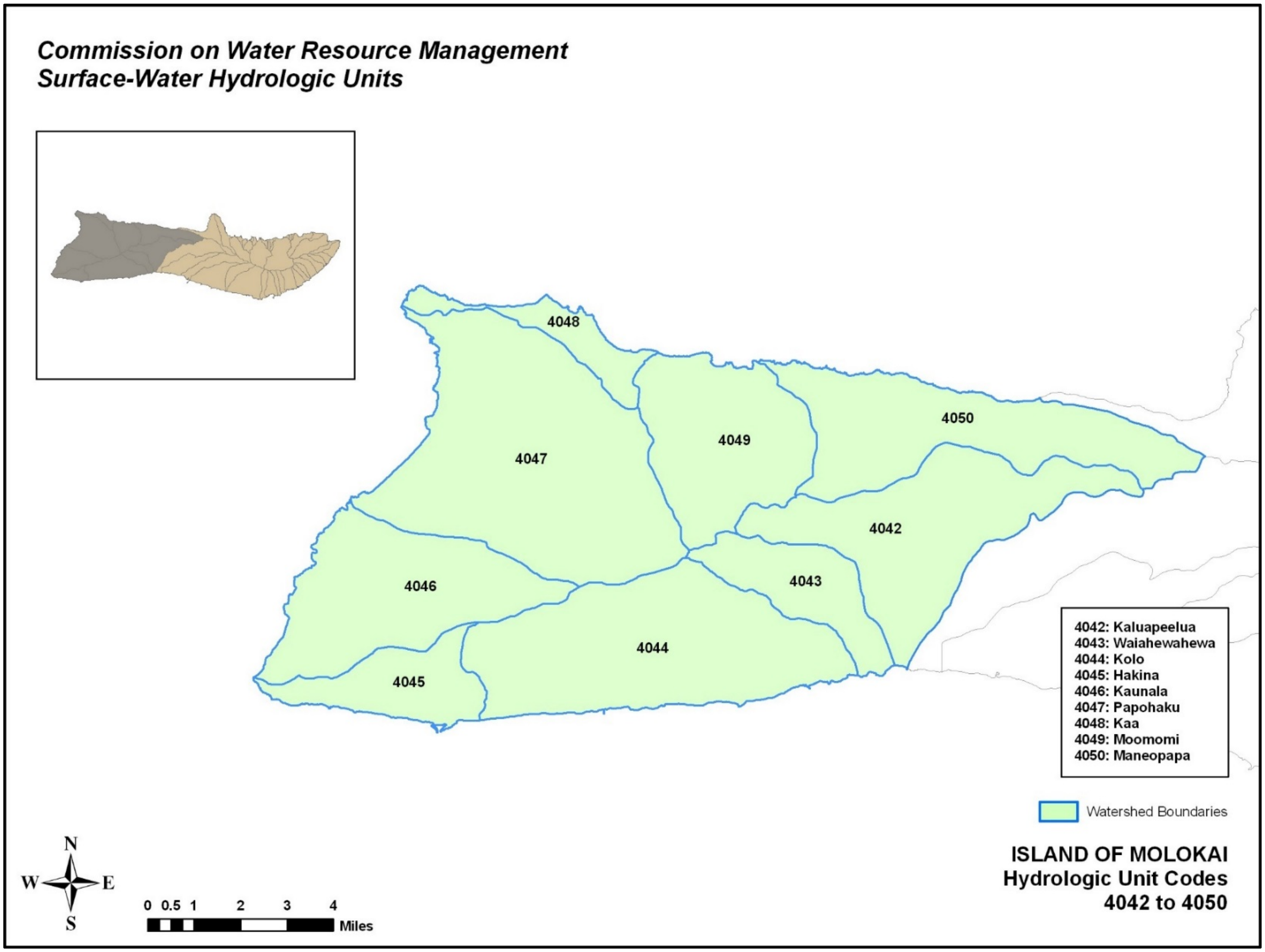


Figure F-27 Lāna'i Surface Water Hydrologic Units, Unit Codes 5001 to 5032

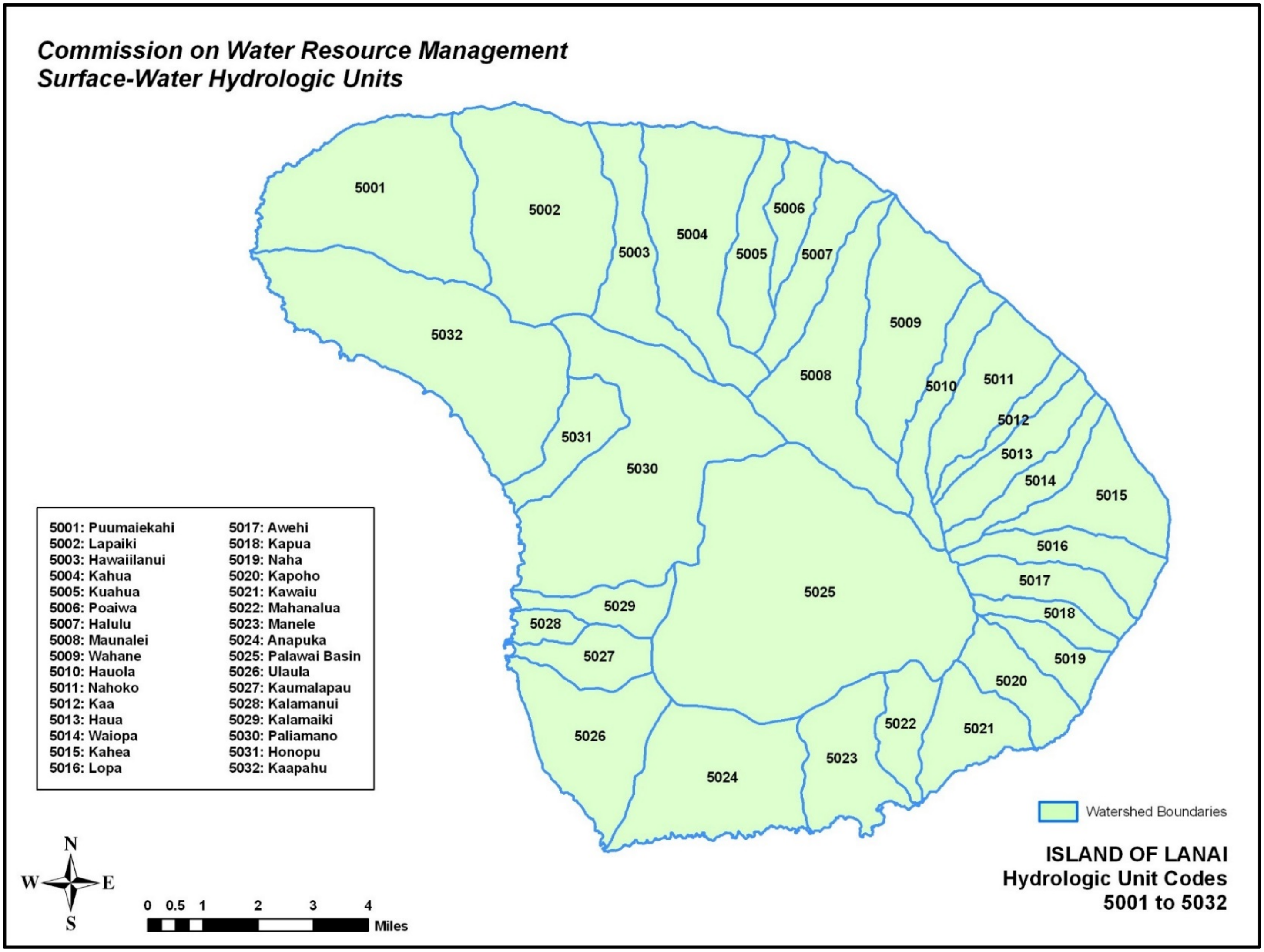


Figure F-28 Maui Surface Water Hydrologic Units, Unit Codes 6001 to 6112

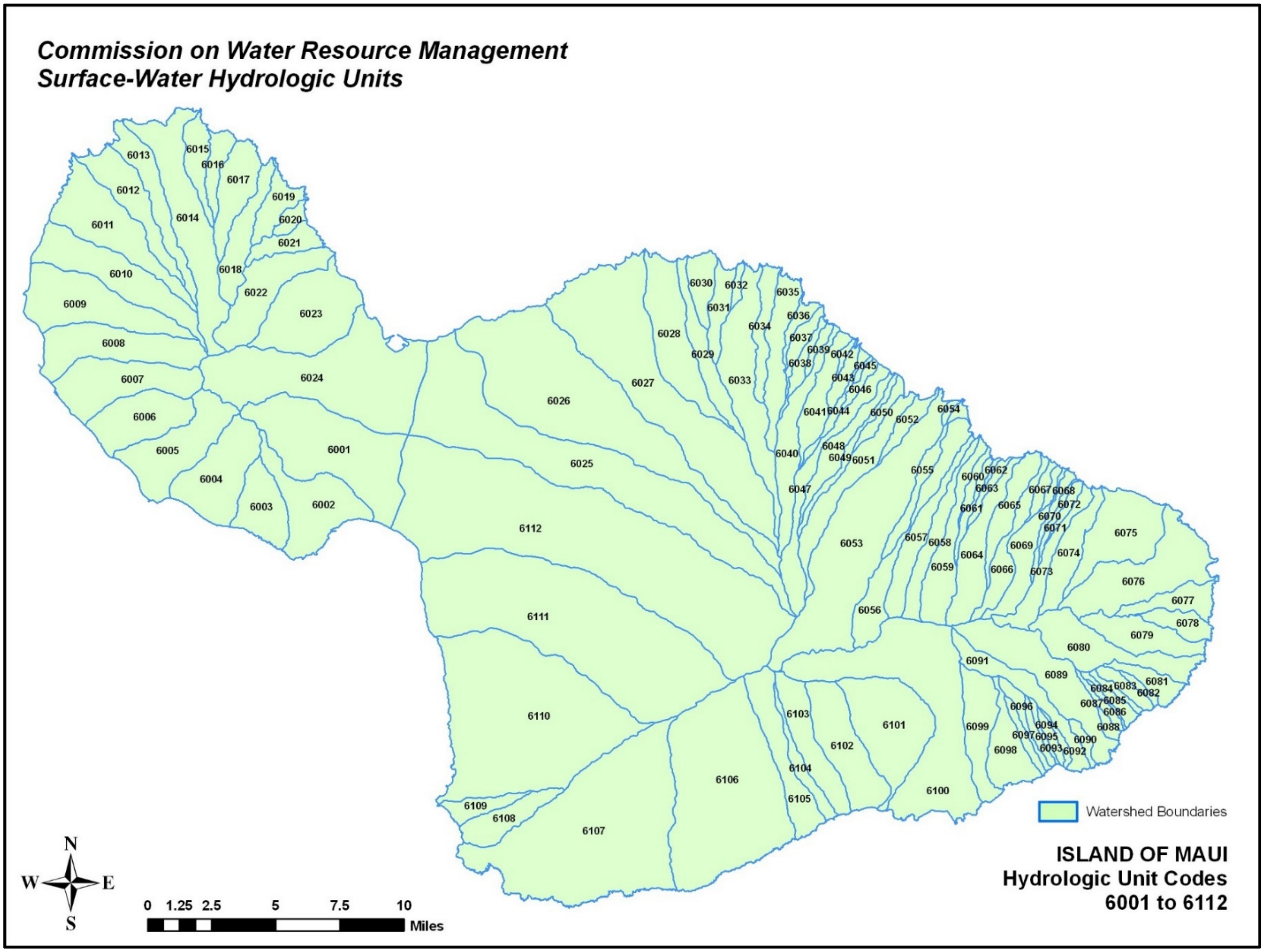


Figure F-28A Maui Surface Water Hydrologic Units, Unit Codes 6001 to 6010

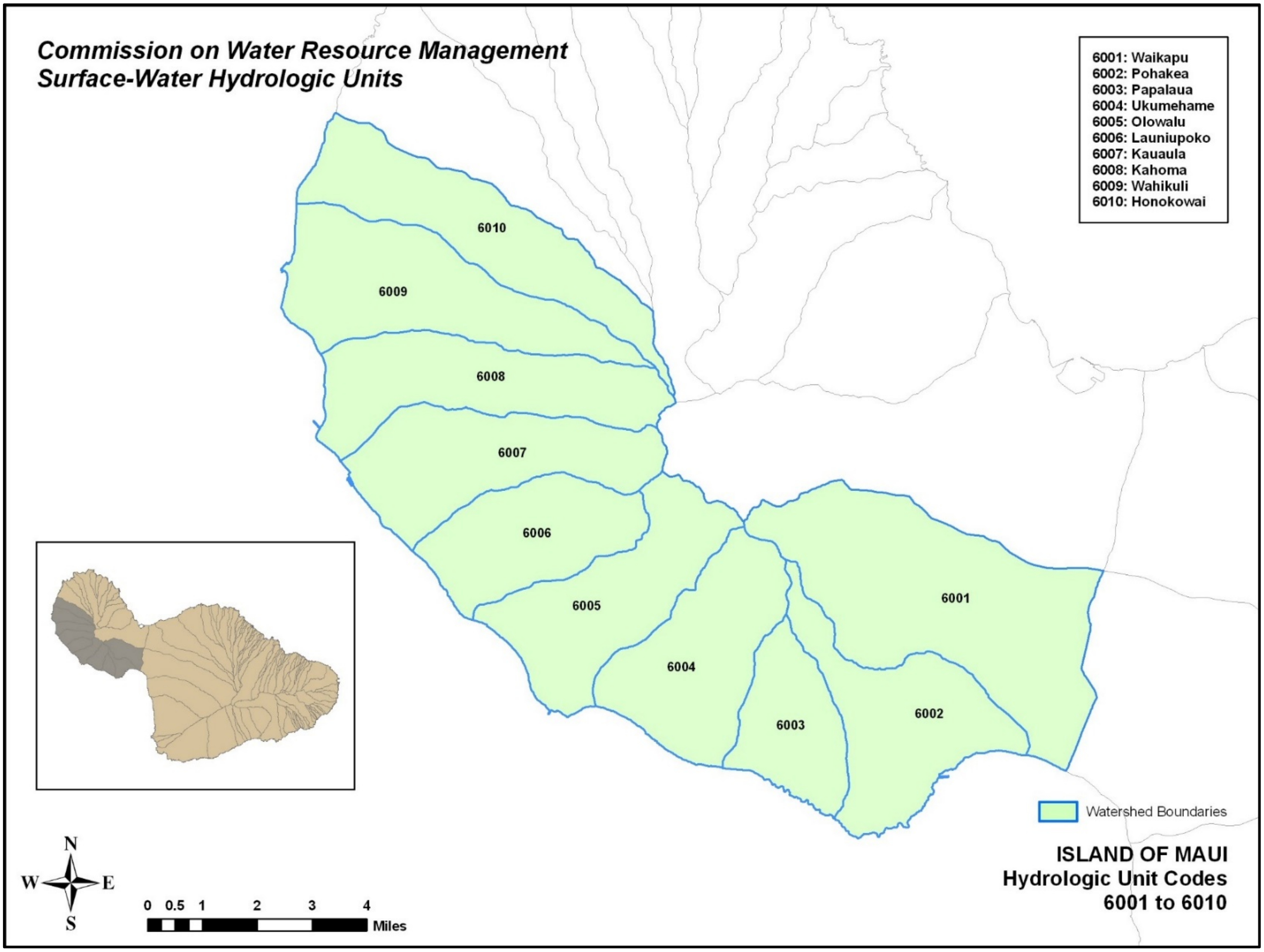


Figure F-28B Maui Surface Water Hydrologic Units, Unit Codes 6011 to 6024

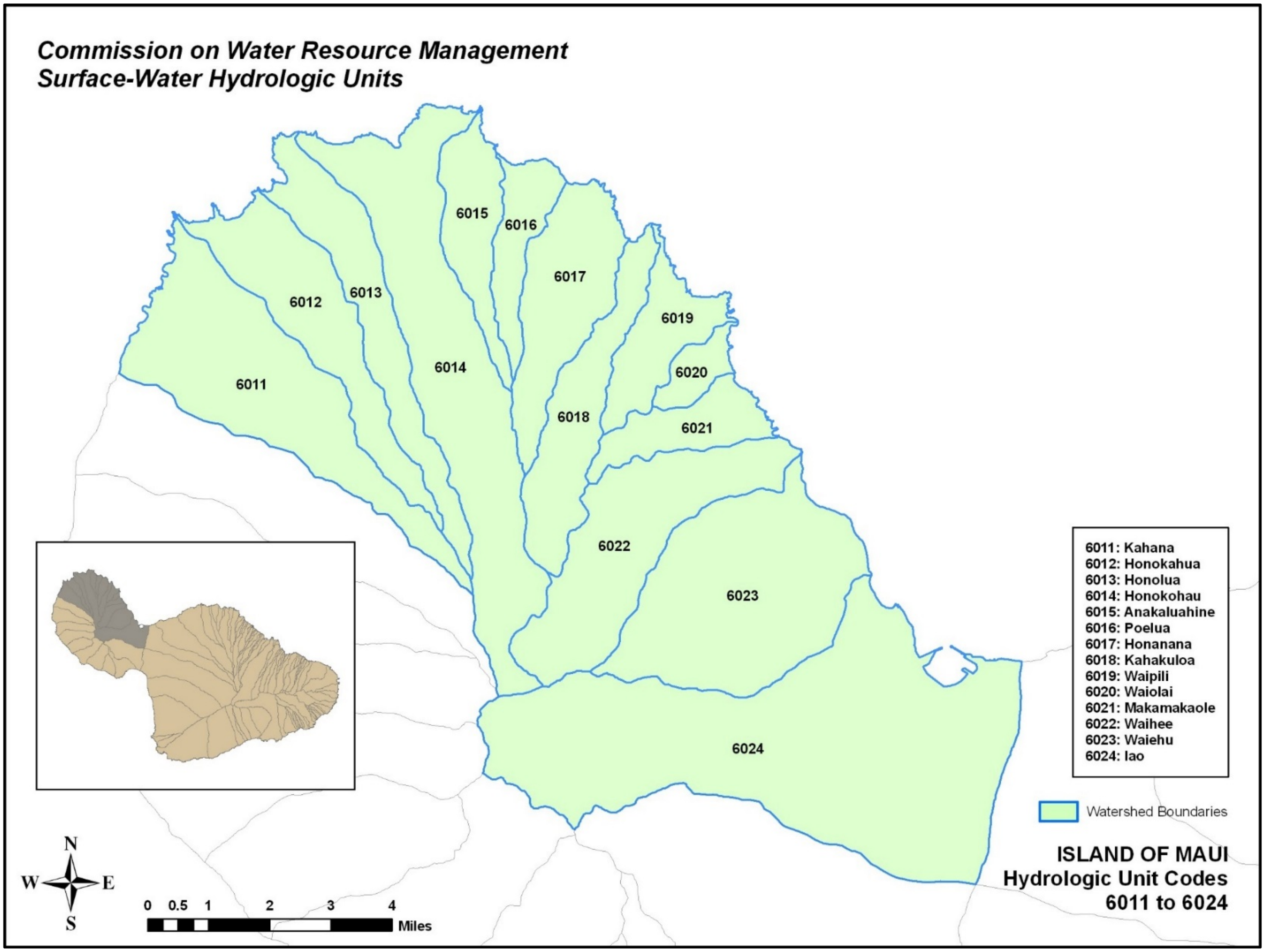


Figure F-28C Maui Surface Water Hydrologic Units, Unit Codes 6025 to 6035

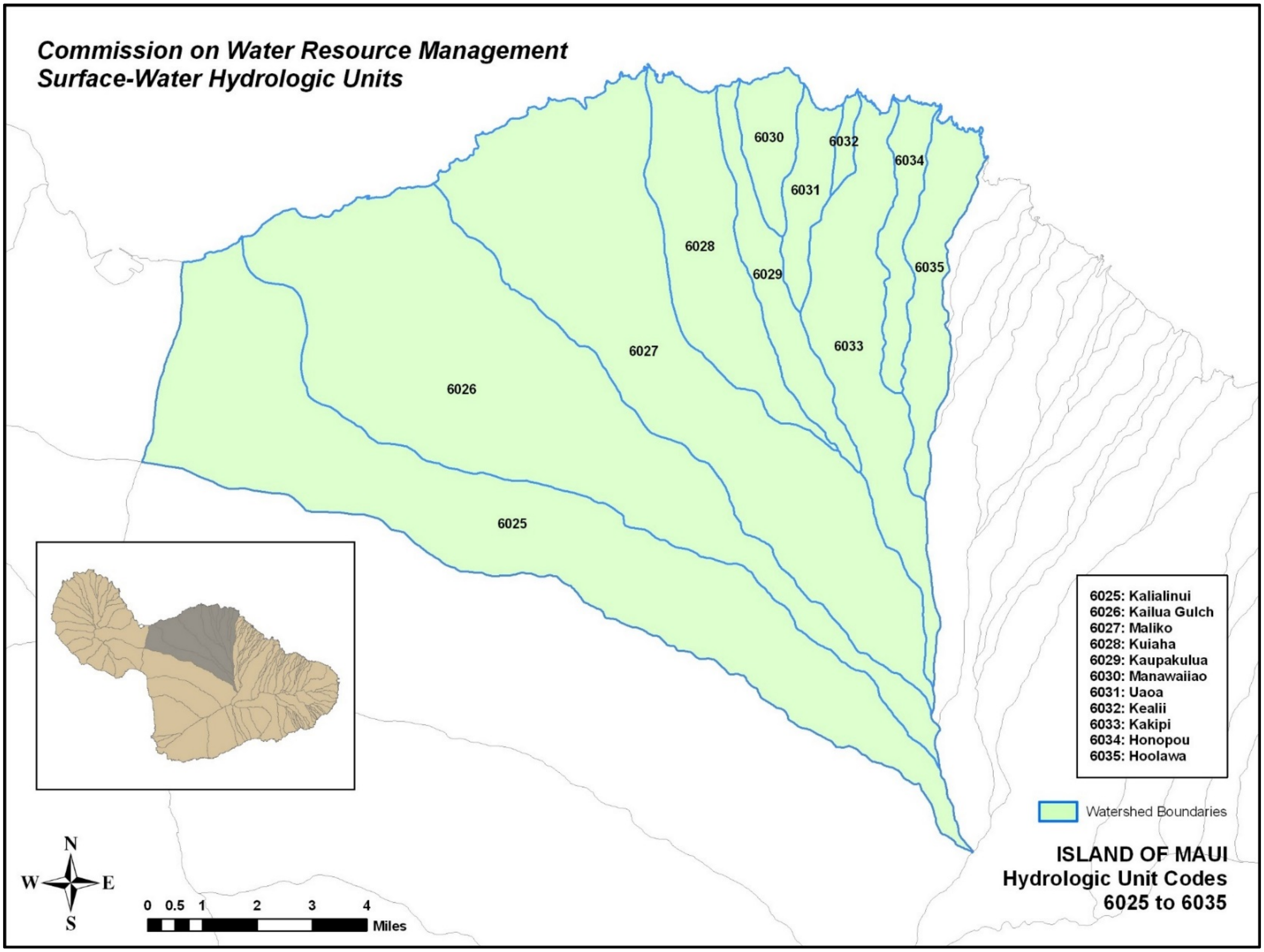


Figure F-28D Maui Surface Water Hydrologic Units, Unit Codes 6036 to 6065

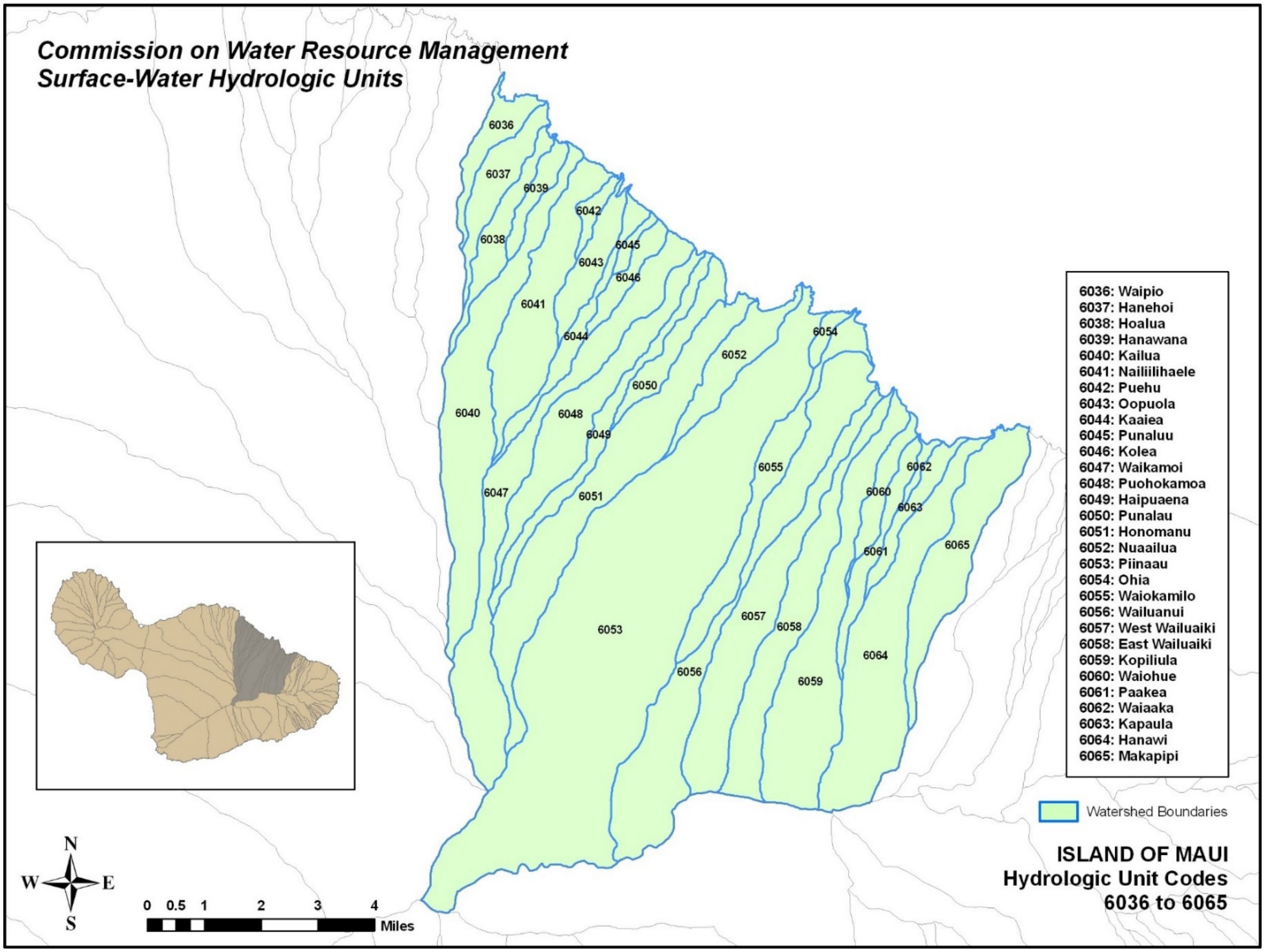


Figure F-28E Maui Surface Water Hydrologic Units, Unit Codes 6066 to 6088

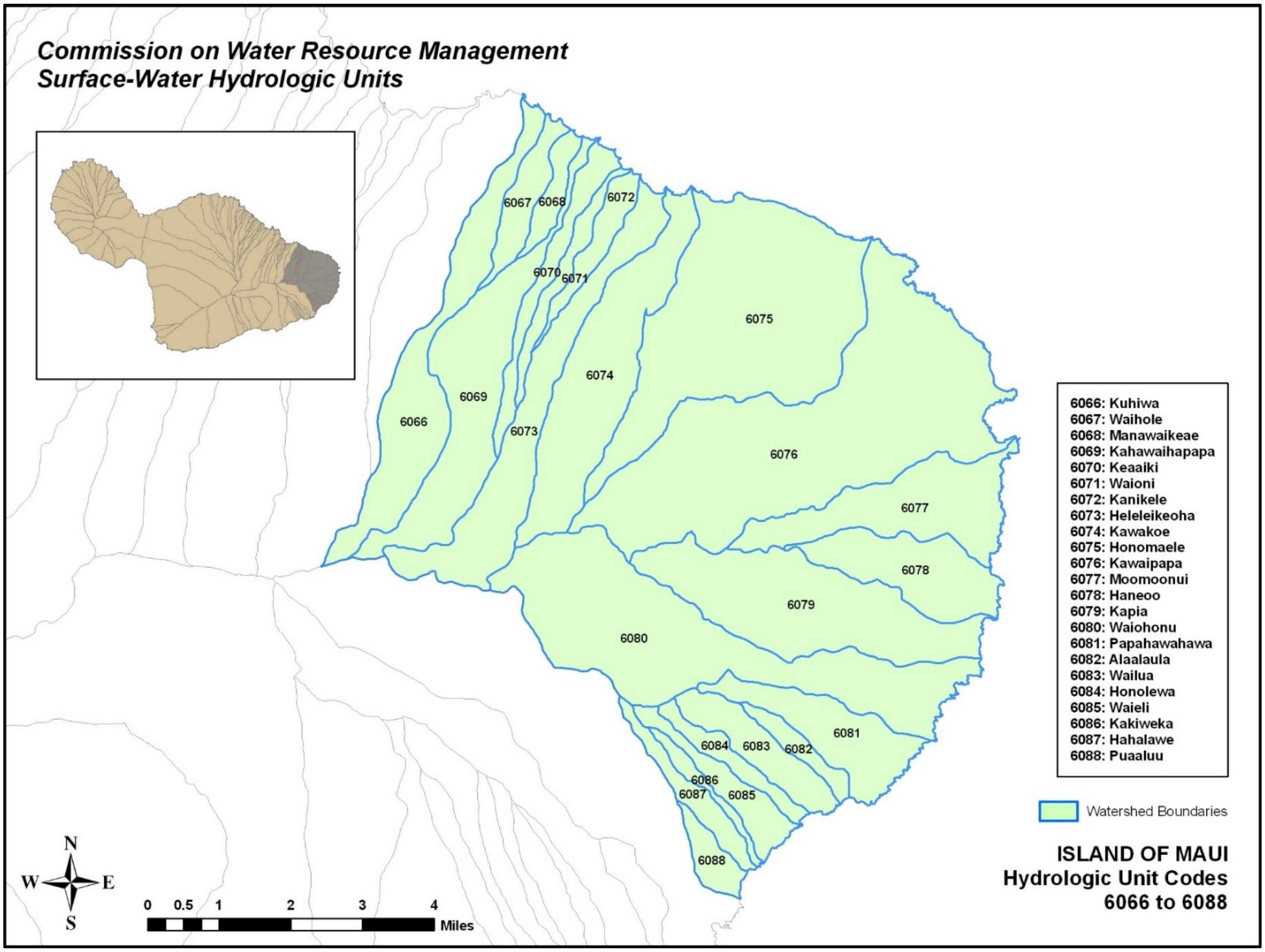


Figure F-28F Maui Surface Water Hydrologic Units, Unit Codes 6089 to 6104

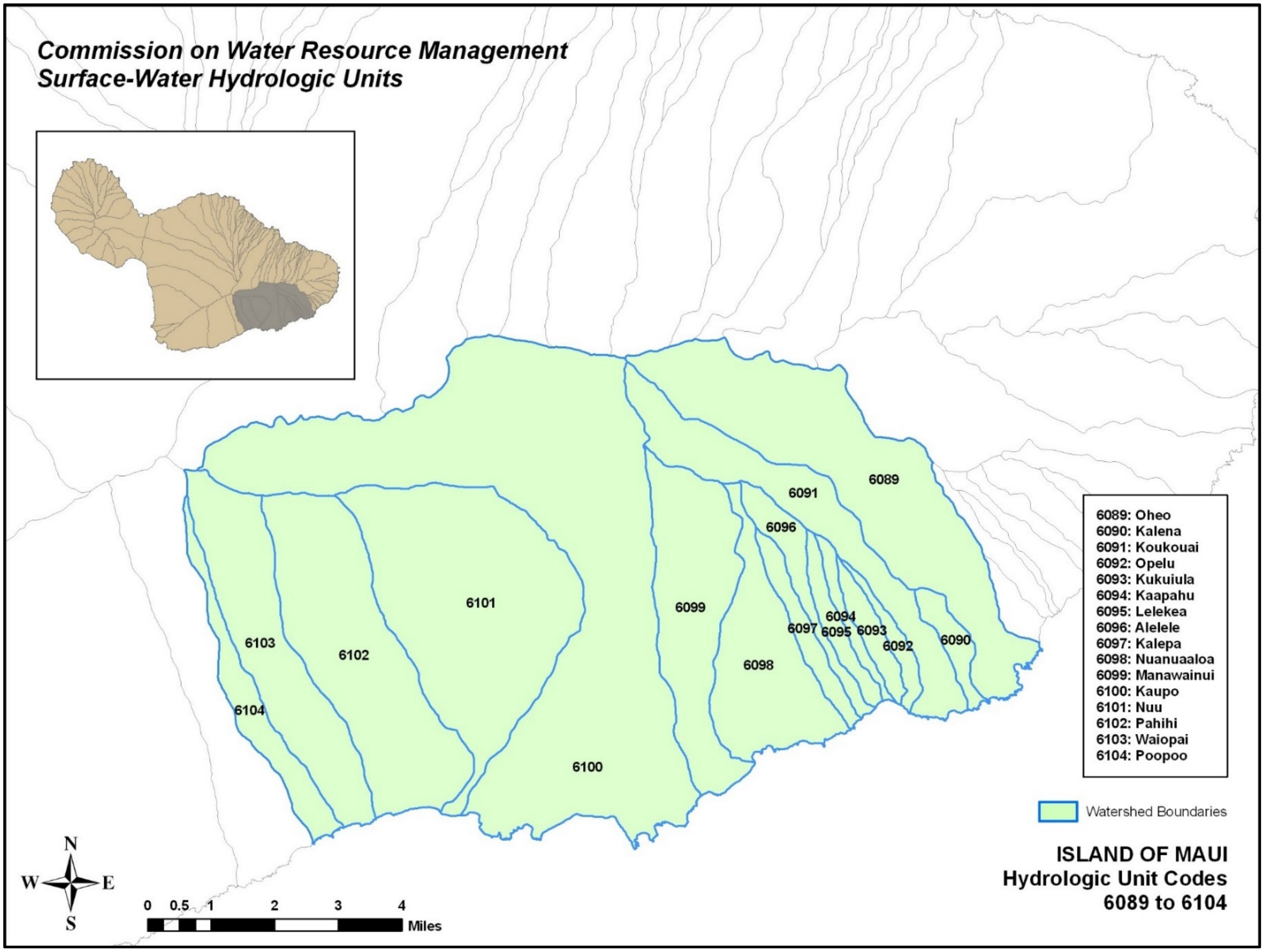


Figure F-28G Maui Surface Water Hydrologic Units, Unit Codes 6105 to 6112

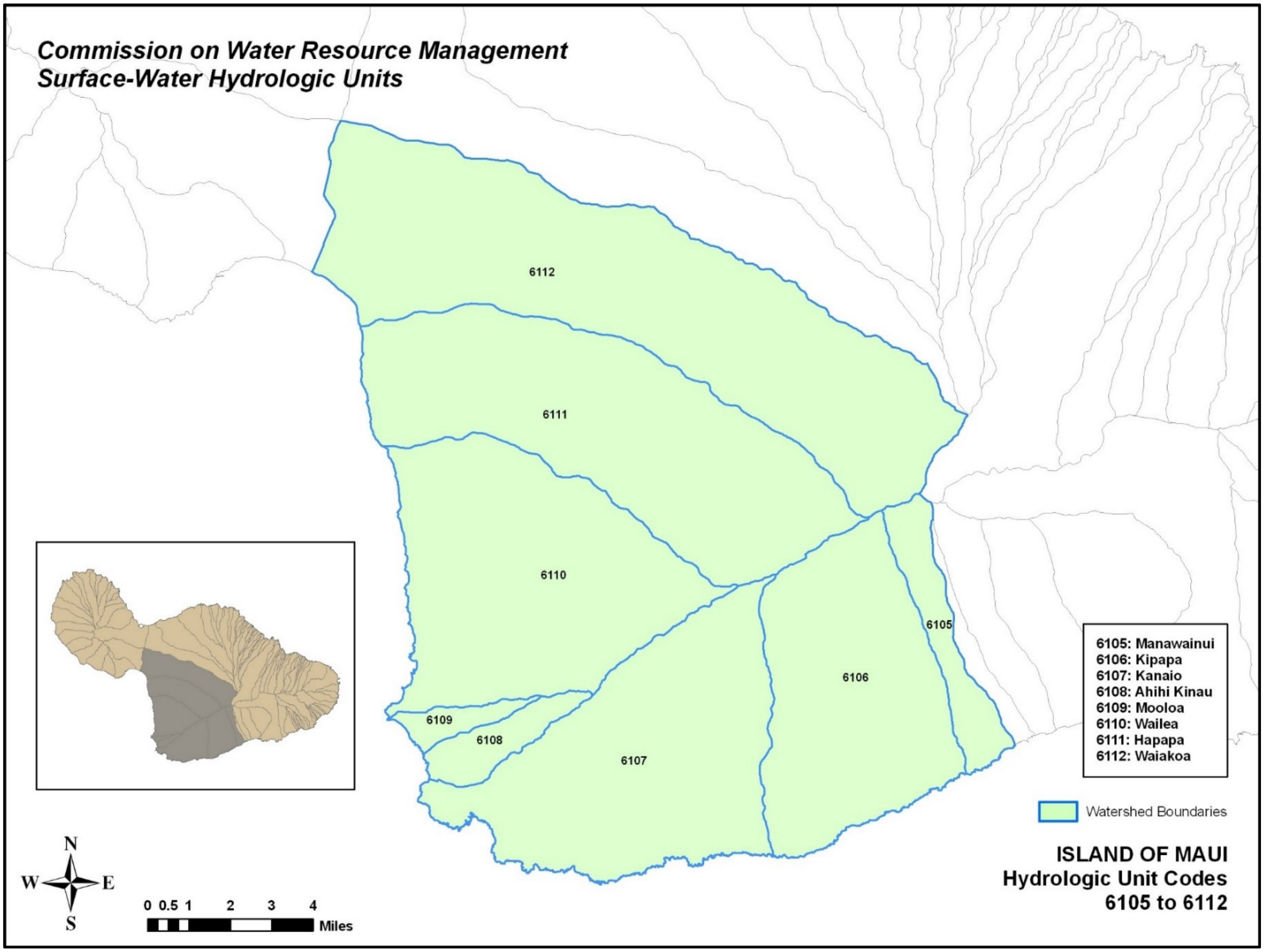


Figure F-29 Kaho‘olawe Surface Water Hydrologic Units, Unit Codes 7001 to 7024

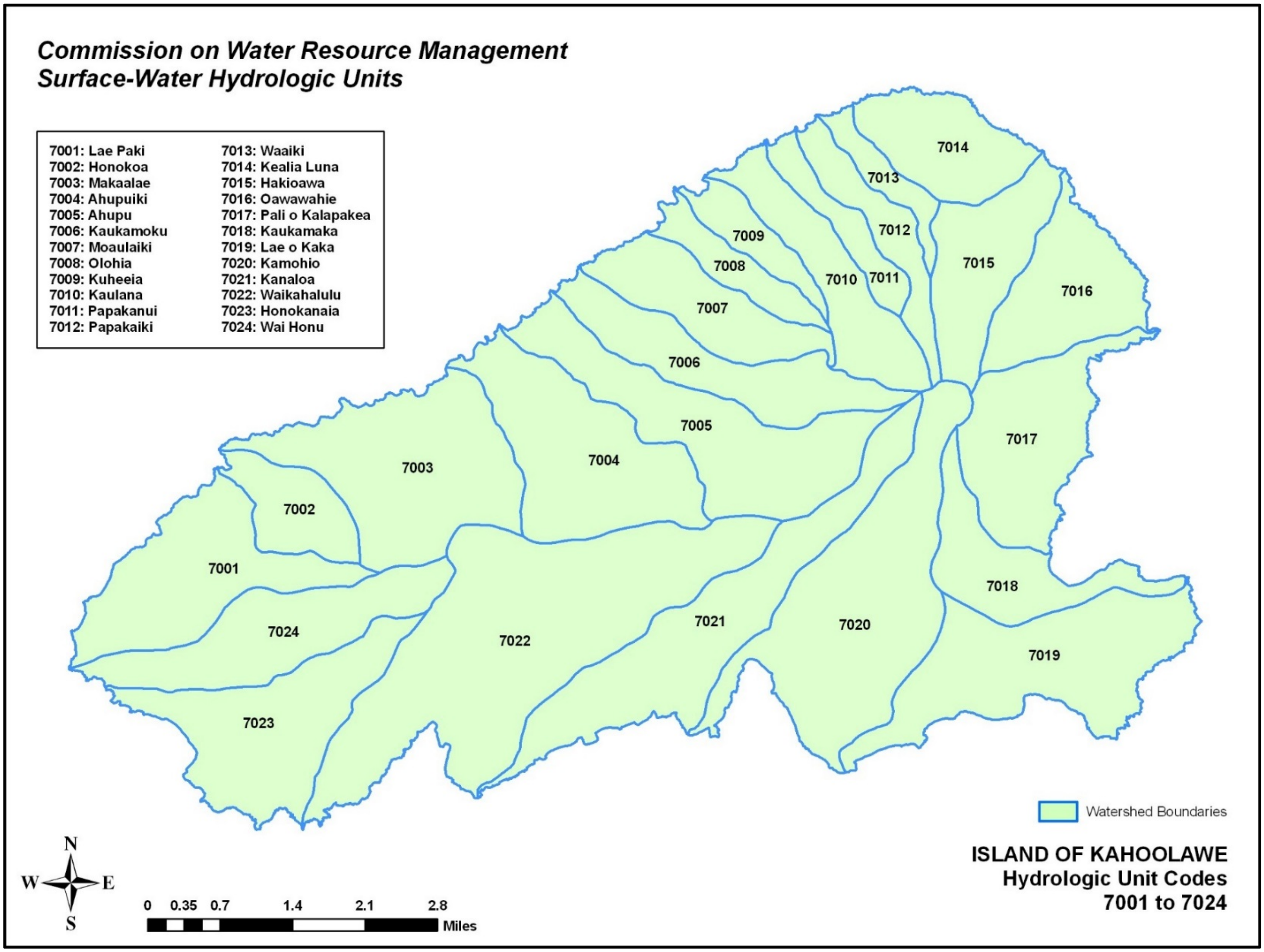


Figure F-30 Hawai‘i Surface Water Hydrologic Units, Unit Codes 8001 to 8166

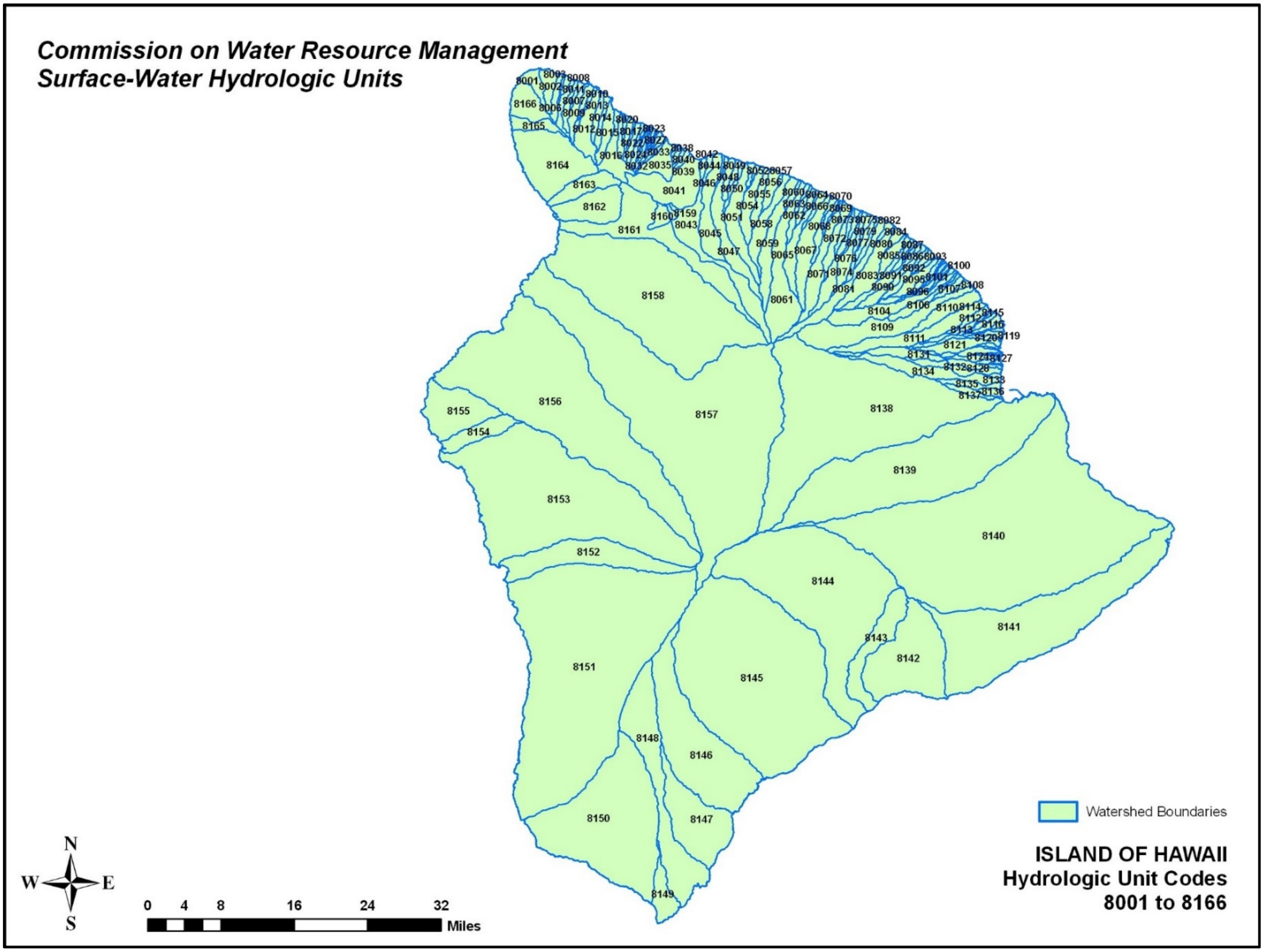


Figure F-30A Hawaiʻi Surface Water Hydrologic Units, Unit Codes 8001 to 8022

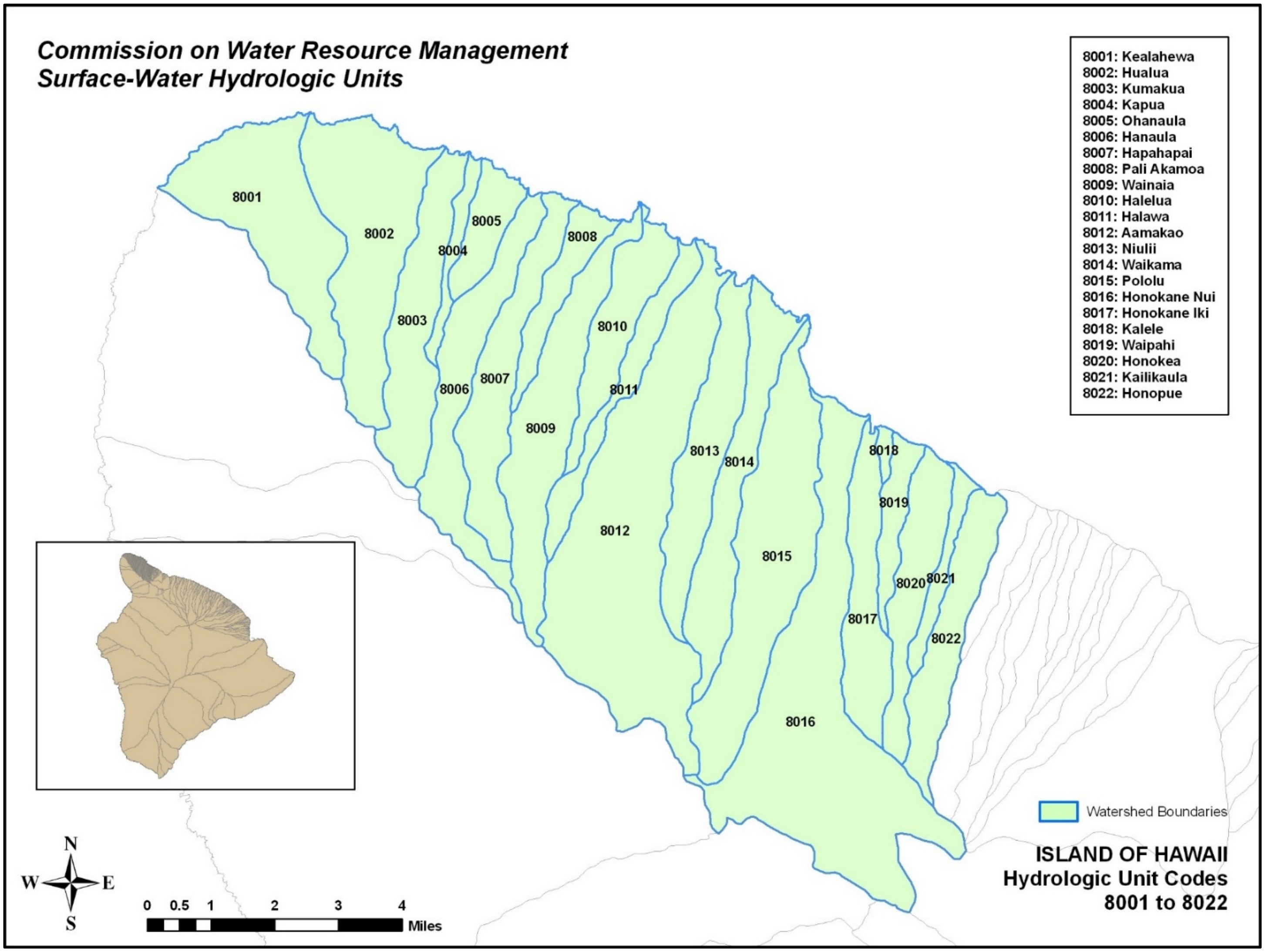


Figure F-30B Hawai‘i Surface Water Hydrologic Units, Unit Codes 8023 to 8042

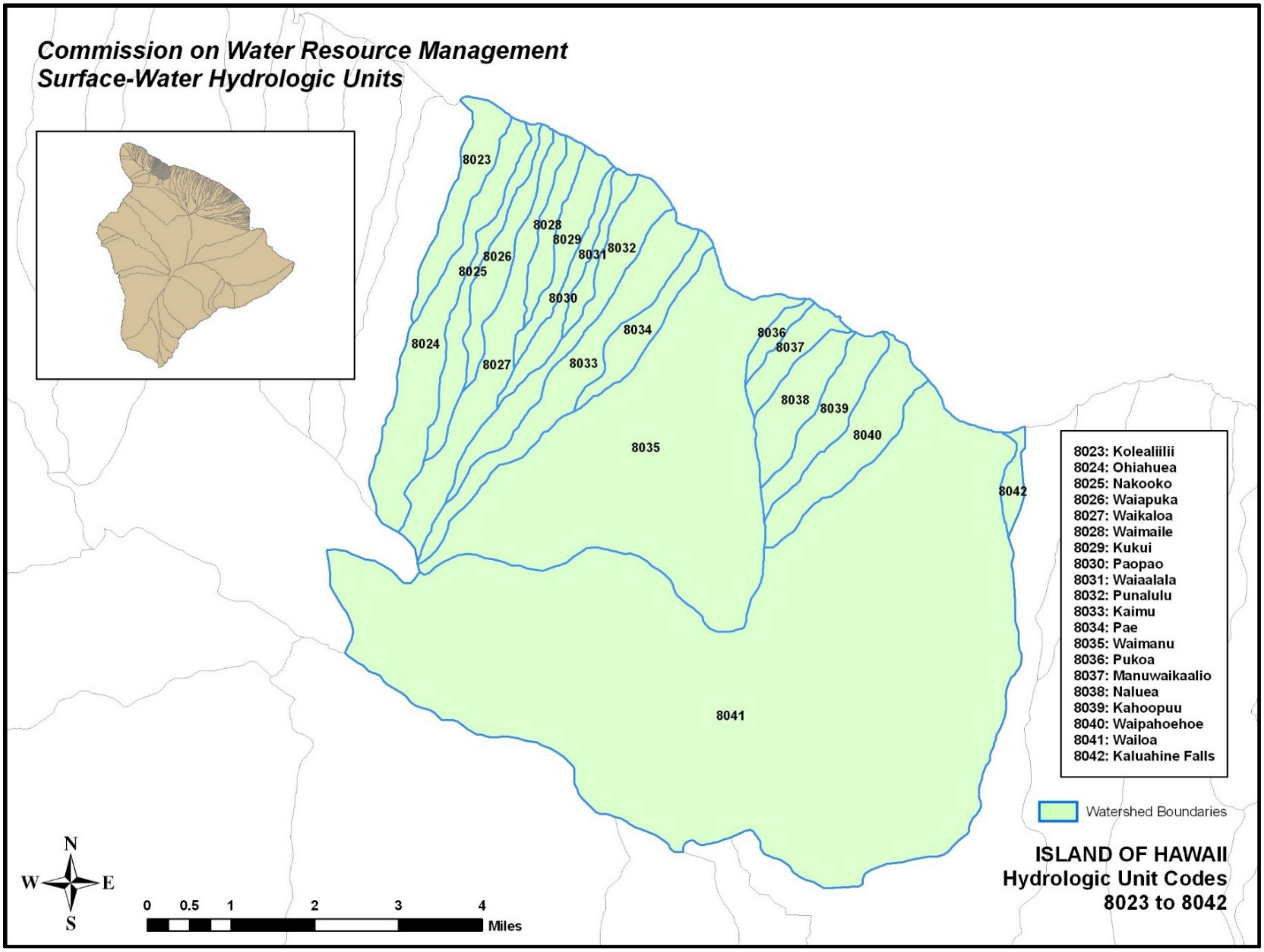


Figure F-30C Hawai‘i Surface Water Hydrologic Units, Unit Codes 8043 to 8066

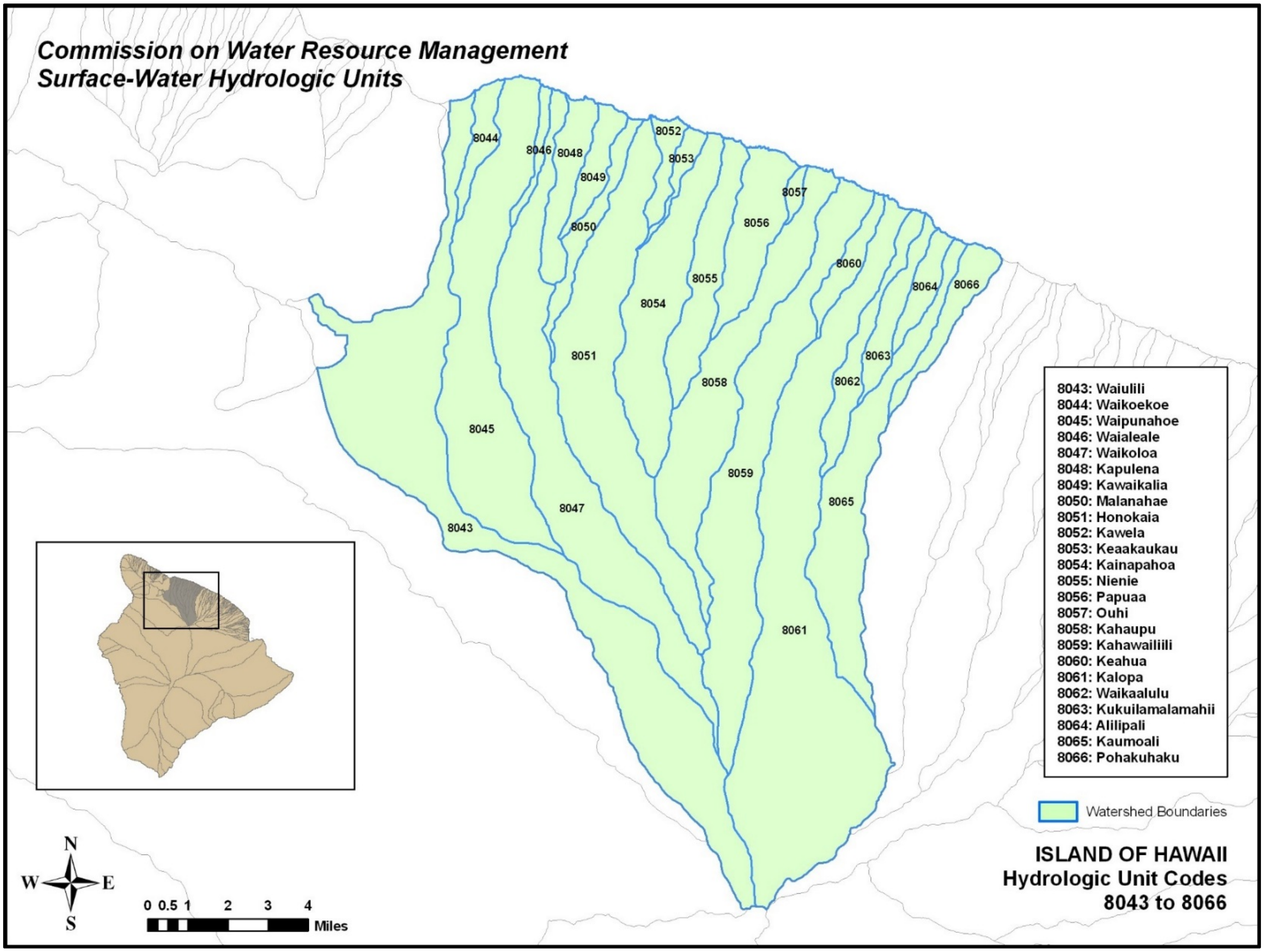


Figure F-30D Hawai‘i Surface Water Hydrologic Units, Unit Codes 8067 to 8083

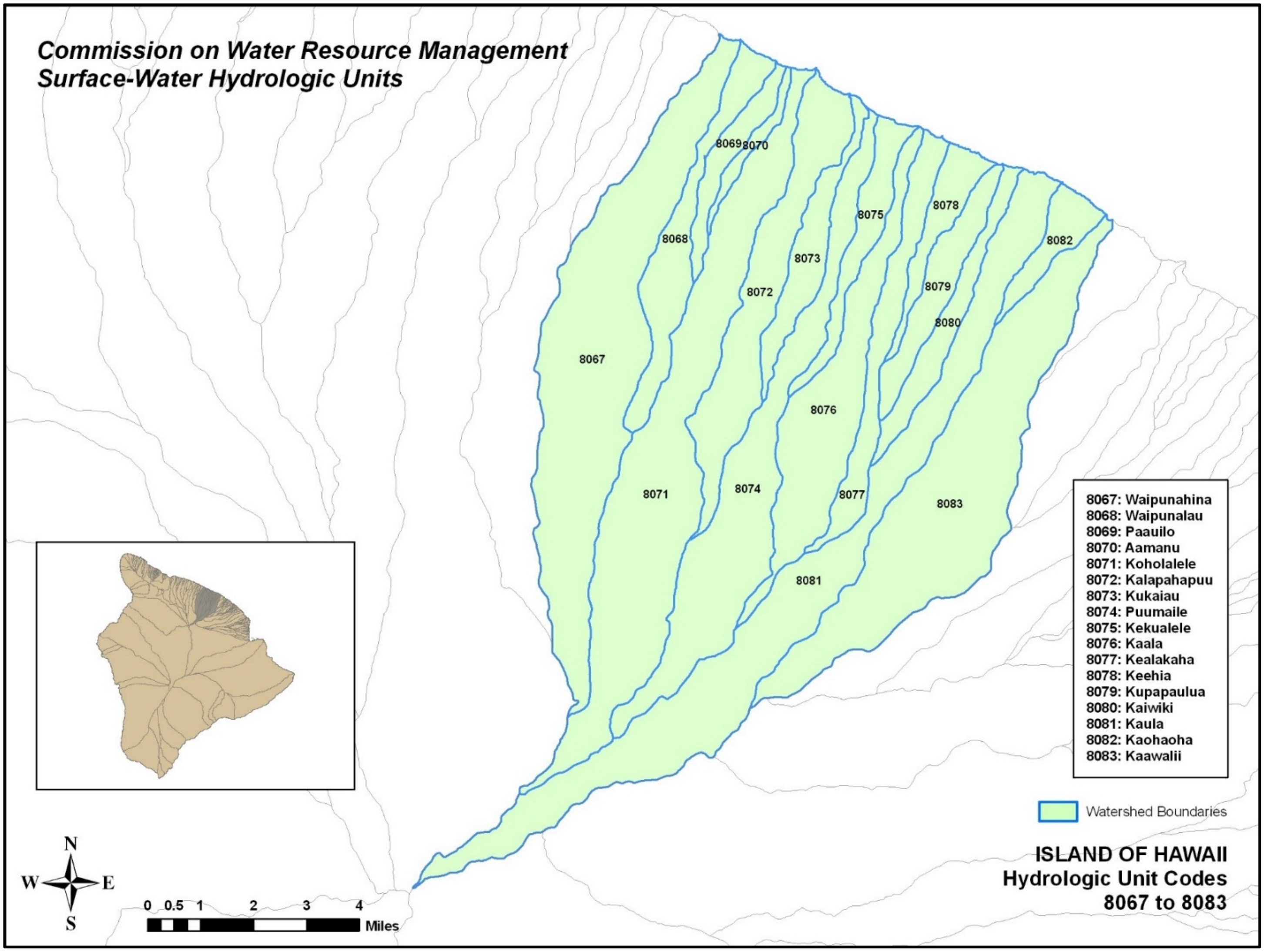


Figure F-30E Hawai‘i Surface Water Hydrologic Units, Unit Codes 8084 to 8107

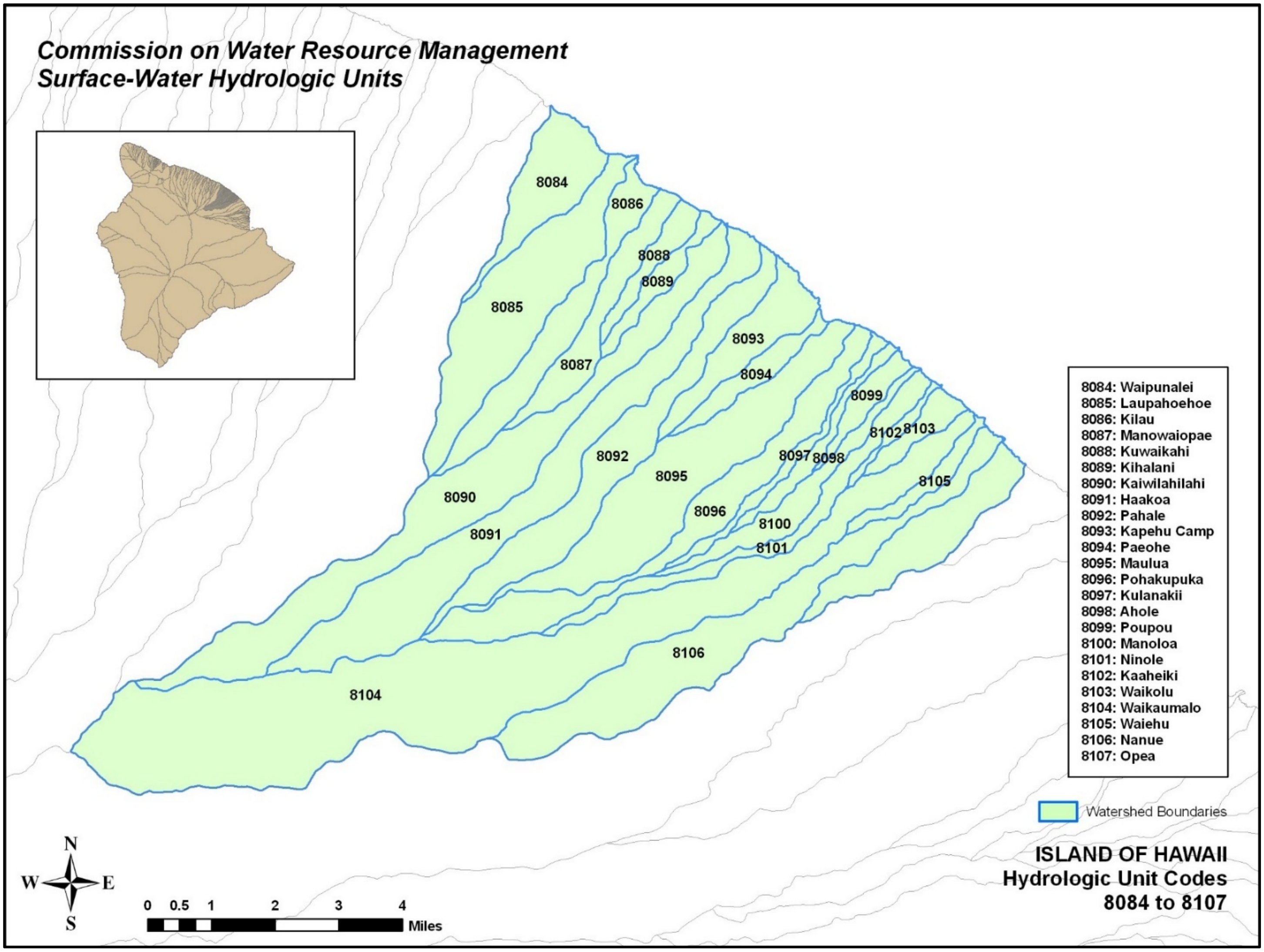


Figure F-30F Hawai'i Surface Water Hydrologic Units, Unit Codes 8108 to 8113

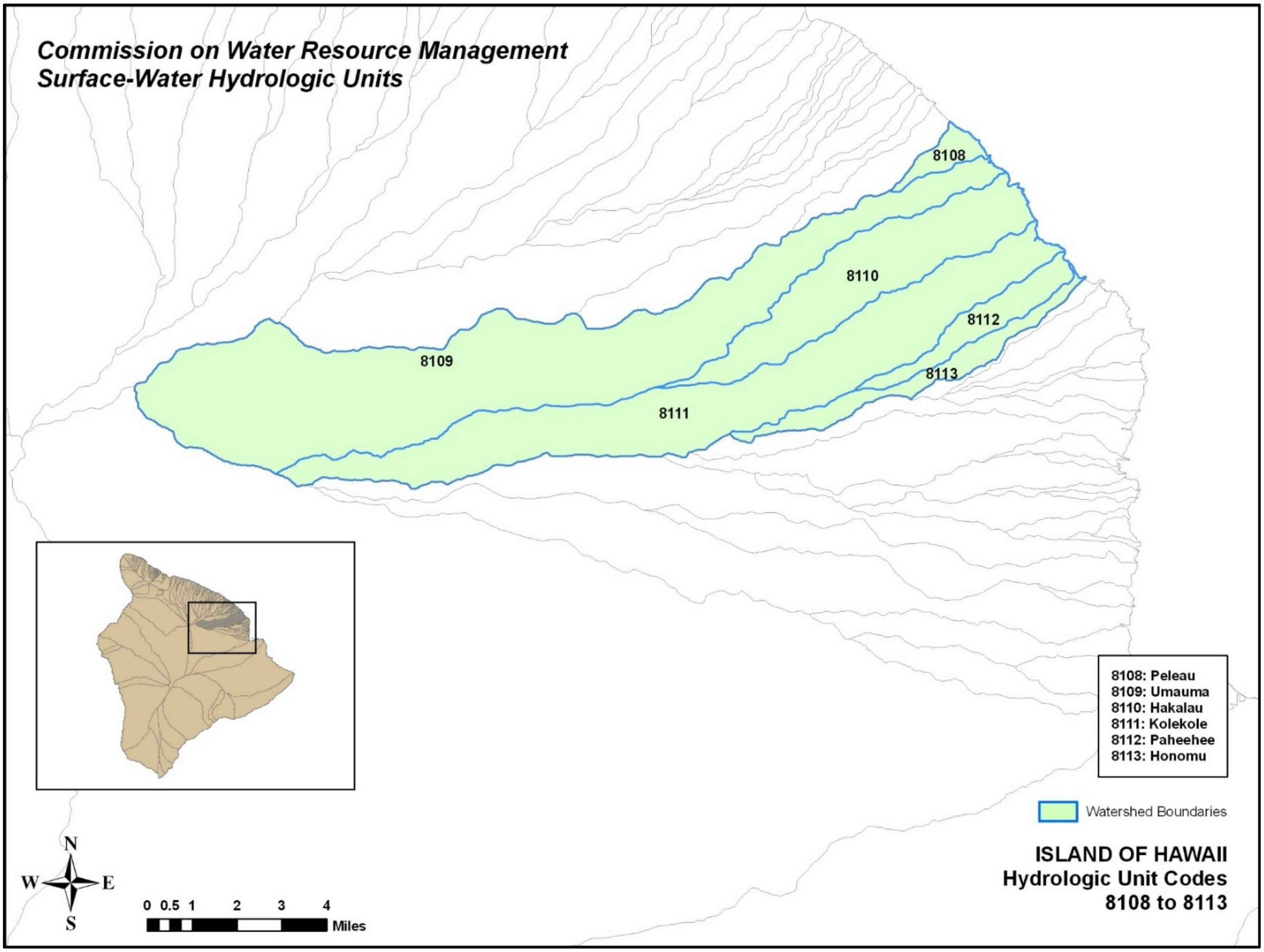


Figure F-30G Hawai‘i Surface Water Hydrologic Units, Unit Codes 8114 to 8137

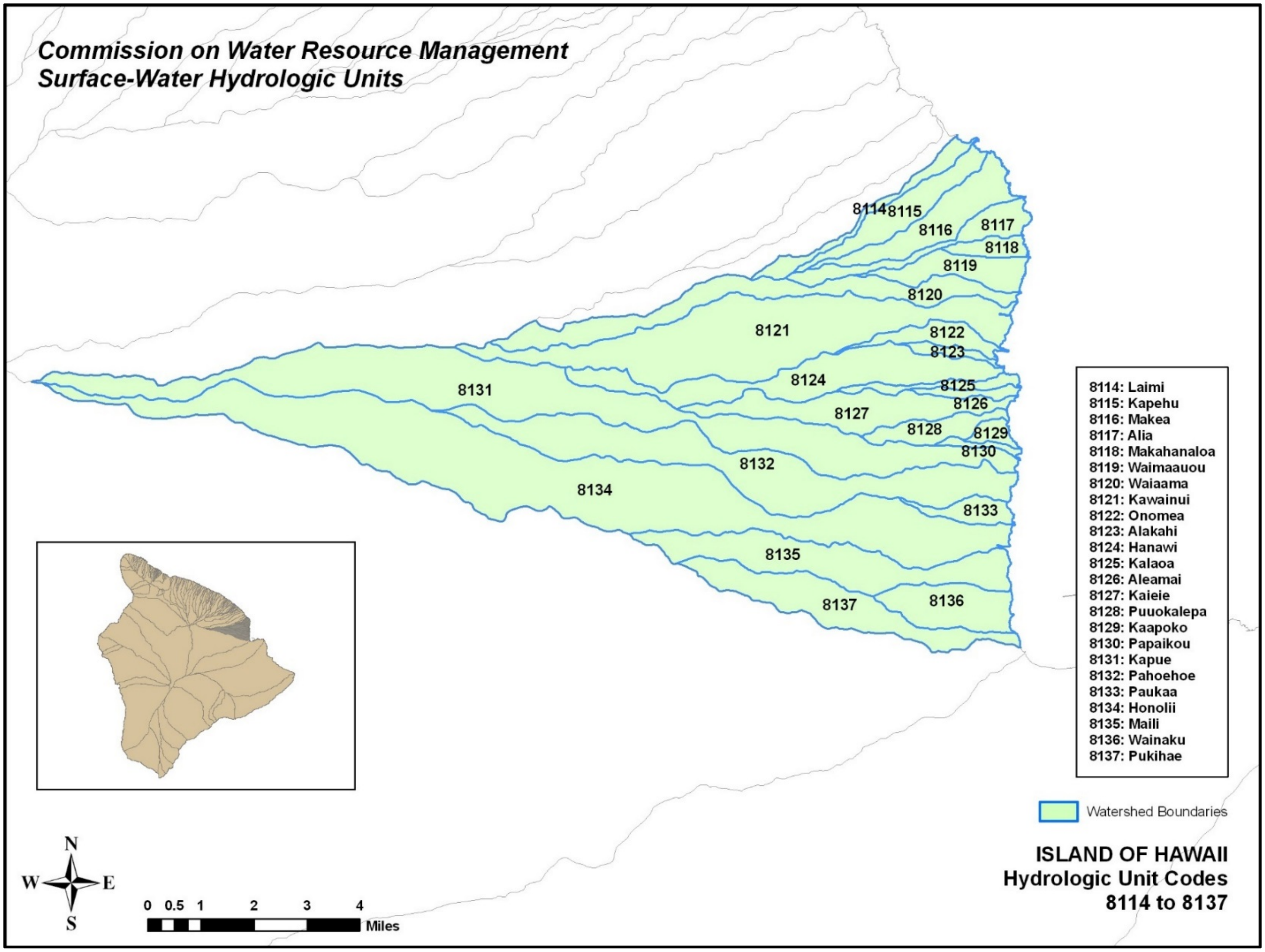


Figure F-30H Hawai‘i Surface Water Hydrologic Units, Unit Codes 8138 to 8147

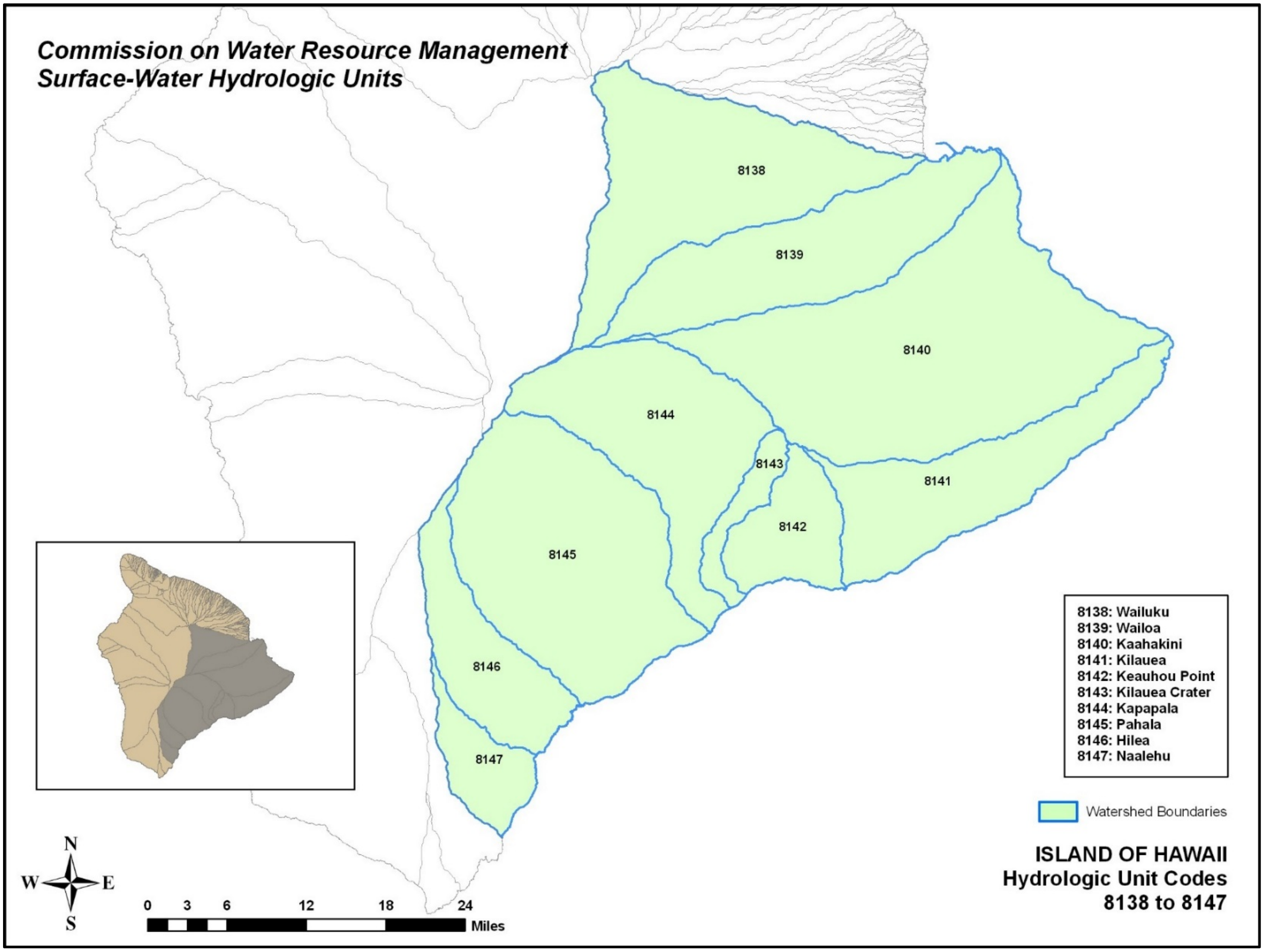


Figure F-30I Hawai‘i Surface Water Hydrologic Units, Unit Codes 8148 to 8157

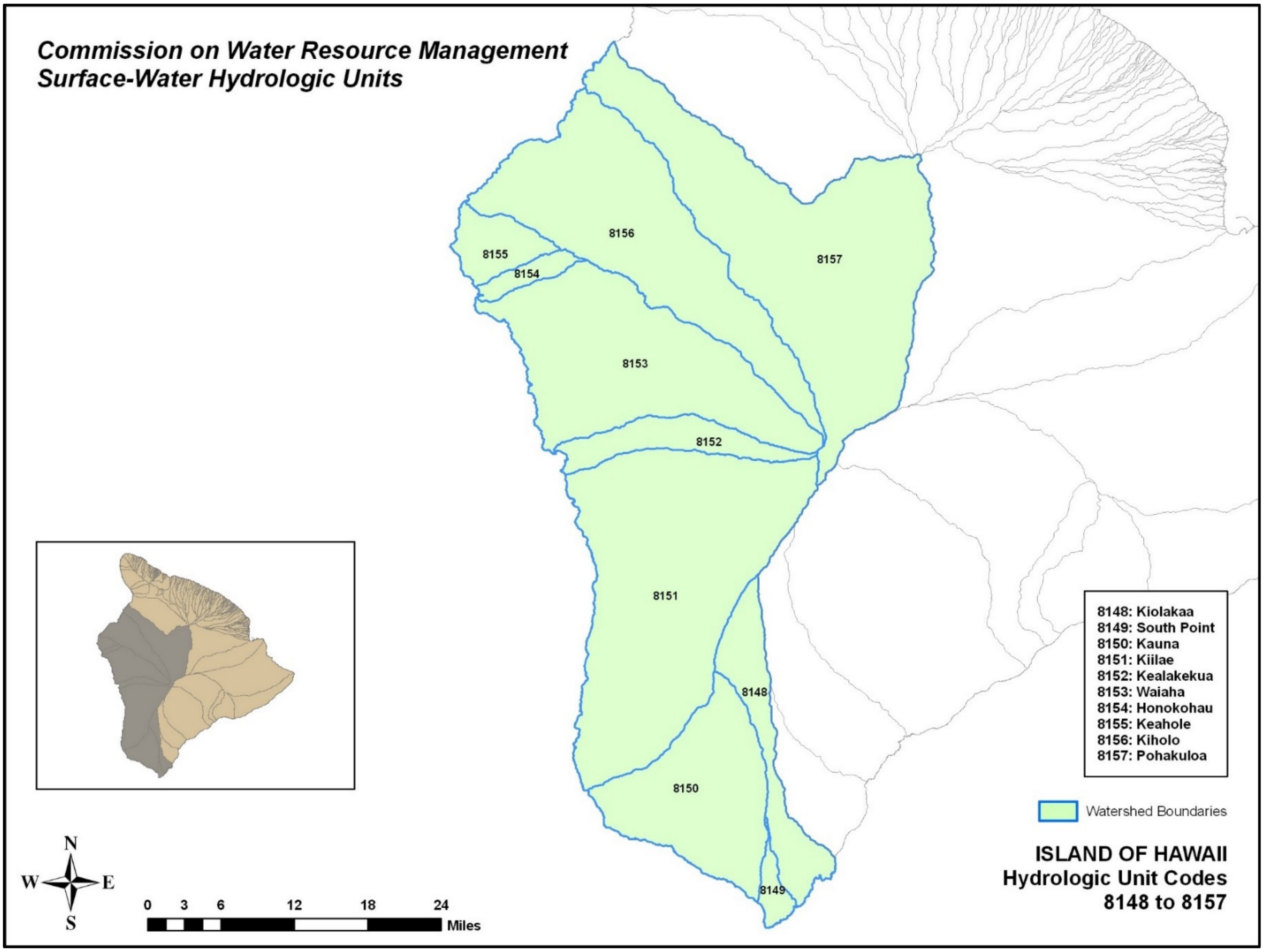
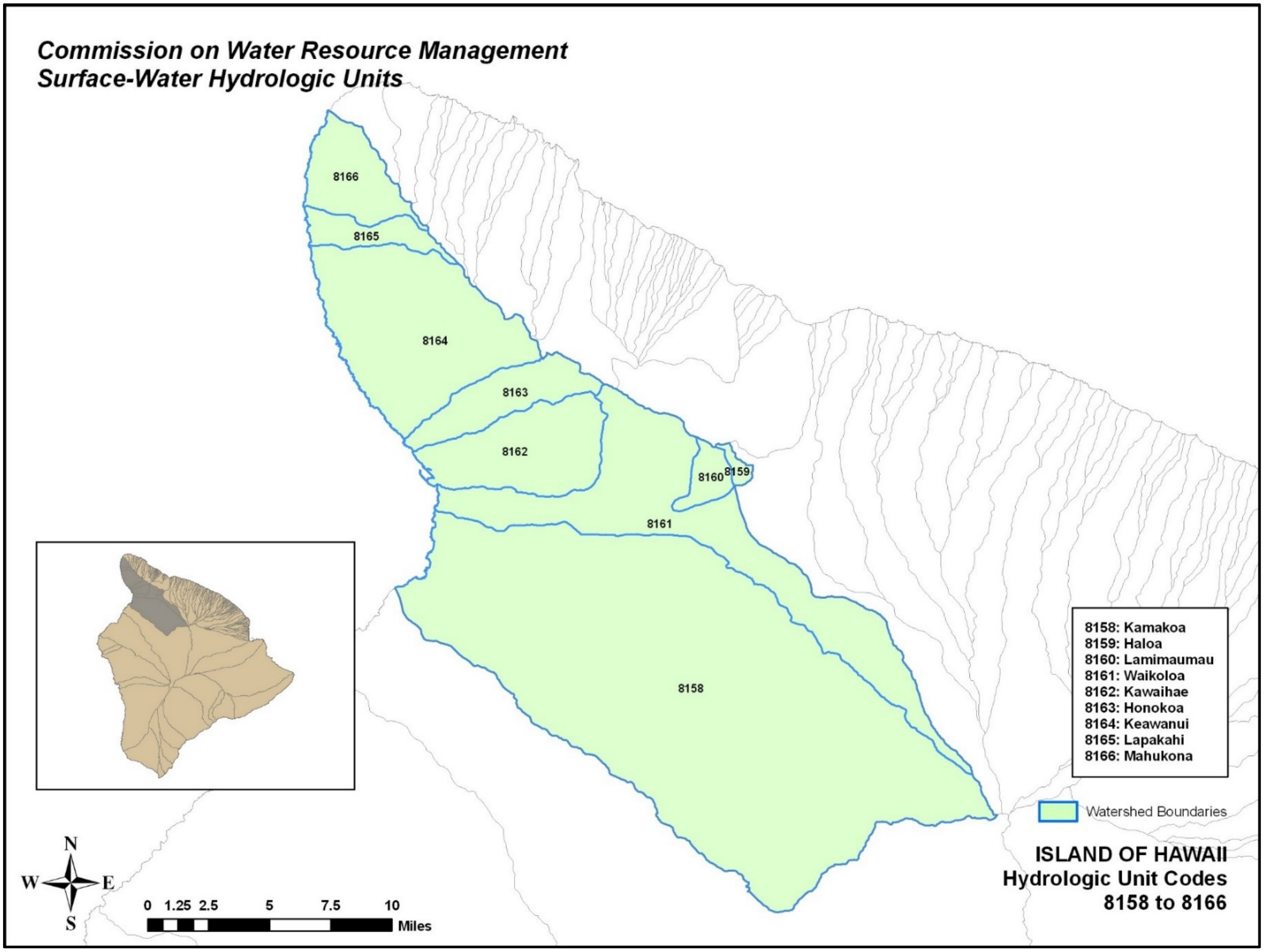


Figure F-30J Hawai‘i Surface Water Hydrologic Units, Unit Codes 8158 to 8166



F.5.3 Determining the Availability of Surface Water Resources: Assessing Instream Flow Standards

Unlike ground water resources that occur in subsurface aquifers, surface water resources are readily observed and measured. Scientists can rely on large amounts of field data and direct measurements, rather than assumptions based on interpolation and modeling tools. Field measurements can provide reliable information on streamflow and spring discharge, effectively indicating how much water is present in surface water settings. However, it is a different exercise to determine the amount of surface water available for human use and consumption. Determining the availability of surface water resources requires the evaluation of environmental, social, cultural, and economic considerations as indicated by the State Water Code. The following sections provide an overview of the factors that must be addressed in the establishment of instream flow standards and the data available for review. For a diagram of the regulatory process for setting instream flow standards, see **Appendix D CWRM Permit Process Diagrams**.

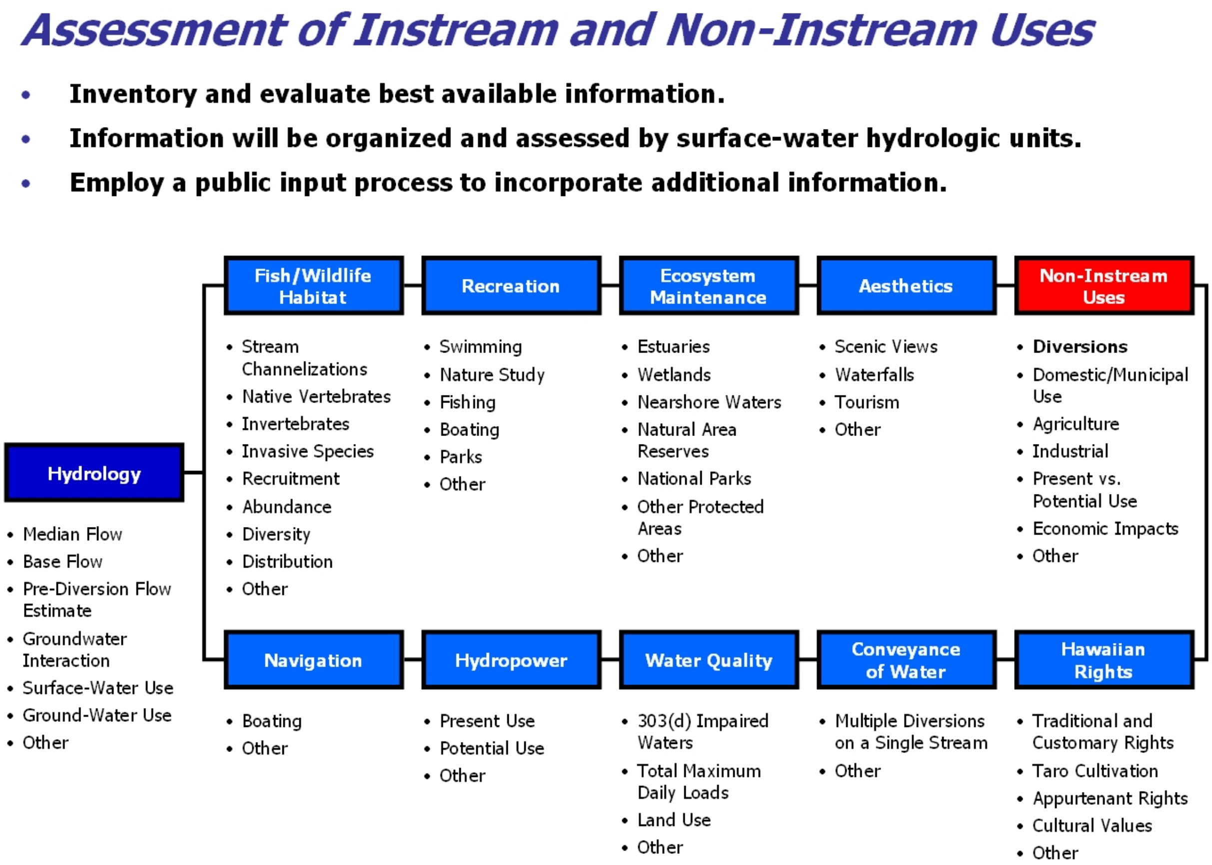
F.5.3.1 Assessing Instream Flow Standards

Instream flow standards are defined by the State Water Code as "*a quantity or flow of water or depth of water which is required to be present at a specific location in a stream system at certain specified times of the year to protect fishery, wildlife, recreational, aesthetic, scenic, and other beneficial instream uses*." However, the State Water Code also prescribes that "*in formulating the proposed standard, the commission shall weigh the importance of the present or potential uses of water from the stream for noninstream purposes, including the economic impact of restriction of such use*." CWRM has developed a methodology for establishing measurable instream flow standards based upon best available information, along with input from interested parties and agencies.

The sections below describe the types of information, based on the State Water Code's definition of instream use, to be evaluated in establishing instream flow standards. In addition, instream flow standards must address water for public trust purposes (see **Appendix C Legal Authorities and Guidance** for a discussion of the Public Trust Doctrine and public trust purposes). **Figure** F-31 provides a conceptual illustration of information categories that should inform instream flow standard assessments.

Maintenance of Fish and Wildlife Habitats: A stream's ability to provide for fish and wildlife habitat is largely dependent upon the condition of the stream bed and/or stream banks. A stream in its natural, unaltered condition tends to have a higher potential for ensuring the survival of native stream animals. Streams that are highly altered, with features such as embankments, hardened channels, realignments, and culverts, have a tendency to inhibit the recruitment and viability of native species. Channelizations and, conversely, the integrity of stream channels are major factors in defining faunal habitat.

Figure F-31 Conceptual illustration of information that should be considered in assessments of instream flow standards and in the evaluation of instream and non-instream uses.



Stream channelization projects are generally implemented to reduce flood risk, drain low-lying areas, mitigate erosion, and provide road crossings or other construction. The effect is an increase in developable land area. Channelization can result in the loss of habitat for marine, aquatic and riparian species. Other negative impacts may include reduced recreational opportunities, loss of view planes and aesthetic resources, and reduced ground water recharge.

Hawaiian streams support a relatively small number of native aquatic fauna, including freshwater fish, mollusks, crustaceans, and insects. A number of these native stream animals have a life cycle involving both the stream and the ocean. This type of life history, in which an animal lives its entire adult life in freshwater and its early larval period in the ocean, is called amphidromy.

Although the habitat requirements of native stream animals are not fully understood, it is widely accepted that some native species utilize the entire stream in their life history. Stream connectivity with nearshore waters is important for recruitment of amphidromous organisms. Another consideration is the prevalence of non-native species that compete for food and habitat any may prey upon native species. Habitat requirements of native stream animals generally include clear, well-oxygenated stream water that flows over cobble and gravel. Some native fishes are clearly adapted to life in turbulent streams with modified (fused) ventral fins that function as suction disks. These organisms can climb waterfalls and colonize stream reaches inaccessible to other fishes.

In addition to native stream fauna, waterbirds such as stilts, coots, and the native duck Koloa, rely upon stream systems for breeding, nesting, and feeding. Aquatic stream fauna provide a supply of food, while natural riparian areas present quality nesting and breeding habitats.

The HSA includes an assessment of biological and riparian resources for perennial streams statewide, including an inventory of channelizations statewide. Recent work by the DLNR Division of Aquatic Resources provides an updated and improved database of information on biological resources statewide. Other sources of habitat information include the DLNR Division of Forestry and Wildlife, the U.S. Fish and Wildlife Service, and other studies conducted for specific streams. CWRM is also developing a comprehensive statewide database of stream channel activities (i.e., stream channel alteration permits, requests for determination, complaints, etc.). Information from the database may provide additional insight as to stream habitat availability.

Outdoor Recreational Activities: Water-related recreation is a part of everyday life in Hawaiʻi, and though beaches clearly attract more users, many local residents grew up recreating in backyard streams. Certain recreational water activities, such as fishing, swimming, boating, and nature study, are relatively limited in Hawaiʻi due to the short, narrow, and shallow nature of typical Hawaiʻi streams in comparison to continental streams and rivers. Although not directly dependent upon streamflow, other land-based recreational activities, such as hiking, camping, and hunting, are enhanced by streams that provide added value to the experience.

A state Recreational Resources Committee was formed as part of the Hawaiʻi Stream Assessment to design a recreation inventory and assessment that identified various opportunities related to specific streams. Regional committees were established on each island. Committees were tasked with compiling an inventory for their respective island. The regional committees ranked each stream using a modified U.S. Forest Service Recreation Opportunity Spectrum, based on factors such as diversity of experiences, quality of experiences, specific unique characteristics, and unique combinations of attributes. This assessment provides an excellent starting point for assessing streamflow requirements for outdoor recreational activities.

Maintenance of Estuarine, Wetland, and Stream Ecosystems: The maintenance of estuarine, wetland, and stream vegetation are directly dependent upon streamflow. These areas provide important riparian habitats for many species, often serving as nursery areas. Although relatively few studies have been conducted on the function of estuaries within the larger ecosystem, it is widely believed that estuaries play a vital role in the recruitment of native stream macrofauna and the development of fish species in the nearshore waters. For example, one study indicates that increases in salinity resulting from a reduction of freshwater to the estuary could affect the juvenile development of two native fish species. [43] In general, estuaries are regarded as some of the most ecologically productive areas in the world, primarily attributed to two general phenomena; 1) the continual movement of water, and 2) the trapping of nutrients. Tidal influences, salinity gradients, freshwater discharge, runoff, and winds, all contribute to water movement, while nutrients are washed into the estuary from the entire watershed and metabolic wastes are removed. The movement of nutrients throughout the entire estuarine system is critical to sustain both plants and animals.

There are various types of wetland classifications, not all of which are directly related to streamflow. However, it is widely accepted that wetlands are valuable because they perform multiple ecosystem functions. Wetlands encourage ground water recharge, provide flood water storage, offer biological habitat, and promote the cycling, storage, and removal of nutrients. In Hawaiʻi, many wetlands have been drained and converted to agricultural or urban land uses. It is increasingly important to protect remaining wetland areas.

The HSA briefly addresses wetlands, however, there are few studies of estuaries, wetlands, and stream vegetation in relation to instream uses. In recent years, awareness of the importance of estuaries and wetlands to the greater ecosystem has been emphasized. The DLNR Division of Aquatic Resources plans to expand its biological assessments into estuaries and study the recruitment patterns of native stream fishes, the function of estuaries as fishery nurseries, and energy flows within estuaries.

Aesthetic Values such as Waterfalls and Scenic Waterways: The relationship between streamflow and aesthetic value cannot be determined in quantitative or absolute terms. Aesthetic value depends on the perception of multi-sensory experiences that vary between individuals. Despite the qualitative nature of aesthetics, the HSA attempts to address scenic views as part of its recreational resource assessment, considering view planes from roads, trails, and the ocean. Additional studies would need to be conducted and other resources should be examined to further assess the present and potential streamflow requirements to support aesthetic values.

[43] Englund, R. 1998, Biological assessment and the effects of water withdrawls on Waikele Stream, Oahu, Aquatic biota, Report prepared for Belt-Collins Hawaii, 31 p.

Navigation: There are few navigable streams in Hawai‘i. Streams tend to be short, narrow, and shallow. Only a few areas have developed estuaries where recreational boating is possible. Even fewer streams are actually used for commercial boating operations. The HSA addresses boating as part of its recreational resource assessment but does not differentiate between recreational and commercial use. Additional studies should be conducted, and other resources should be examined to further assess the present and potential uses of streams for navigation and boating.

Instream Hydropower Generation: Hydroelectricity is typically generated by instream dams and power generators, but the nature of Hawai‘i streams requires a different hydropower plant design whereby surface water is usually diverted to an offstream power plant. Generally, water is diverted through ditches, pipes and penstocks to the power plant, then returned to the stream. Hydropower plants may take advantage of changes in elevation to generate power; energy is recovered from the change in head and diverted water is subsequently applied to irrigate agricultural fields at lower elevations. When the HSA was conducted, 18 hydroelectric power plants were identified (seven on Kauai, four on Maui, and seven on Hawai‘i). At the time, hydroelectricity accounted for roughly 1.5% of the state’s total electrical energy consumption.

In 1981, the State Department of Planning and Economic Development (now Department of Business, Economic Development and Tourism [DBEDT]), published *Hydrolectric Power in Hawaii: A Reconnaissance Survey*, in conjunction with the U.S. Department of Energy. The purpose of the survey was to assess potential sources of hydroelectric power, in consideration of various parameters such as storage, utilization of irrigation systems and reservoirs, upgrading of existing facilities, and construction of new power plants. Although the appeal of hydropower has since declined, renewed interest may be spurred by the desire to reduce Hawai‘i’s dependence on oil, provided environmental considerations can be satisfied.

Maintenance of Water Quality: Water quality is an essential part of any evaluation of water requirements for health, safety and habitat protection. Information on surface water quality has been collected in Hawai‘i since the 1960’s, however most agencies collect water quality data to meet specific short-term goals that are usually problem-oriented. The results of water quality monitoring are often used to assess mitigation actions and improve management practices. Though surface water monitoring at instream locations is ideal, testing of nearshore waters may also provide information about the quality of contributing surface water flows. Water quality parameters range widely, but can generally be grouped into the four categories listed below:

- **Physical characteristics** include temperature, specific conductance, turbidity, color, odor, pH, and suspended solids.

- **Biological characteristics** include bacteria (fecal coliform and fecal **streptococcus**), phytoplankton, zooplankton, periphyton, and macroinvertebrates.

- **Chemical characteristics** include total dissolved solids, major ions, hardness, silica, phosphorus species, nitrogen species, detergents, other minor elements, radiochemical species, organic species, pesticide species, biochemical oxygen demand, chemical oxygen demand, dissolved oxygen, and other dissolved gasses.

- **Sediment characteristics** include suspended sediment concentration, suspended sediment discharge, bed load, total concentration, and particle size and distribution.

The two primary sources of surface water quality information are the USGS and the DOH. The USGS has collected basic water quality information at stream gaging stations since 1967 as part of a nationwide program. More detailed water quality parameters are collected at certain sites for specific programs (e.g., National Stream Quality Accounting Network, National Water Quality Assessment) and projects. The DOH is responsible for monitoring the quality of water used for consumptive or recreational purposes and has varying standards for acceptable levels of contaminants, depending on the use. County water departments are another source of water quality information, as these agencies cooperate with DOH to monitor drinking water. Water quality data, both general and site-specific, may also be found in studies and reports that have been completed for particular projects.

The Conveyance of Irrigation and Domestic Water Supplies to Downstream Points of Diversion: To ensure the availability of steam water for irrigation and domestic use in downstream areas, upstream diversions must allow the bypass of sufficient water supplies and the stream channel must be protected to allow for unimpeded flow downstream. The State Water Code provides for the regulation stream diversions and alterations through a permitting system. In addition, CWRM has jurisdiction statewide to hear and render decisions on any dispute regarding water resource protection, water permits, constitutionally protected water interests, or insufficient water supply to meet competing needs.

CWRM is in the process of developing a comprehensive database to manage surface water resources statewide, which will include all registered and permitted surface water diversions, permitted stream channel alterations, complaints, and requests for determination of permitting requirements. A project to verify and characterize all registered surface water diversions is also being executed by CWRM to provide updated information on diversion structures, water uses, and basic stream conditions. Additional information related to stream channel conditions can be obtained through the various regulatory agencies that have jurisdiction related to stream channel alteration. Example of such agencies include the U.S. Army Corps of Engineers, the DOH’s Environmental Management Division, DBEDT’s Coastal Zone Management Program, and county planning and/or permitting departments.

The Protection of Traditional and Customary Hawaiian Rights: With regard to surface water resources, the State Water Code provides for the protection of traditional and customary rights including, but not limited to, the cultivation or propagation of taro and the gathering of hihiwai, opae, and oopu for subsistence, cultural, and religious purposes. This State Water Code also protects appurtenant water rights (see **Appendix C Legal Authorities and Guidance** for a discussion of water rights and uses in Hawai‘i).

The process for claiming and proving an appurtenant water right is the responsibility of the landowner and can be arduous, however, the State Water Code also assures that appurtenant rights shall not be diminished or extinguished by a failure to apply for, or claim, such right. With the exception of Na Wai Eha on the Island of Maui, very few claims for appurtenant rights have been made. Therefore, at this time, it is difficult to quantify the amount of water required to satisfy all appurtenant rights for a given area or hydrologic unit. Regardless, if an appurtenant right is established, it is CWRM's responsibility to assure that an appropriate volume of water is afforded to the claimant.

One method for assessing the protection of traditional and customary Hawaiian rights is to evaluate incidental sources of information, such as taro cultivation and various other cultural resources and studies. The HSA provides an initial assessment of cultural resources in relation to the stream valley, considering the extent of archaeological survey coverage, the ability to predict what historic sites might be in unsurveyed areas, the actual number of known historic sites, the overall significance of the valley, the density and significance of historic sites, and the overall sensitivity of the valley.

The HSA Cultural Resources Committee identified a number of factors important to current Hawaiian cultural practices: current taro cultivation, the potential for taro cultivation, appurtenant rights, subsistence gathering areas, and stream-related hydrology. Though the committee felt that these items should be included in the assessment, information was limited at the time such that only current taro cultivation could be assessed. Various other cultural studies and surveys are available for specific regions and may provide additional information with respect to present and potential surface water requirements.

F.5.3.2 Recommendations for Assessing Instream Flow Standards

Considerably more research and study should be completed to accumulate the data and perspective necessary to conduct a thorough and meaningful assessment of instream flow standards. While some of the information categories described above are partially addressed through existing federal, State, and county programs, other categories remain virtually unexplored. In many respects, CWRM's ability to assess instream flow standards are dependent upon policy and program direction, funding availability, and staffing requirements. However, CWRM recognizes that the information in the HSA should be updated, expanded, and interpreted in light of developing case law. Notwithstanding the requirements of CWRM's process for adopting interim instream flow standards, the following actions are recommended.

- Develop, fund, and conduct cultural resource studies or surveys in priority areas;
- Fund and complete an inventory of stream channel alterations; and
- Continue to coordinate with the USGS to fund and execute stream studies and share surface water information.

F.5.4 Inventory of Surface Water Resources and Interim IFS

Table F-21 lists the surface water hydrologic units by island according to hydrologic unit code. Key characteristics of each hydrologic unit are listed, including the total area (in square miles), the number of registered and/or permitted stream diversions, and the number of historic and currently active continuous USGS and CWRM gages within the unit. The final column indicates the current interim IFS. In most cases, the current interim IFS were established pursuant to amendments to HAR §13-169, as noted here.

- Interim Instream Flow Standard for East Maui, HAR §13-169-44
  Date of Adoption: 6/15/1988
  Effective Date: 10/8/1988
- Interim Instream Flow Standard for Kauaʻi, HAR §13-169-45
  Date of Adoption: 6/15/1988
  Effective Date: 10/8/1988
- Interim Instream Flow Standard for Hawaiʻi, HAR §13-169-46
  Date of Adoption: 6/15/1988
  Effective Date: 10/8/1988
- Interim Instream Flow Standard for Molokaʻi, HAR §13-169-47
  Date of Adoption: 6/15/1988
  Effective Date: 10/8/1988
- Interim Instream Flow Standard for West Maui, HAR §13-169-48
  Date of Adoption: 10/19/1988
  Effective Date: 12/10/1988
- Interim Instream Flow Standard for Leeward Oʻahu, HAR §13-169-49
  Date of Adoption: 10/19/1988
  Effective Date: 12/10/1988

- Interim Instream Flow Standard for Windward Oʻahu, HAR §13-169-49.1
  Date of Adoption: 4/19/1989
  Effective Date: 5/4/1992

Generally, the interim IFS for all streams in a given region were adopted by CWRM and defined as the "amount of water flowing in each stream on the effective date of this standard, and as that flow may naturally vary throughout the year and from year to year without further amounts of water being diverted offstream through new or expanded diversions." The interim IFS of individual streams have subsequently been amended as a direct result of petitions to amend the instream flow standards, contested case hearings, or other regulatory actions. References to specific actions amending the interim instream flow standard of specific streams are also provided in the last column of **Table F-21 Inventory of Surface Water Resources**. For further clarification, refer to HAR §13-169. For a discussion of the regulatory process for setting IFS, see **Appendix I CWRM Regulatory Programs**.

Table F-21 Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi^2)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
KAUAI						
2001	Awaʻawapuhi	1.29	0	0	0/0	HAR §13-169-45
2002	Honopū	1.74	0	0	0/0	HAR §13-169-45
2003	Nakeikionaiwi	0.49	0	0	0/0	HAR §13-169-45
2004	Kalalau	4.23	0	1	0/0	HAR §13-169-45
2005	Pōhakuao	0.58	0	0	0/0	HAR §13-169-45
2006	Waiolaa	0.36	0	0	0/0	HAR §13-169-45
2007	Hanakoa	2.01	0	1	0/0	HAR §13-169-45
2008	Waiahuakua	0.66	0	0	0/0	HAR §13-169-45
2009	Hoʻolulu	0.38	0	0	0/0	HAR §13-169-45
2010	Hanakāpīʻai	3.76	0	1	0/0	HAR §13-169-45
2011	Maunapuluo	0.45	0	0	0/0	HAR §13-169-45
2012	Limahuli	1.92	7	1	0/0	HAR §13-169-45. Amended to include SCAP KA-155 on Limahuli Stream for diversion of 0.115 MGD for landscape irrigation (07/19/1995).
2013	Mānoa	1.04	1	0	0/0	HAR §13-169-45
2014	Wainiha	23.71	29	3	1/0	HAR §13-169-45
2015	Lumahaʻi	14.44	0	1	0/0	HAR §13-169-45. Amended to include SDWP.3936.2 for diversion of 0.54 MGD
2016	Waikoko	0.69	0	0	0/0	HAR §13-169-45

Table F-21 (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi²)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
KAUAI (continued)						
2017	Waipā	2.52	2	0	0/0	HAR §13-169-45
2018	Waiʻoli	5.48	1	1	0/0	HAR §13-169-45
2019	Hanalei	23.96	10	3	1/0	HAR §13-169-45
2020	Waileia	0.82	0	0	0/0	HAR §13-169-45
2021	ʻAnini	3.20	4	0	0/0	HAR §13-169-45
2022	Kalihikai West	0.30	0	0	0/0	HAR §13-169-45
2023	Kalihikai Center	0.24	0	0	0/0	HAR §13-169-45
2024	Kalihikai East	0.49	0	0	0/0	HAR §13-169-45
2025	Kalihiwai	11.36	6	2	0/0	HAR §13-169-45. Amended to include SCAP KA-060 on Pake Stream for diversion of 0.028 MGD for aquaculture (10/18/1989).
2026	Puʻukumu	1.28	3		0/0	HAR §13-169-45
2027	Kauapea	1.05	0	0	0/0	HAR §13-169-45
2028	Kīlauea	12.87	9	3	1/0	HAR §13-169-45
2029	Kulihaili	1.10	0	0	0/0	HAR §13-169-45
2030	Pilaʻa	2.58	4	0	0/0	HAR §13-169-45
2031	Waipake	2.46	1	0	0/0	HAR §13-169-45
2032	Moloaa	3.67	7	0	0/0	HAR §13-169-45
2033	Pāpaʻa	4.41	5	0	0/0	HAR §13-169-45
2034	Aliomanu	1.64	0	0	0/0	HAR §13-169-45
2035	Anahola	13.86	6	3	0/0	HAR §13-169-45
2036	Kumukumu	1.21	0	0	0/0	HAR §13-169-45
2037	Kapaʻa	16.74	13	2	0/0	HAR §13-169-45
2038	Moikeha	2.26	1	0	0/0	HAR §13-169-45
2039	Waikaea	7.13	2	5	0/0	HAR §13-169-45. Amended to include SCAP KA-396 on Waikaea and Konohiki Streams for streams are impacted by a pumped well (07/12/2006).
2040	Wailua	53.34	30	7	3/1	HAR §13-169-45

Table F-21 (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi2)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
KAUAI (continued)						
2041	Kawailoa	3.94	0	0	0/0	HAR §13-169-45
2042	Hanamāʻulu	11.65	4	1	0/0	HAR §13-169-45
2043	Līhuʻe Airport	1.83	0	0	0/0	HAR §13-169-45
2044	Nāwiliwili	6.40	3	0	0/0	HAR §13-169-45
2045	Puali	2.05	6	0	0/0	HAR §13-169-45
2046	Huleia	28.32	26	5	0/0	HAR §13-169-45
2047	Kipu Kai	3.04	1	0	0/0	HAR §13-169-45
2048	Mahaulepu	13.43	6	0	0/0	HAR §13-169-45
2049	Waikomo	9.12	11	0	0/0	HAR §13-169-45
2050	Aepo	2.58	5	0	0/0	HAR §13-169-45
2051	Lāwaʻi	9.73	11	2	0/0	HAR §13-169-45
2052	Kalāheo	6.56	9	0	0/0	HAR §13-169-45
2053	Wahiawa	7.34	1	0	0/0	HAR §13-169-45
2054	Hanapēpē	27.09	9	4	1/0	HAR §13-169-45
2055	Kukamahu	3.21	0	0	0/0	HAR §13-169-45
2056	Kaumakani	3.09	0	0	0/0	HAR §13-169-45
2057	Mahinauli	8.78	1	0	0/0	HAR §13-169-45
2058	Aʻakukui	5.27	3	0	0/0	HAR §13-169-45
2059	Waipao	9.26	1	0	0/0	HAR §13-169-45
2060	Waimea	86.50	46	15	3/0	Natural flow on Kokee Stream; 0.7 MGD on Kauaikinana Stream below Kokee Ditch; 4.9 MGD on Kawaikoi Stream below Kokee Ditch; 1.4 MGD on Waiakoali Stream below Kokee Ditch; 2.0 MGD on Koaie Stream below Kekaha Ditch; 8.0 MGD on Waimea River below Kekaha Ditch (Waiahulu diversion); 25 MGD at USGS gaging station 16031000 on Waimea River with a minimum flow of 6.0 MGD in the Kekaha Ditch (04/18/2017).
2061	Kapilimao	6.44	1	0	0/0	HAR §13-169-45
2062	Paua	5.10	0	0	0/0	HAR §13-169-45
2063	Hōʻea	16.64	1	0	0/0	HAR §13-169-45
2064	Niu	2.82	0	0	0/0	HAR §13-169-45
2065	Kaʻawaloa	7.50	0	0	0/0	HAR §13-169-45

Table F-21 (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi^2)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
KAUAI (continued)						
2066	Nahomalu	17.63	1	1	0/0	HAR §13-169-45
2067	Ka‘ula‘ula	2.55	0	0	0/0	HAR §13-169-45
2068	Hā‘ele‘ele	2.45	0	0	0/0	HAR §13-169-45
2069	Hikimoe	2.20	0	0	0/0	HAR §13-169-45
2070	Kā‘aweiki	2.15	0	0	0/0	HAR §13-169-45
2071	Kauhao	3.98	1	0	0/0	HAR §13-169-45
2072	Mākaha	2.80	0	0	0/0	HAR §13-169-45
2073	Miloli‘i	4.34	1	0	0/0	HAR §13-169-45
2074	Nu‘alolo	2.83	0	0	0/0	HAR §13-169-45
O‘AHU						
3001	Kālunawaika‘ala	2.30	1	0	0/0	HAR §13-169-49.1
3002	Pākūlena	0.90	0	0	0/0	HAR §13-169-49.1
3003	Paumalū	7.79	1	0	0/0	HAR §13-169-49.1
3004	Kawela	2.07	1	0	0/0	HAR §13-169-49.1
3005	‘Ō‘io	10.74	3	0	0/0	HAR §13-169-49.1
3006	Mālaekahana	7.03	0	3	0/0	HAR §13-169-49.1
3007	Kahawainui	5.49	1	1	0/0	HAR §13-169-49.1
3008	Wailele	2.28	0	1	0/0	HAR §13-169-49.1
3009	Koloa	2.41	1	1	0/0	HAR §13-169-49.1
3010	Kaipapa‘u	3.00	0	1	0/0	HAR §13-169-49.1
3011	Ma‘akua	1.55	1	0	0/0	HAR §13-169-49.1
3012	Waipuhi	1.10	2	0	0/0	HAR §13-169-49.1
3013	Kaluanui	2.37	0	2	1/0	HAR §13-169-49.1
3014	Pāpa‘akoko	0.29	0	0	0/0	HAR §13-169-49.1
3015	Halehaa	0.25	0	0	0/0	HAR §13-169-49.1
3016	Punalu‘u	6.79	9	4	1/0	HAR §13-169-49.1
3017	Kahana	8.42	2	4	1/0	13.3 MGD (07/13/2006).
3018	Makaua	0.83	0	0	0/0	HAR §13-169-49.1
3019	Ka‘a‘awa	2.76	5	0	0/0	HAR §13-169-49.1
3020	Kualoa	0.87	0	0	0/0	HAR §13-169-49.1
3021	Hakipu‘u	2.09	7	1	0/0	HAR §13-169-49.1
3022	Waikāne	2.69	3	2	1/0	3.5 MGD (07/13/2006).
3023	Waianu	1.07	0	0	0/0	HAR §13-169-49.1
3024	Waiāhole	3.99	9	7	1/0	8.7 MGD on Waiahole Stream; 3.5 MGD on Waianu Stream (07/13/2006).
3025	Ka‘alaea	1.78	9	0	0/0	HAR §13-169-49.1
3026	Haiamoa	0.64	9	0	0/0	HAR §13-169-49.1
3027	Kahalu‘u	6.74	23	9	2/0	HAR §13-169-49.1

Table F-21 (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi²)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
O‘AHU (continued)						
3028	He‘eia	4.47	1	3	1/0	HAR §13-169-49.1
3029	Kea‘ahala	1.17	1	0	0/0	HAR §13-169-49.1
3030	Kāne‘ohe	5.73	2	11	1/0	HAR §13-169-49.1
3031	Kawa	2.11	1	1	1/0	HAR §13-169-49.1
3032	Pu‘u Hawai‘iloa	3.68	0	0	0/0	HAR §13-169-49.1
3033	Kawainui	15.05	15	10	2/0	HAR §13-169-49.1
3034	Ka‘elepulu	5.27	0	0	0/0	HAR §13-169-49.1
3035	Waimānalo	5.95	9	1	1/0	HAR §13-169-49.1
3036	Kahawai	4.68	0	0	0/0	HAR §13-169-49.1
3037	Makapu‘u	0.51	0	0	0/0	HAR §13-169-49.1
3038	Koko Crater	3.66	0	0	0/0	HAR §13-169-49
3039	Hanauma	0.39	0	0	0/0	HAR §13-169-49
3040	Portlock	0.74	0	0	0/0	HAR §13-169-49
3041	Kamiloiki	2.39	0	0	0/0	HAR §13-169-49
3042	Kamilonui	2.02	0	0	0/0	HAR §13-169-49
3043	Haha‘ione	2.18	0	0	0/0	HAR §13-169-49
3044	Kuli‘ou‘ou	1.82	0	1	0/0	HAR §13-169-49
3045	Niu	2.70	0	0	0/0	HAR §13-169-49
3046	Wailupe	5.12	0	1	0/0	HAR §13-169-49
3047	Wai‘alaenui	6.03	0	0	0/0	HAR §13-169-49. Amended to include SCAP OA-309 on Kapakahi Stream for restoration of wetland habitat at Pouhala Marsh (06/21/2000).
3048	Diamond Head	0.39	0	0	0/0	HAR §13-169-49
3049	Ala Wai	19.02	16	11	6/1	HAR §13-169-49
3050	Nu‘uanu	9.54	9	3	0/0	HAR §13-169-49
3051	Kapālama	3.38	3	0	0/0	HAR §13-169-49
3052	Kalihi	6.27	1	3	1/0	HAR §13-169-49
3053	Moanalua	10.70	0	3	1/0	HAR §13-169-49
3054	Ke‘ehi	2.49	0	0	0/0	HAR §13-169-49
3055	Manuwai	6.65	0	0	0/0	HAR §13-169-49
3056	Salt Lake	0.62	0	0	0/0	HAR §13-169-49
3057	Hālawa	14.21	1	6	2/0	HAR §13-169-49
3058	‘Aiea	2.06	0	0	0/0	HAR §13-169-49
3059	Kalauao	3.34	0	2	0/0	HAR §13-169-49
3060	Waimalu	12.30	1	2	0/0	HAR §13-169-49

Table F-21: (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi2)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
Oʻ AHU (continued)						
3061	Waiawa	27.47	5	1	0/0	HAR §13-169-49. Amended to include SCAP OA-221 on Panakauahi Stream to address instream uses impacted by an arched culvert (10/22/1997).
3062	Waipiʻo	2.81	0	0	0/0	HAR §13-169-49
3063	Kapakahi	3.45	3	0	0/0	HAR §13-169-49
3064	Waikele	48.92	13	4	1/0	HAR §13-169-49. Amended to include SCAP OA-046 on Waikele Stream for diversion of 2.95 MGD for irrigation of three golf courses (07/15/1992)
3065	Honouliuli	19.93	0	2	2/0	HAR §13-169-49
3066	Kaloʻi	26.53	0	0	0/0	HAR §13-169-49
3067	Makaīwa	12.03	0	0	0/0	HAR §13-169-49
3068	Nānākuli	5.45	0	0	0/0	HAR §13-169-49
3069	Ulehawa	4.62	0	0	0/0	HAR §13-169-49
3070	Māʻiliʻili	19.85	0	1	0/0	HAR §13-169-49
3071	Kaupuni	9.41	6	2	0/1	HAR §13-169-49
3072	Kamaileʻunu	1.97	0	0	0/0	HAR §13-169-49
3073	Mākaha	7.37	0	1	1/0	HAR §13-169-49
3074	Keaʻau	4.24	0	0	0/0	HAR §13-169-49
3075	Mākua	6.62	0	0	0/0	HAR §13-169-49
3076	Kaluakauila	2.14	0	0	0/0	HAR §13-169-49
3077	Manini	3.03	1	0	0/0	HAR §13-169-49
3078	Kawaihāpai	7.01	0	0	0/0	HAR §13-169-49
3079	Pahole	2.45	0	0	0/0	HAR §13-169-49
3080	Makaleha	6.85	1	1	0/0	HAR §13-169-49
3081	Waialua	4.70	0	0	0/0	HAR §13-169-49
3082	Kiikii	59.03	4	11	4/0	HAR §13-169-49
3083	Paukauila	22.11	9	3	2/0	HAR §13-169-49
3084	Anahulu	16.48	4	0	0/0	HAR §13-169-49
3085	Loko Ea	2.17	4	0	0/0	HAR §13-169-49
3086	Keamanea	7.77	0	0	0/0	HAR §13-169-49
3087	Waimea	13.89	1	3	2/0	HAR §13-169-49

Table F-21 (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi2)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
MOLOKAI						
4001	Waihānau	7.73	1	1	0/0	HAR §13-169-47
4002	Waiʻaleʻia	4.36	0	0	0/0	HAR §13-169-47
4003	Waikolu	4.63	6	3	0/1	HAR §13-169-47. Amended to include SCAP MO-169 onWaikolu Stream for the installation of a fish ladder (03/14/1995).
4004	Wainēnē	0.54	0	0	0/0	HAR §13-169-47
4005	Anapuhi	0.44	0	0	0/0	HAR §13-169-47
4006	Waiohookalo	1.40	0	0	0/0	HAR §13-169-47
4007	Keawanui	0.21	1	0	0/0	HAR §13-169-47
4008	Kaʻiliʻili	0.50	0	0	0/0	HAR §13-169-47
4009	Pelekunu	7.11	2	5	0/0	HAR §13-169-47
4010	Waipū	0.54	0	0	0/0	HAR §13-169-47
4011	Hāloku	0.15	0	0	0/0	HAR §13-169-47
4012	Oloupena	0.37	0	0	0/0	HAR §13-169-47
4013	Puʻukaʻōkū	0.31	0	0	0/0	HAR §13-169-47
4014	Wailele	0.42	1	0	0/0	HAR §13-169-47
4015	Wailau	11.94	4	2	0/0	HAR §13-169-47
4016	Kalaemilo	0.19	0	0	0/0	HAR §13-169-47
4017	Waiahookalo	0.25	0	0	0/0	HAR §13-169-47
4018	Kahiwa	0.20	0	0	0/0	HAR §13-169-47
4019	Kawainui	3.74	0	1	0/0	HAR §13-169-47
4020	Pīpīwai	1.21	0	0	0/0	HAR §13-169-47
4021	Hālawa	7.64	3	1	1/0	HAR §13-169-47
4022	Pāpio	1.90	1	1	0/0	HAR §13-169-47
4023	Honowewe	2.45	0	0	0/0	HAR §13-169-47
4024	Pōhakupili	1.61	0	0	0/0	HAR §13-169-47
4025	Honoulimaloʻo	1.62	2	0	0/0	HAR §13-169-47
4026	Honouliwai	2.65	8	0	0/0	HAR §13-169-47. Amended to include SCAP MO-139 on Honouliwai Stream for diversion of 1.008 MGD for taro and aquaculture (04/14/1994).
4027	Waialua	3.41	4	0	0/0	HAR §13-169-47
4028	Kainalu	1.41	0	0	0/0	HAR §13-169-47
4029	Honomuni	1.59	1	0	0/0	HAR §13-169-47
4030	ʻAhaʻino	2.14	1	0	0/0	HAR §13-169-47
4031	Mapulehu	4.22	1	1	0/0	HAR §13-169-47
4032	Kaluaʻaha	2.05	1	0	0/0	HAR §13-169-47

Table F-21 (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi2)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
MOLOKAI (continued)						
4033	Kahananui	1.78	0	0	0/0	HAR §13-169-47
4034	ʻŌhiʻa	3.77	2	0	0/0	HAR §13-169-47
4035	Wāwāʻia	2.67	1	0	0/0	HAR §13-169-47
4036	Kamalō	13.74	1	0	0/0	HAR §13-169-47
4037	Kawela	5.44	5	2	1/1	HAR §13-169-47
4038	Kamiloloa	12.54	0	0	0/0	HAR §13-169-47
4039	Kaunakakai	9.23	0	2	1/0	HAR §13-169-47
4040	Kalamaʻula	9.65	0	0	0/0	HAR §13-169-47
4041	Manawainui	13.82	1	2	0/0	HAR §13-169-47
4042	Kāluapeʻelua	14.70	0	0	0/0	HAR §13-169-47
4043	Waiahewahewa	5.64	0	0	0/0	HAR §13-169-47
4044	Kolo	19.02	0	0	0/0	HAR §13-169-47
4045	Hakina	5.32	0	0	0/0	HAR §13-169-47
4046	Kaunalā	13.27	0	0	0/0	HAR §13-169-47
4047	Pāpōhaku	25.42	0	1	0/0	HAR §13-169-47
4048	Kaʻa	3.19	0	0	0/0	HAR §13-169-47
4049	Moʻomomi	11.45	0	0	0/0	HAR §13-169-47
4050	Maneʻopapa	13.79	0	0	0/0	HAR §13-169-47
MAUI						
6001	Waikapū	16.40	12	1	0/1	2.9 MGD below the South Waikapū Ditch diversion (04/17/2014).
6002	Pōhākea	8.31	0	0	0/0	HAR §13-169-48
6003	Pāpalaua	4.88	0	0	0/0	HAR §13-169-48
6004	Ukumehame	8.28	2	1	0/2	2.9 MGD below the lower dam (03/20/2018)
6005	Olowalu	8.40	2	1	0/1	2.33 MGD at abandoned USGS gaging station 16646200 (03/20/2018)
6006	Launiupoko	6.60	1	1	0/0	0.0 MGD (03/20/2018)
6007	Kauaʻula	8.44	1	3	0/1	3.36 MGD below the main diversion near 1540-ft. elevation and 4.1 MGD below kuleana users near 270-ft. elevation (03/20/2018)
6008	Kahoma	8.50	7	6	0/1	3.49 MGD below diversion 951 near 1850-ft. elevation; 0.8 MGD below diversion 954; By November 2023 IIFS becomes 1.55 MGD (11/20/2018)
6009	Wahikuli	9.79	0	0	0/1	HAR §13-169-48

Table F-21 (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi2)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
MAUI (continued)						
6010	Honokōwai	8.86	2	3	0/2	HAR §13-169-48. Amended to include SCAP MA-117 on Honokōwai Stream for the installation of a flow-through desilting basin (08/17/1994).
6011	Kāhana	9.07	1	0	0/0	HAR §13-169-48
6012	Honokahua	5.35	0	0	0/0	HAR §13-169-48
6013	Honolua	4.79	4	2	0/1	HAR §13-169-48
6014	Honokōhau	11.58	8	1	1/0	HAR §13-169-48
6015	Anakaluahine	2.73	0	0	0/0	HAR §13-169-48
6016	Poʻelua	2.02	0	0	0/0	HAR §13-169-48
6017	Honanana	4.66	2	0	0/0	HAR §13-169-48
6018	Kahakuloa	4.24	10	3	1/0	HAR §13-169-48. Amended to include SCAP MA-133 on Kahakuloa Stream for reconstruction of an existing stream diversion (06/02/1994).
6019	Waipili	2.65	2	0	0/0	HAR §13-169-48
6020	Waiolai	0.97	1	0	0/0	HAR §13-169-48
6021	Makamakaʻole	2.28	4	1	0/0	HAR §13-169-48
6022	Waiheʻe	7.11	5	1	1/1	10.0 MGD below Spreckels Ditch (04/17/2014).
6023	Waiehu	10.14	12	3	0/2	1.0 MGD below the Waiheʻe Ditch on North Waiehu Stream; Remaining instream flow allowing for 0.25 MGD to kuleana users on South Waiehu Stream (04/17/2014).
6024	ʻĪao	22.55	10	3	1/0	10.0 MGD below ʻĪao - Waikapu and ʻĪao -Maniania Ditch Diversion with stipulations for low-flows; 5.0 MGD at or near the stream mouth (04/17/2014).
6025	Kalialinui	30.28	0	0	0/0	HAR §13-169-44
6026	Kailua Gulch	29.76	0	0	0/0	HAR §13-169-44
6027	Māliko	27.38	10	0	0/0	HAR §13-169-44
6028	Kuiaha	8.38	30	0	0/0	HAR §13-169-44
6029	Kaupakulua	3.84	15	1	0/0	HAR §13-169-44

Table F-21 (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi2)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
MAUI (continued)						
6030	Manawaiiao	2.37	3	0	0/0	HAR §13-169-44
6031	Uaoa	2.39	6	0	0/0	HAR §13-169-44
6032	Keali‘i	0.53	4	0	0/0	HAR §13-169-44
6033	Kakipi	9.53	21	4	0/0	HAR §13-169-44
6034	Honopou	2.73	23*	4	1/1	Full restoration of streamflow at East Maui Irrigation Co. diversions per CCH-MA13-01 (06/20/2018).
6035	Ho‘olawa	4.86	37	2	0/0	HAR §13-169-44
6036	Waipi‘o	1.03	15	0	0/0	HAR §13-169-44
6037	Hanehoi	1.43	12*	0	0/1	Full restoration of streamflow at East Maui Irrigation Co. diversions per CCH-MA13-01 (06/20/2018).
6038	Hoalua	1.24	4	0	0/0	HAR §13-169-44
6039	Hanawana	0.65	5	0	0/0	HAR §13-169-44
6040	Kailua	5.25	6	5	0/0	HAR §13-169-44
6041	Nailiilihaele	3.57	12	2	0/0	HAR §13-169-44
6042	Puehu	0.36	1	0	0/0	HAR §13-169-44
6043	Oopuola	1.24	15	2	0/0	HAR §13-169-44
6044	Kaaiea	1.15	3	1	0/0	HAR §13-169-44
6045	Punalu‘u	0.22	1	0	0/0	HAR §13-169-44
6046	Kolea	0.71	8	0	0/0	HAR §13-169-44
6047	Waikamoi	5.30	11	7	1/1	3.8 CFS (2.46 MGD) above Hana Hwy. per CCH-MA13-01 (06/20/2018).
6048	Puohokamoa	3.18	8	6	0/0	1.1 CFS (0.71 MGD) below Hana Hwy. per CCH-MA13-01 (06/20/2018).
6049	Haipua‘ena	1.59	5	5	0/0	1.36 CFS (0.88 MGD) below Hana Hwy. per CCH-MA13-01 (06/20/2018).
6050	Punalau	1.16	3	0	0/0	2.9 CFS (1.88 MGD) above Hana Hwy. per CCH-MA13-01 (06/20/2018).
6051	Honomanū	5.60	8	4	0/1	4.2 CFS (2.72 MGD) above Hana Hwy. per CCH-MA13-01 (06/20/2018).

** Stream Diversion Works Abandonment pending.*

Table F-21 (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi2)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
MAUI (continued)						
6052	Nuaʻailua	1.56	2	0	0/0	2.2 CFS (1.42 MGD) per CCH-MA13-01 (06/20/2018).
6053	Piʻinaʻau	21.95	14*	0	0/0	Full restoration of streamflow at East Maui Irrigation Co. diversions per CCH-MA13-01 (06/20/2018).
6054	ʻŌhiʻa	0.28	1	0	0/0	HAR §13-169-44
6055	Waiokamilo	2.47	18*	1	0/0	Full restoration of streamflow at East Maui Irrigation Co. diversions per CCH-MA13-01 (06/20/2018).
6056	Wailuanui	6.05	8*	3	1/1	Full restoration of streamflow at East Maui Irrigation Co. diversions per CCH-MA13-01 (06/20/2018).
6057	W. Wailuaiki	4.18	1*	1	1/1	Full restoration of streamflow at East Maui Irrigation Co. diversions per CCH-MA13-01 (06/20/2018).
6058	E. Wailuaiki	3.52	1	1	0/1	3.7 CFS (2.39 MGD) at Hana Hwy. per CCH-MA13-01 (06/20/2018).
6059	Kopiliula	5.20	2	1	0/1	Kopiliula: 3.2 CFS (2.07 MGD) below Hana Hwy. per CCH-MA13-01 (06/20/2018). Puaʻakaʻa: 0.2 CFS (0.13 MGD) above Hana Hwy. per CCH-MA13-01 (06/20/2018).
6060	Waiohue	0.82	3*	1	0/1	Full restoration of streamflow at East Maui Irrigation Co. diversions per CCH-MA13-01 (06/20/2018).

** Stream Diversion Works Abandonment pending.*

Table F-21 (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi2)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
MAUI (continued)						
6061	Pa‘akea	1.05	2	1	0/0	0.77 CFS (0.12 MGD) at Hana Hwy. per CCH-MA13-01 (06/20/2018).
6062	Waiaaka	0.19	1	1	0/0	0.77 CFS (0.5 MGD) above Hana Hwy. per CCH-MA13-01 (06/20/2018).
6063	Kapā‘ula	0.84	2	2	0/0	0.56 CFS (0.36 MGD) on diversion at Ko‘olau Ditch per CCH-MA13-01 (06/20/2018).
6064	Hanawī	5.60	6	2	1/0	0.92 CFS (0.6 MGD) below Hana Hwy. per CCH-MA13-01 (06/20/2018).
6065	Makapipi	3.32	3*	1	0/2	Full restoration of streamflow at East Maui Irrigation Co. diversions per CCH-MA13-01 (06/20/2018).
6066	Kūhiwa	3.41	0	0	0/0	HAR §13-169-44
6067	Waihole	0.88	2	0	0/0	HAR §13-169-44
6068	Manawaikeae	0.52	0	0	0/0	HAR §13-169-44
6069	Kahawaihapapa	3.73	0	0	0/0	HAR §13-169-44
6070	Keaaiki	1.03	2	0	0/0	HAR §13-169-44
6071	Waioni	0.63	2	0	0/0	HAR §13-169-44
6072	Lanikele	0.70	1	0	0/0	HAR §13-169-44
6073	Helele‘ike‘ōhā	3.48	14	0	0/0	HAR §13-169-44
6074	Kawakoe	4.04	15	0	0/0	HAR §13-169-44
6075	Honomā‘ele	7.94	4	0	0/0	HAR §13-169-44
6076	Kawaipapa	10.78	0	0	0/0	HAR §13-169-44
6077	Moomoonui	2.95	0	0	0/0	HAR §13-169-44
6078	Haneo‘o	2.13	0	0	0/0	HAR §13-169-44
6079	Kapia	4.71	3	0	0/0	HAR §13-169-44
6080	Waiohonu	7.15	0	0	0/0	HAR §13-169-44
6081	Papahawahawa	1.96	0	0	0/0	HAR §13-169-44
6082	Alaalaula	0.48	2	0	0/0	HAR §13-169-44
6083	Wailua	1.26	4	0	0/0	HAR §13-169-44
6084	Honolewa	0.63	1	0	0/0	HAR §13-169-44
6085	Wai‘eli	0.96	0	0	0/0	HAR §13-169-44
6086	Kakiweka	0.34	1	0	0/0	HAR §13-169-44
6087	Hāhālawe	0.74	1	1	0/0	HAR §13-169-44

** Stream Diversion Works Abandonment pending.*

Table F-21 (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi2)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
MAUI (continued)						
6088	Puaʻaluʻu	0.53	4	0	0/0	HAR §13-169-44
6089	ʻOheʻo	9.70	0	2	1/0	HAR §13-169-44
6090	Kalena	0.71	1	0	0/0	HAR §13-169-44
6091	Koukouai	4.56	2	0	0/0	HAR §13-169-44
6092	Opelu	0.53	2	0	0/0	HAR §13-169-44
6093	Kukuiʻula	0.74	1	1	0/0	HAR §13-169-44
6094	Kaʻāpahu	0.50	0	0	0/0	HAR §13-169-44
6095	Lelekea	0.78	0	0	0/0	HAR §13-169-44
6096	Alelele	1.20	0	0	0/0	HAR §13-169-44
6097	Kālepa	0.97	2	0	0/0	HAR §13-169-44
6098	Nuanuaaloa	4.24	3	0	0/0	HAR §13-169-44
6099	Manawainui	5.17	3	0	0/0	HAR §13-169-44
6100	Kaupō	22.50	1	0	0/0	HAR §13-169-44
6101	Nuʻu	10.48	0	0	0/0	HAR §13-169-44
6102	Pāhihi	7.85	0	0	0/0	HAR §13-169-44
6103	Waiopai	5.38	0	0	0/0	HAR §13-169-44
6104	Poʻopoʻo	1.92	0	0	0/0	HAR §13-169-44
6105	Manawainui Gulch	6.07	0	0	0/0	HAR §13-169-44
6106	Kīpapa	28.42	0	1	0/0	HAR §13-169-44
6107	Kanaio	34.11	0	0	0/0	HAR §13-169-44
6108	ʻĀhihi Kinau	3.68	0	0	0/0	HAR §13-169-44
6109	Moʻoloa	1.90	0	0	0/0	HAR §13-169-44
6110	Wailea	35.76	4	0	0/0	HAR §13-169-44
6111	Hāpapa	40.89	0	1	0/0	HAR §13-169-44
6112	Waiakoa	55.76	0	0	0/0	HAR §13-169-44
HAWAIʻI						
8001	Kealahewa	5.08	0	0	0/0	HAR §13-169-46
8002	Hualua	5.53	0	0	0/0	HAR §13-169-46
8003	Kumakua	3.48	0	0	0/0	HAR §13-169-46
8004	Kapua	0.65	0	0	0/0	HAR §13-169-46
8005	Ohanaula	1.26	0	0	0/0	HAR §13-169-46
8006	Hanaʻula	3.55	0	0	0/0	HAR §13-169-46
8007	Hapahapai	3.33	1	0	0/0	HAR §13-169-46
8008	Pali Akamoa	1.36	0	0	0/0	HAR §13-169-46
8009	Wainaia	4.30	5	0	0/0	HAR §13-169-46
8010	Halelua	2.28	0	0	0/0	HAR §13-169-46
8011	Hālawa	1.75	2	0	0/0	HAR §13-169-46
8012	Aamakao	10.56	7	0	0/0	HAR §13-169-46
8013	Niuliʻi	3.27	9	0	0/0	HAR §13-169-46
8014	Waikama	3.39	7	0	0/0	HAR §13-169-46

Table F-21 (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi2)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
HAWAIʻI (continued)						
8015	Pololū	6.31	6	0	0/0	HAR §13-169-46
8016	Honokāne Nui	10.51	6	5	0/0	HAR §13-169-46
8017	Honokāne Iki	2.62	0	0	0/0	HAR §13-169-46
8018	Kalele	0.17	0	0	0/0	HAR §13-169-46
8019	Waipahi	1.00	0	0	0/0	HAR §13-169-46
8020	Honokeʻā	2.38	0	0	0/0	HAR §13-169-46
8021	Kāʻilikaula	0.79	0	0	0/0	HAR §13-169-46
8022	Honopue	2.65	0	0	0/0	HAR §13-169-46
8023	Kōlealiʻiliʻi	0.86	0	0	0/0	HAR §13-169-46
8024	Ohiahuea	1.96	0	0	0/0	HAR §13-169-46
8025	Nakooko	0.76	0	0	0/0	HAR §13-169-46
8026	Waiʻāpuka	0.73	0	0	0/0	HAR §13-169-46
8027	Waikaloa	1.62	0	0	0/0	HAR §13-169-46
8028	Waimaile	0.48	0	0	0/0	HAR §13-169-46
8029	Kukui	0.67	0	1	0/0	HAR §13-169-46
8030	Paopao	0.54	0	1	0/0	HAR §13-169-46
8031	Waiaalala	0.34	0	1	0/0	HAR §13-169-46
8032	Punalulu	1.25	0	1	0/0	HAR §13-169-46
8033	Kaimu	1.70	0	1	0/0	HAR §13-169-46
8034	Pae	0.65	0	0	0/0	HAR §13-169-46
8035	Waimanu	8.79	0	2	0/0	HAR §13-169-46
8036	Pūkoʻa	0.21	0	0	0/0	HAR §13-169-46
8037	Manuwaikaalio	0.50	0	0	0/0	HAR §13-169-46
8038	Naluea	0.88	0	0	0/0	HAR §13-169-46
8039	Kahoʻopuʻu	0.86	0	0	0/0	HAR §13-169-46
8040	Waipāhoehoe	1.34	0	0	0/0	HAR §13-169-46
8041	Wailoa/Waipiʻo	25.84	37	18	2/0	HAR §13-169-46
8042	Kaluahine Falls	0.22	0	0	0/0	HAR §13-169-46
8043	Waiulili	28.93	1	1	0/0	HAR §13-169-46
8044	Waikoekoe	1.61	0	0	0/0	HAR §13-169-46
8045	Waipunahoe	16.51	0	0	0/0	HAR §13-169-46
8046	Waiʻaleʻale	0.79	0	0	0/0	HAR §13-169-46
8047	Waikoloa	16.95	0	0	0/0	HAR §13-169-46
8048	Kapulena	3.08	0	0	0/0	HAR §13-169-46
8049	Kawaikalia	1.84	0	0	0/0	HAR §13-169-46
8050	Malanahae	2.24	0	0	0/0	HAR §13-169-46
8051	Honokaia	16.09	0	0	0/0	HAR §13-169-46
8052	Kawela	1.31	0	0	0/0	HAR §13-169-46
8053	Keaakaukau	0.87	0	0	0/0	HAR §13-169-46
8054	Kainapahoa	9.08	1	0	0/0	HAR §13-169-46
8055	Nienie	4.95	2	0	0/0	HAR §13-169-46

Table F-21 (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi2)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
HAWAIʻI (continued)						
8056	Papuaa	4.73	0	0	0/0	HAR §13-169-46
8057	Ouhi	0.45	0	0	0/0	HAR §13-169-46
8058	Kahaupu	11.27	0	0	0/0	HAR §13-169-46
8059	Kahawailiʻilʻi	15.56	0	0	0/0	HAR §13-169-46
8060	Keahua	1.70	0	0	0/0	HAR §13-169-46
8061	Kalōpā	30.94	0	0	0/0	HAR §13-169-46
8062	Waikaalulu	3.06	0	0	0/0	HAR §13-169-46
8063	Kukuilamalama hii	2.28	0	0	0/0	HAR §13-169-46
8064	Alilipali	1.60	0	0	0/0	HAR §13-169-46
8065	Kaumōʻali	9.39	0	0	0/0	HAR §13-169-46
8066	Pohakuhaku	2.45	0	0	0/0	HAR §13-169-46
8067	Waipunahina	15.86	0	0	0/0	HAR §13-169-46
8068	Waipunalau	3.84	0	0	0/0	HAR §13-169-46
8069	Paʻauilo	1.57	1	0	0/0	HAR §13-169-46
8070	ʻĀʻāmanu	0.64	0	0	0/0	HAR §13-169-46
8071	Koholālele	14.40	0	0	0/0	HAR §13-169-46
8072	Kalapahapuu	6.43	0	0	0/0	HAR §13-169-46
8073	Kūkaʻiau	2.40	0	0	0/0	HAR §13-169-46
8074	Puʻumaile	9.13	0	0	0/0	HAR §13-169-46
8075	Kekualele	2.18	0	0	0/0	HAR §13-169-46
8076	Kaʻala	6.62	0	0	0/0	HAR §13-169-46
8077	Kealakaha	3.49	0	0	0/0	HAR §13-169-46
8078	Keehia	1.72	0	0	0/0	HAR §13-169-46
8079	Kupapaulua	2.54	0	0	0/0	HAR §13-169-46
8080	Kaiwiki	2.24	0	0	0/0	HAR §13-169-46
8081	Kaʻula	14.35	0	0	0/0	HAR §13-169-46
8082	Kaohaoha	1.49	0	0	0/0	HAR §13-169-46
8083	Kaawalii	13.93	0	0	0/0	HAR §13-169-46
8084	Waipunalei	2.07	0	0	0/0	HAR §13-169-46
8085	Laupāhoehoe	4.71	0	0	0/0	HAR §13-169-46
8086	Kilau	2.43	1	0	0/0	HAR §13-169-46
8087	Manowaiʻōpae	1.74	2	1	0/0	HAR §13-169-46. Amended to include SCAP HA-195 on Manowaiopae Stream for a permitted diversion (05/03/1996).
8088	Kuwaikahi	0.72	1	0	0/0	HAR §13-169-46
8089	Kihalani	0.70	1	0	0/0	HAR §13-169-46

Table F-21 (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi2)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
HAWAIʻI (continued)						
8090	Kaiwilahilahi	6.69	1	0	0/0	HAR §13-169-46
8091	Haʻakoa	6.26	0	0	0/0	HAR §13-169-46
8092	Pāhale	3.92	0	0	0/0	HAR §13-169-46
8093	Kapehu Camp	1.74	2	0	0/0	HAR §13-169-46
8094	Paeohe	0.85	0	0	0/0	HAR §13-169-46
8095	Maulua	5.30	0	0	0/0	HAR §13-169-46
8096	Pōhakupuka	3.63	1	1	0/0	HAR §13-169-46
8097	Kulanakiʻi	0.71	0	0	0/0	HAR §13-169-46
8098	Ahole	0.67	0	0	0/0	HAR §13-169-46
8099	Poupou	0.62	0	0	0/0	HAR §13-169-46
8100	Manoloa	1.32	0	0	0/0	HAR §13-169-46
8101	Nīnole	1.67	2	0	0/0	HAR §13-169-46
8102	Kaaheiki	0.27	1	0	0/0	HAR §13-169-46
8103	Waikolu	0.63	4	0	0/0	HAR §13-169-46
8104	Waikaumalo	16.10	0	0	0/0	HAR §13-169-46
8105	Waiehu	0.61	1	0	0/0	HAR §13-169-46
8106	Nanue	5.53	1	0	0/0	HAR §13-169-46
8107	Opea	2.31	0	0	0/0	HAR §13-169-46
8108	Peleau	1.12	3	0	0/0	HAR §13-169-46. Amended to include SCAP HA-314 on Peleau Stream for diversion of 8.0 MGD for agricultural use (08/23/2000).
8109	Umauma	33.83	1	0	0/0	HAR §13-169-46
8110	Hakalau	10.26	0	0	0/0	HAR §13-169-46
8111	Kolekole	20.82	8	0	0/0	HAR §13-169-46
8112	Pāheʻeheʻe	2.87	0	0	0/0	HAR §13-169-46
8113	Honomū	3.12	2	0	0/0	HAR §13-169-46. Amended to include SCAP HA-317 on Malamalamaiki Stream for 2.0-in. pipe diversion for washing farm equipment (02/28/2001).
8114	Laʻimi	0.89	1	0	0/0	HAR §13-169-46
8115	Kapehu	1.60	2	0	0/0	HAR §13-169-46
8116	Makea	2.08	4	0	0/0	HAR §13-169-46
8117	Alia	1.31	2	1	0/0	HAR §13-169-46. Amended to include SCAP HA-387 on Alia Stream for diversion of 0.058 MGD for agricultural use (05/24/2006).
8118	Makahanaloa	0.48	0	0	0/0	HAR §13-169-46

Table F-21 (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi2)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
HAWAIʻI (continued)						
8119	Waimaauou	1.33	1	0	0/0	HAR §13-169-46
8120	Waiaama	3.53	2	0	0/0	1.0 MGD below diversion at 890-ft elevation (01/15/19)
8121	Kawainui	8.52	1	1	0/0	HAR §13-169-46
8122	Onomea	0.85	5	0	0/0	HAR §13-169-46. Amended to include SCAP HA-214 on Onomea Stream for relocation of a pipe diversion to mitigate concerns over an existing diversion dam (03/19/1997).
8123	Alakahi	0.30	1	0	0/0	HAR §13-169-46
8124	Hanawī	3.96	0	0	0/0	HAR §13-169-46
8125	Kalaoa	0.51	3	0	0/0	HAR §13-169-46
8126	ʻAleamai	0.32	0	0	0/0	HAR §13-169-46
8127	Kaʻieʻie	2.75	0	0	0/0	HAR §13-169-46
8128	Puuokalepa	0.93	2	0	0/0	HAR §13-169-46
8129	Kaʻāpoko	0.32	0	0	0/0	HAR §13-169-46
8130	Pāpaʻikou	0.19	0	0	0/0	HAR §13-169-46
8131	Kapue	11.86	0	0	0/0	HAR §13-169-46
8132	Pāhoehoe	6.96	1	0	0/0	HAR §13-169-46
8133	Paukaa	0.65	0	0	0/0	HAR §13-169-46
8134	Honoliʻi	16.59	0	2	1/0	HAR §13-169-46
8135	Maili	4.09	1	0	0/0	HAR §13-169-46
8136	Wainaku	1.86	0	0	0/0	HAR §13-169-46
8137	Pukihae	3.23	0	0	0/0	HAR §13-169-46
8138	Wailuku	225.56	11	7	1/0	HAR §13-169-46. Amended to include SCAP HA-219 on Waiau Stream for a diversion dam constructed to generate electricity for a farm operation (10/22/1997). Amended to include SCAP HA-047 on Hookelekele Stream for three diversions structures constructed as part of a hydroelectric project (10/18/1989).
8139	Wailoa	180.18	1	5	0/0	HAR §13-169-46

Table F-21 (continued)
Inventory of Surface Water Resources

Unit Code	Unit Name	Area (mi²)	No. of Diversions	No. of Gages	Active Gages	Interim IFS
HAWAIʻI (continued)						
8140	Kaahakini	388.99	3	0	0/0	HAR §13-169-46
8141	Kīlauea	152.29	0	0	0/0	HAR §13-169-46
8142	Keauhou Point	66.58	0	0	0/0	HAR §13-169-46
8143	Kīlauea Crater	27.10	0	0	0/0	HAR §13-169-46
8144	Kapāpala	183.57	0	0	0/0	HAR §13-169-46
8145	Pahala	271.38	1	1	1/0	HAR §13-169-46
8146	Hīlea	94.44	6	3	0/0	HAR §13-169-46
8147	Nāʼālehu	46.45	1	0	0/0	HAR §13-169-46
8148	Kiolakaʻa	66.21	0	0	0/0	HAR §13-169-46
8149	South Point	11.75	1	0	0/0	HAR §13-169-46
8150	Kauna	140.63	0	0	0/0	HAR §13-169-46
8151	Kiʻilae	340.31	4	1	0/0	HAR §13-169-46
8152	Kealakekua	45.29	0	0	0/0	HAR §13-169-46
8153	Waiʻaha	224.39	8	4	1/0	HAR §13-169-46
8154	Honokōhau	14.20	0	0	0/0	HAR §13-169-46
8155	Keahole	32.73	0	0	0/0	HAR §13-169-46
8156	Kīholo	236.29	0	0	0/0	HAR §13-169-46
8157	Pōhakuloa	348.76	4	0	0/0	HAR §13-169-46
8158	Kamakoa	192.20	0	0	0/0	HAR §13-169-46
8159	Hāloa	1.07	0	0	0/0	HAR §13-169-46
8160	Lamimaumau	3.88	0	1	0/0	HAR §13-169-46
8161	Waikoloa	51.96	11	6	0/0	HAR §13-169-46
8162	Kawaihae	22.03	0	0	0/0	HAR §13-169-46
8163	Honokoa	12.61	10	0	0/0	HAR §13-169-46
8164	Keawanui	43.90	2	0	0/0	HAR §13-169-46
8165	Lapakahi	6.27	0	0	0/0	HAR §13-169-46
8166	Māhukona	12.61	0	0	0/0	HAR §13-169-46

APPENDIX G

Monitoring of Water Resources

Water Resource Protection Plan 2019 Update

G Monitoring of Water Resources

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G Monitoring of Water Resources

A vital component of water resource protection is the implementation of an effective program to monitor resource conditions. In 2001, the USGS published Circular 1217, entitled *Ground-Water-Level Monitoring and the Importance of Long-Term Water-Level Data*[1]*,* intending to highlight the importance of ground water-level measurements, and to foster a more comprehensive and systematic approach to the long-term collection of water-level data. The report calls attention to the need for a nationwide program to obtain more systematic and comprehensive records of water levels in observation wells, as a joint effort among the United States Geological Survey (USGS) and state and local agencies:

> *"…[W]ater-level monitoring in the United States is fragmented and largely subject to the vagaries of existing local projects. A stable, base network of water-level monitoring wells exists only in some locations. Moreover, agency planning and coordination vary greatly throughout the United States with regard to construction and operation of water-level observation networks and the sharing of collected data."*
>
> *…More recently, the National Research Council (2000) reiterated, "An unmet need is a national effort to track water levels over time in order to monitor water-level declines."*
>
> *…It is hoped that this report [Circular 1217] will provide a catalyst toward the establishment of a more rigorous and systematic nationwide approach to ground-water-level monitoring – clearly an elusive goal thus far. The time is right for progress toward this goal. Improved access to water data over the Internet offers the opportunity for significant improvements in the coordination of water-level monitoring and the sharing of information by different agencies, as well as the potential means for evaluation of water-level monitoring networks throughout the United States."*

The need for improved monitoring programs and agency coordination described in Circular 1217 is true for Hawai‘i's ground water monitoring activities, but the need is even more apparent for Hawai‘i's surface water and climate monitoring programs, which are fairly new and in need of sensible expansion. The overall goal of establishing a "rigorous and systematic" approach to resource monitoring across the State should be carefully addressed by program planning, implementation of prioritized actions, plan update and revision, and interagency & private/public cooperation. This appendix of the Water Resources Protection Plan (WRPP) describes Hawai‘i's existing ground water, surface water, and climate monitoring and

[1] Taylor, Charles J. and William M. Alley. 2001. *Ground-Water-Level Monitoring and the Importance of Long-Term Water-Level Data: U.S. Geological Survey Circular 1217.* Internet, available online at: http://pubs.usgs.gov/circ/circ1217/html/pdf.html.

assessment programs, as well as recommendations for follow-up action, program expansion, and agency coordination.

Under the State Water Code, the Commission on Water Resource Management (CWRM) is primarily responsible for assessing the quantity issues of ground and surface water resources, while the Department of Health (DOH) has primacy over ground and surface water quality issues. Please refer to **Appendix M** for more information about DOH programs and plans.

G.1 Overview

CWRM, in cooperation with federal agencies, State DOH, and county agencies, is responsible for monitoring ground water resources, surface water resources, and climate conditions throughout the state of Hawaiʻi. Monitoring activities include the collection of:

- Vertical-profile conductivity and temperature data (indicates the extent of saltwater intrusion and the behavior of the freshwater and transition zone over time) from state, Honolulu Board of Water Supply (BWS), USGS, and private deep monitor wells;
- Instantaneous and continuous long-term water-level data from water-level monitoring wells;
- Continuous and long-term stream discharge data and surface water quality data;
- Rainfall data from the National Weather Service (NWS), the USGS, the State, and privately-operated rain gages;
- Ground water pumping, chloride (or conductivity), water-level, and temperature data from all production wells statewide; and
- Surface water diversion data from streams

As water usage increases, it is necessary that at least minimal hydrologic data be collected and made available for decision-making, regarding availability and use of the resource. Climate change, including sea level fluctuations, will directly affect aquifers adjacent to the coastlines, and inland aquifers will be affected by changes in recharge from precipitation, necessitating careful monitoring to maintain an accurate assessment of aquifer health. Water withdrawals must be continuously inventoried, and the impacts of these withdrawals must be monitored to protect and prevent any degradation of ground and surface water sources.

In an effort to respond to the increasing pressure on Hawaiʻi's water resources, CWRM and the USGS have begun a joint effort to evaluate water-resource monitoring needs in Hawaiʻi. The current network of groundwater, streamflow, and rainfall monitoring stations will be examined to determine how data collections sites can be best utilized and expanded to protect and manage Hawaiʻi's water resources. The results of this effort will be published in a USGS Scientific

Investigations Report and will include a 20-year implementation plan with preliminary cost estimates.

Continuous and consistent water data collection is critical to CWRM's ability to protect water resources. CWRM collects, analyzes, and verifies hydrologic data; this is then correlated, or analyzed to provide an understanding of water within a particular area. Ground water data are used to observe empirical trends and calibrate computer models that will refine sustainable yield estimates, and surface water data are used in the development of instream flow standards. Data is also obtained through required, regular reports by well owners. At the time of this publication, a new online water use reporting database has been implemented (Water Resource Information Management System [WRIMS]), and will be able to provide reports on water use and other time-series data by aquifer system area, island, user, type of use (e.g., domestic, municipal, and agricultural), and other source information and documentation.

Although it is recognized that groundwater and surface water resources are interconnected, CWRM splits the data collection and management duties between two separate programs. Groundwater monitoring is the responsibility of the Ground Water Regulation Branch, and surface water monitoring is the responsibility of the Stream Protection and Management Branch. The following sections are organized to reflect this separation of duties within CWRM.

G.1.1 Water Resource Monitoring Goal and Objectives

The following goals, policies, and objectives have been determined by CWRM to guide and focus water resource monitoring programs and the use of resultant monitoring data:

Goal: Develop the best available information on water resources, including current and future water use monitoring and data collection, surface water and ground water quality (e.g., chlorides) and availability, stream flow, stream biota, and watershed health to make wise decisions about reasonable and beneficial use and protection of the resource.

- Compile water-use and resource data collected by CWRM, other government agencies, community organizations, and other private entities into a comprehensive database.
- Enhance surface and ground water use data collection throughout the State, such that stream diversion and well operators and users participate in recording and reporting stream diversion withdrawals, well pumpage, well water chloride (or conductivity) concentrations, non-pumping water-levels, and temperatures.
- Identify priority areas for new ground and surface water monitoring. Submit funding requests, as needed, for monitoring programs (e.g., deep monitor wells, water-level observation wells, spring flow measurements, rain gage data, fog drip analysis, stream gaging, stream surveys, etc.).
- Pursue cooperative agreements and partnerships with other governmental agencies and private stakeholders to work with the USGS in the collection of hydrologic data.

- o Participate in watershed partnerships to better understand and facilitate the collection of data to support watershed management.
- o Assess the impacts of climate change on the components of the hydrologic cycle.
- o Maintain awareness of latest technologies and methodologies of hydrologic computer/numerical models.
- o Promote and support the continuation of long-term hydrologic and climate data collection stations as well as the establishment of new stations and the reinstatement of important discontinued stations.
- o Update:
  - Hydrologic Geographic Information System (GIS) data for the State;
  - Ground water recharge information;
  - Benchmark ground water well network for water level elevations; and
  - Deep monitor well network.

G.2 Monitoring of Ground Water Resources

Management of ground water resources cannot be responsibly accomplished without long-term monitoring information. Long-term data allows water scientists and managers to identify emerging trends and problems in Hawaiʻi's ground water aquifers. For example, the effects of natural climatic variations and induced stresses upon aquifer systems could be better identified. Since ground water provides much of the municipal and drinking water supply statewide, and demand for high-quality ground water continues to increase, long-term monitoring data is needed to determine the response of island aquifers to climatic variability and change, changing land use, and increasing withdrawals. Such data is useful in defining trends, providing a basis for comparison, measuring the impacts of water development, detecting ground water threats, and determining the best management and corrective measures.

The practical applications of data from monitoring activities are numerous and varied, but generally include actions toward:

- Managing ground water withdrawals for purposes such as protecting sustainable yields and existing wells;
- Providing insight into regional hydrology including emerging regional conceptual ground water model differences; and
- Providing data to construct and test analytical and numerical ground water models to assess ground water occurrence and recharge.

The following comprise the main elements that contribute to ground water monitoring activities in Hawaiʻi, and these elements are further described in the sections below:

- Deep monitor wells;
- Water-level observation wells;
- Spring discharge measurements and conductivity measurements;
- Pumpage, chloride (or conductivity), water-level, and temperature data from well owners; and
- Rainfall data.

Deep Monitor Wells: Deep monitor wells (DMWs) penetrate through the freshwater zone and transition zone and terminate in the saltwater zone. In some cases, on the island of Hawaiʻi, DMWs have encountered deep confined freshwater aquifers below saltwater. Deep monitor wells allow for the study of the entire basal aquifer water column. The wells are used to track changes in the thickness of the freshwater lens over time; thereby providing data on the aquifer's response to groundwater withdrawals and longer-term precipitation changes. In addition, deep monitor wells serve as water-level observation wells and can be used to sample the water chemistry at depth (refer to the cross section depicted on **Figure G-1 Schematic Diagram of a Deep Monitor Well**). The location of DMWs in the State of Hawaiʻi are shown on **Figure G-2 Deep Monitor Wells (DMWs) in the State of Hawaiʻi**. **Table G-1 Summary of CWRM Deep** Monitor Wells provides a list of the CWRM DMWs.

Figure G-1 Schematic Diagram of a Deep Monitor Well

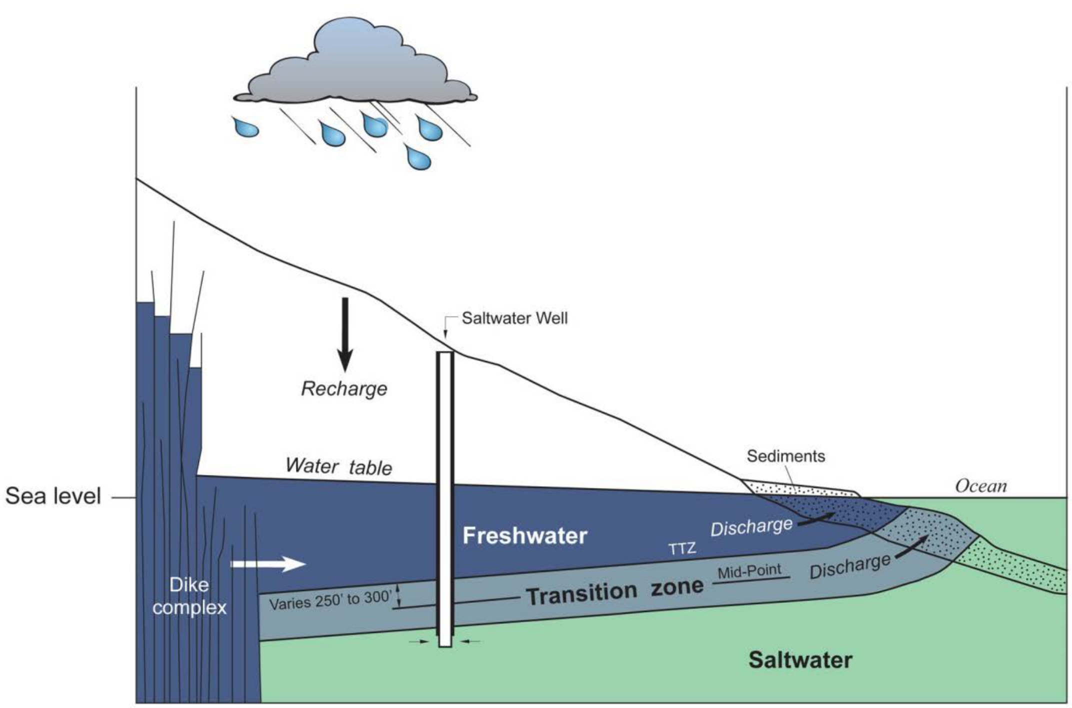
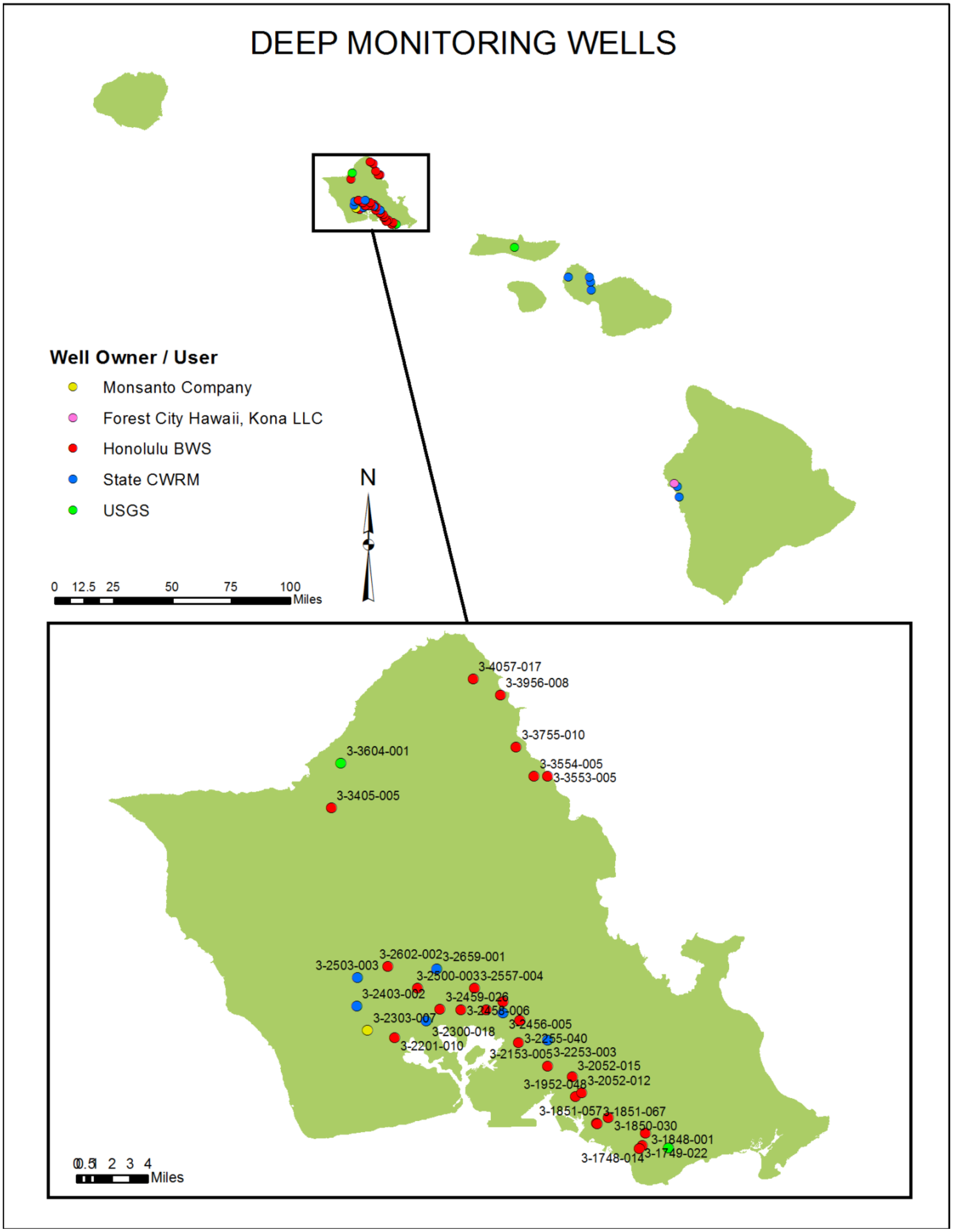


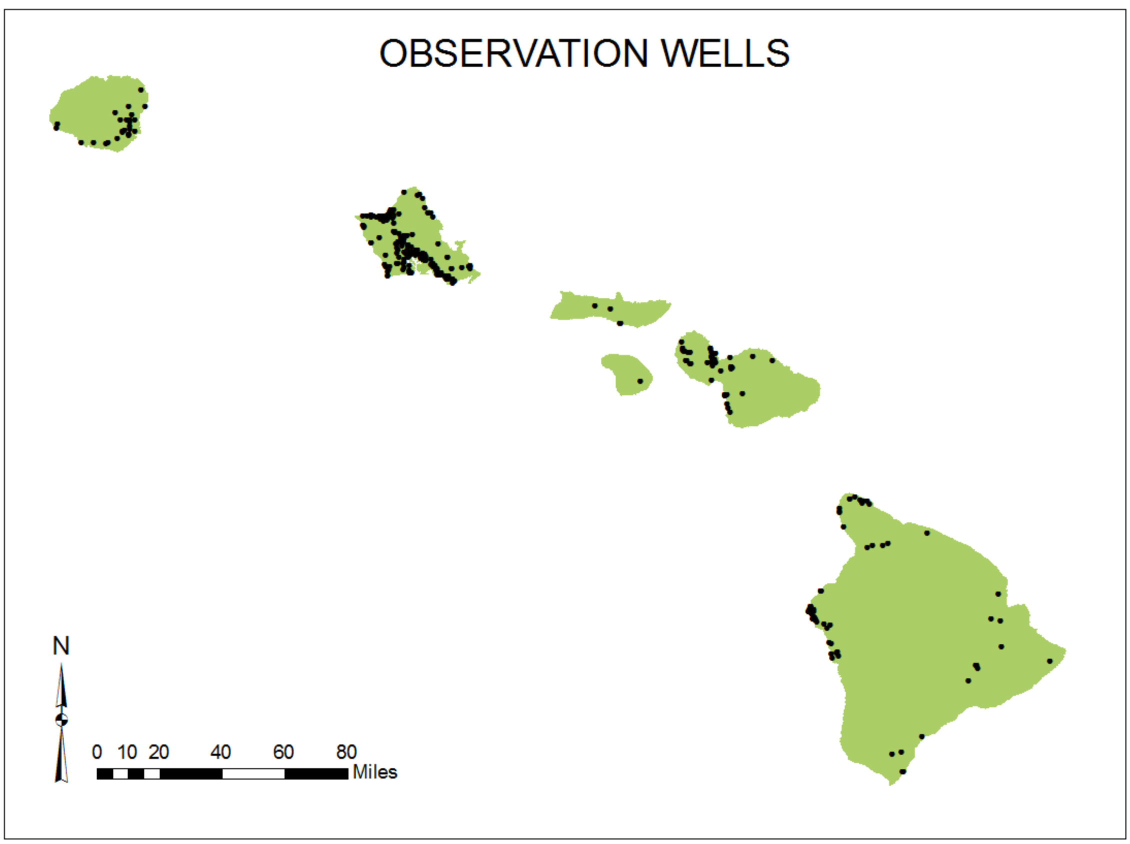
Figure G-2 Deep Monitor Wells (DMWs) in the State of Hawai‘i



Recent studies (Rotzoll USGS, 2010) have shown that natural or anthropogenic vertical borehole flows within a DMW can influence the measured transition zone elevations, and as a result, Conductivity, Temperature, and Depth (CTD) profiles may not accurately reflect the transition zone elevations within the aquifer. CWRM will evaluate the influence of vertical borehole flow on a well by well basis and develop recommendations for future DMW design and installation details (and consider existing DMW retrofits) to mitigate the influence of vertical flow within the DMWs.

Water-Level Observation Wells: Water level data can be obtained from any well that penetrates the desired aquifer. Water level is the height of water in a well relative to mean sea level. Such data provides information on aquifer response to rainfall patterns and ground water withdrawals. Water level data can be analyzed in combination with spring discharge, pumpage, and chloride (or conductivity) data to study aquifer response to climatic events and induced stresses. A summary list of observation well in the State of Hawaiʻi (including water level and DMWs) is provided in **Table G-5 Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring** Programs. The locations of water level observation wells in the State of Hawaiʻi are shown on **Figure G-3 Water-Level Observation Wells in the State of Hawaiʻi**.

Figure G-3 Water-Level Observation Wells in the State of Hawaiʻi



Spring Discharge and Conductivity Measurements: Spring flow can represent the visible discharge from a basal freshwater lens or from dike-impounded ground water. Information on the rate of spring discharge and chloride concentrations (or conductivity) can be correlated to water-level data and chloride (or conductivity) trends at observation wells in the vicinity of the spring. The relationship between the amount of ground water withdrawals (pumpage) and spring discharge can provide estimates on the amount of ground water flux through an aquifer. The USGS is the primary collector and disseminator of this information.

Pumpage, Chloride, Water-Level, and Temperature Data from well owners: There are over 4,000 wells statewide that are required to report monthly to CWRM. Reported water use and chloride (or conductivity) data over the long-term provides information on the rate of ground water withdrawals and the resulting water quality, water-levels, and temperature responses within aquifer system areas. Water use and chloride (or conductivity) information can be compared with monitor water-level data, deep monitor well data, irrigation practices, and land use and demographic changes to gain insight into the sustainability of ground water resources. Pumpage is also compared against current supply and uses. For more information on this refer to **Appendix H, Existing and Future Demands**.

Pumping Test Data: Data collected during pump tests as required by the HWCPIS (2004) can provide information to help identify and interpret flow relationships between ground water bodies and can also be indicative of geothermal activity. For example, water levels can help determine if the pumpage will impact streams or other existing wells. A rise in chlorides can indicate upconing and pump capacity limitations. Additionally, if ground water temperature remains constant throughout a pumping test, it is most likely that all water derived from the borehole or test well is from the same source. Conversely, if water temperature changes, it could be that observed variations are due to the introduction of water from another related source. As for indicating geothermal activity, a rise in water temperature accompanied by an increase in chloride concentration, typically suggests that the water is associated with regions of geothermal activity.

Rainfall Data: Rainfall data represents the “input” to ground water systems and provides basic information to complete the water balance equation. Ground water recharge models rely on rainfall and land use information to determine how much rainfall percolates into the subsurface aquifer systems. Rainfall data should be complemented by fog drip and evapotranspiration data to allow computation of more accurate recharge information. Rainfall and precipitation monitoring are discussed further in **Section G.4 Rainfall Monitoring Activities**.

G.2.1 Data Management

WRIMS, is a computer program that maintains a record of water resource withdrawals for the State of Hawaiʻi. WRIMS provides the basis for informed decisions that:

- Protect and sustain viable sources of ground and surface water in the state;
- Promote efficient and environmentally-compatible withdrawals of water resources;
- Provide best available information to resolve water disputes involving ground and surface water resources.

One of the primary functions of WRIMS is to allow CWRM water users to report their water-use via a web-based interface. Data is stored on secure, updated, backed-up daily servers in a highly-secure data center. WRIMS users will never have to download, install or update software and will only input data required by CWRM. The WRIMS water-use reporting function is accessible anywhere with a valid user name and password at:

- Department of Land and Natural Resources (DLNR), Commission on Water Resource Management (CWRM) website at http://dlnr.hawaii.gov/cwrm/;
- Go directly to the WRIMS website at http://dlnr.hawaii.gov/cwrm/info/waterusereport/.

Along with facilitating online water-use reporting, WRIMS is a statewide water resource information management system that is used by CWRM. A common data standard and domain helps to oversee and track permit activities, compliance responses, and water quantity tracking. WRIMS features tools to routinely upload data to fulfill regulatory directives/compliance and regulations, allow for graphing and mapping of data, schedule and track when deliverables/ reports are due from responsible parties, and evaluate sites for risk and allocate staff resources. WRIMS key features include:

- Water resource asset management (wells, diversions, aquifers, hydrologic units, etc.)
- Contact management system
- Complaints management
- Violations management
- Water use electronic reporting
- Electronic document management
- Permit application processing
- Data analysis and reporting

G.2.2 CWRM Ground Water Monitoring Programs in Hawaiʻi

CWRM is responsible for collecting basic hydrologic data and conducting water availability and sustainable yield analyses statewide. The purpose of the monitoring network is to meet the goals, policies, and objectives outlined in **Section G.1.1** by improving our understanding of (1) the movement and behavior of ground water within and between aquifer system areas; (2) the interactions between basal, dike impounded, and other ground water sources; (3) the interactions between ground water and surface water bodies; (4) the response of individual aquifers and ground water systems to changes in land use and climate; and (5) the impacts of ground water withdrawals on aquifers and ground water systems.

CWRM's monitoring activities support the protection, conservation, planning, and utilization of water resources for social, economic, and environmental needs, as mandated by the State Water Code. The information presented below describes CWRM's monitoring activities, as well as monitoring programs undertaken in cooperation with the USGS and the Honolulu BWS. On Oʻahu, CWRM, USGS, and Honolulu BWS have robust monitoring networks; however, monitoring networks in other counties are not as expansive and area data in most cases, is lacking.

G.2.2.1 CWRM Deep Monitor Well Program

Hawaiʻi's unique volcanic geology provides for large aquifers that are able to support the State's population by supplying domestic and municipal potable ground water, as well as water for agriculture and other purposes. These aquifers are naturally replenished by precipitation and, in some areas, by irrigation return flow. Because fresh ground water is less dense than seawater, it floats on top of the saline water, forming what is known as a Ghyben-Herzberg lens, referred to in Hawaiʻi as a "basal" aquifer (see **Appendix F** for a discussion of the Ghyben-Herzberg relationship). According to the Ghyben-Herzberg relationship, for every foot of freshwater above sea level, there is 40 feet of freshwater below sea level. Between the freshwater and saltwater boundaries of the lens is a zone of mixing, known as the "transition zone."

In Hawaiʻi, the chloride-ion concentration (milligrams per liter, or mg/L) is used to determine the freshness or saltiness of ground water. It is also listed as a contaminant in the EPA Secondary Drinking Water Regulations. The Hawaiʻi Revised Statutes do not define "potable water," but the law does provide for the establishment of maximum contaminant levels for various chemicals, as well as other parameters for drinking water quality. While CWRM defers to DOH on most water quality related matters, CWRM management principles utilize operational water quality definitions based on chloride concentration as follows:

- **Fresh Water:** Chloride concentrations from 0 to 250 milligrams per liter (mg/L)
- **Brackish Water:** Chloride concentrations from 251 to 16,999 mg/L
- **Seawater:** Chloride concentrations of 17,000 mg/L and higher

Chloride in small concentrations is not harmful to humans, but in concentrations above 250 mg/L, or two percent that of seawater, it imparts a salty taste in water that is objectionable to many people. By definition, the transition zone is the vertical zone with water quality that varies from 250 mg/L chloride to 19,000 mg/L chloride (approximately seawater). The midpoint of the transition zone (MPTZ) is defined as the area in the vertical profile where the water contains 9,500 mg/L chloride. Because the amount of water that can be developed from a freshwater lens for potable use is constrained by the salinity of the water, the altitude of the top of the transition zone (where chloride concentration is two percent that of seawater) and the thickness of the transition zone are important. The transition zone is in constant flux, responding to changes caused by variations in pumping and ground water recharge.

A deep monitor well penetrates the entire water column from freshwater into saltwater (see **Figure G-1 Schematic Diagram** of a Deep Monitor Well). Well data is used to track the changes in and movement of the transition zone over time. This can be accomplished either by direct sampling at discrete elevations (below mean sea level) or by lowering an instrument known as a CTD logger, which measures changes in the electrical conductance, temperature, and depth of the water, to the bottom of the well. The saltier the water, the greater the conductivity. A sample graph of CTD data, indicating the changes in water salinity and temperature with depth, is shown in **Figure G-4**.

Going inland, water levels increase and the elevation of the MPTZ below mean sea level decreases. Ideally there should be enough deep monitor wells to provide data that adequately defines the vertical cross-section of the transition zone from the mountains to the sea. The deep monitor wells should be roughly located on a mauka to makai orientation. Often, three properly spaced deep monitor wells within each aquifer system area are adequate for this purpose.

Table G-1 lists the deep monitor wells included in the CWRM program. CWRM owns and operates deep monitor wells on Oʻahu, Maui, and Hawaiʻi. Two deep monitor wells are located in the Keauhou Aquifer System Area (ASA) on the island of Hawaiʻi, where there are concerns of development in West Hawaiʻi negatively impacting regional water resources. Four deep monitor wells are located on Maui: two in the ʻĪao ASA, which is an essential municipal water source for the Maui Department of Water Supply and is showing signs of over-pumpage, one located in the adjacent Waiheʻe ASA to provide data to augment information collected from the ʻĪao ASA wells, and one located in the Honokōwai ASA near Lahaina in west Maui. Six deep monitor wells are located in the Pearl Harbor Aquifer Sector Area, which is the most important ground water supply on Oʻahu.

Figure G-4 Sample Graph of CTD Data from a Deep Monitor Well

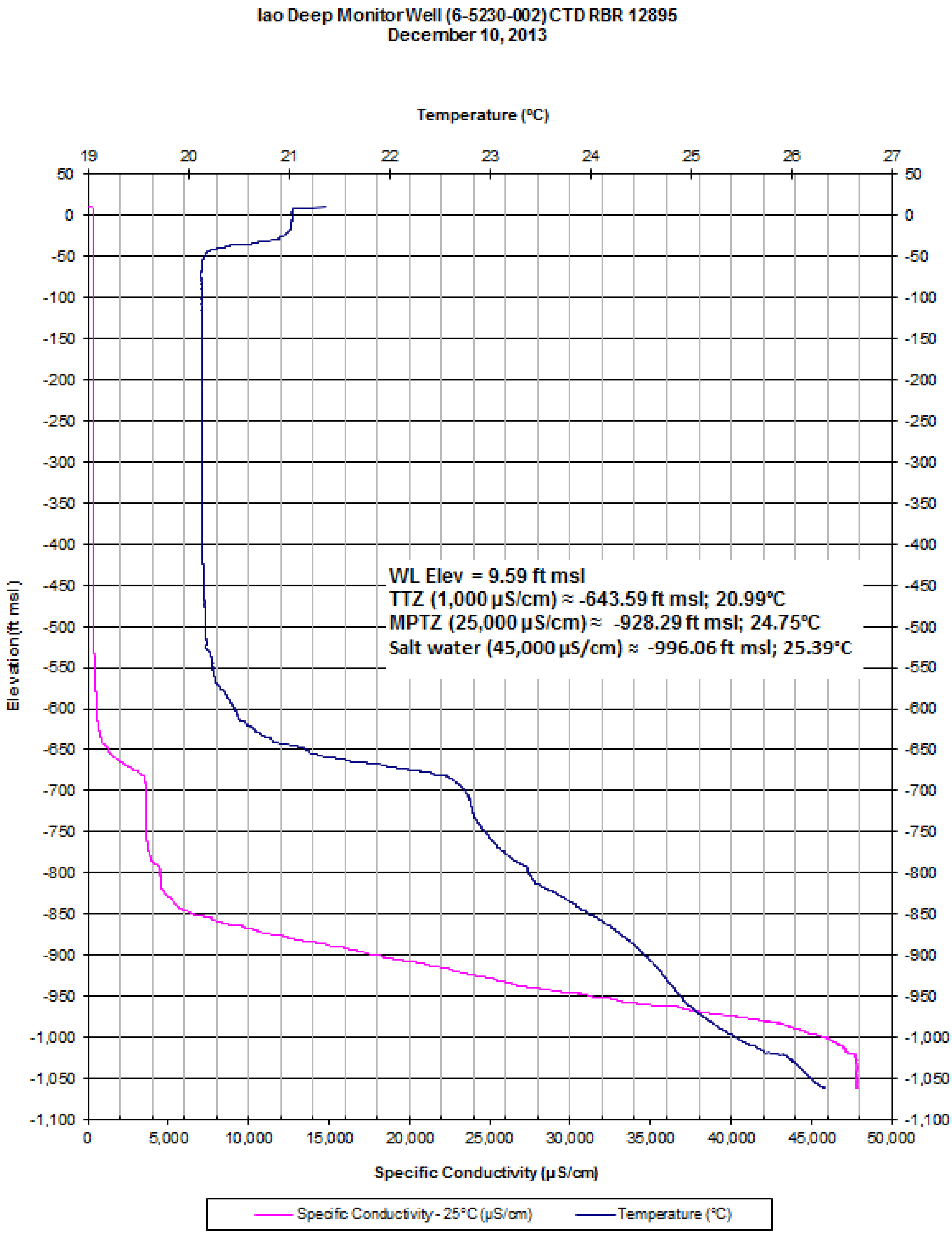


Table G-1 Summary of CWRM Deep Monitor Wells

Island	Aquifer System Area Code	Aquifer System Area Name	Well Number	Well Name
Hawaiʻi	80901	Keauhou	8-3457-004	Kahaluʻu Deep Monitor
Hawaiʻi	80901	Keauhou	8-3858-001	Keōpū Deep Monitor
Maui	60102	ʻĪao	6-5230-002	ʻĪao Deep Monitor
Maui	60102	ʻĪao	6-5430-005	Waiehu Deep Monitor
Maui	60103	Waiheʻe	6-5631-009	Waiheʻe Deep monitor
Maui	60203	Honokōwai	6-5739-003	Lahaina (Māhinahina) Deep Monitor
Oʻahu	30201	Waimalu	3-2253-003	Hālawa Deep Monitor
Oʻahu	30201	Waimalu	3-2456-005	Waimalu Deep Monitor
Oʻahu	30203	Waipahu-Waiawa	3-2300-108	Waipahu Deep Monitor
Oʻahu	30203	Waipahu-Waiawa	3-2659-001	Waipiʻo Mauka Deep Monitor
Oʻahu	30204	ʻEwa-Kunia	3-2403-002	Kunia Middle Deep Monitor
Oʻahu	30204	ʻEwa-Kunia	3-2503-003	Kunia Mauka Deep Monitor

(CWRM DMW Locations shown on **Figure G-2**)

G.2.2.2 Analysis of Selected Aquifer System Areas

As noted above, CWRM has constructed deep monitor wells and established monitoring networks in aquifers facing development pressures and those that are major sources of drinking water supply. **Table G-5** provides a summary of all registered observation wells in Hawaiʻi. Currently there are 357 observation wells, including 45 DMWs, in the state. Wells that are currently classified as unused (896 wells) could potentially provide additional data points for water levels, chlorides, and temperature.

In 2014, CWRM conducted an analysis of current and historic hydrologic data in the following eight selected aquifers to examine aquifer trends, to assess aquifer health and viability, and to develop management recommendations based on the findings. The eight aquifer system areas selected for analyses are: ʻĪao and Waiheʻe aquifer systems on Maui; Waimalu, Waipahu-Waiawa, and ʻEwa-Kunia aquifer system areas on Oʻahu; and the Kealakekua, Keauhou, and Kīholo aquifer system areas on Hawaiʻi.

In each of the above areas historical ground water data from CWRM, USGS, BWS, and a variety of historical sources were compiled to identify hydrologic trends. The identified trends were then analyzed to determine contributing factors so that management and/or monitoring recommendations could be made. This provides CWRM with a critique of the current management and monitoring actions being implemented in these important aquifer systems.

The findings of this report are summarized in the sections below. For the most part, the estimated sustainable yields for each aquifer system appear to be appropriate.

G.2.2.3 Kona Ground Water Monitoring Program

Since 1991, CWRM has collected ground water elevation measurements in public and private wells and test holes throughout the North and South Kona and South Kohala Districts of the County of Hawaiʻi. In September 2003, CWRM published the findings and conclusions of area monitoring activities in a report titled "A Study of the Ground-Water Conditions in North and South Kona and South Kohala Districts, Island of Hawaiʻi, 1991-2002."[2] The background information summarized in CWRM's 2003 and 2014 reports, and the findings of the Kona ground water monitoring activities to date, are presented below.

During the 1980s and through the early 1990s, and continuing into the current millennium, Kailua-Kona has experienced tremendous growth. Associated with the activities of the early 1990s was the high demand on water supplies and competition among large landowners and developers for new sources. As wells were drilled, new and interesting geological and hydrological information began to emerge that spurred additional wells at higher elevations, and at greater cost.

CWRM initiated a series of meetings in the North Kona and South Kohala Districts among the major landowners, developers, engineers, and hydrologic consultants, in order to come to agreement as to the proper development of ground water resources. This effort was in response to competition for well-site locations and CWRM concerns regarding planning, well placement, and well interference. Two ad-hoc groups were formed: 1) The Hualālai Users Group focused on problems near Kailua-Kona and the North Kona District, and 2) the Lālāmilo Users Group that focused on problems related to the South Kohala District. These meetings provided an avenue for collaboration and to forestall designation of the West Hawaiʻi region as a ground water management area due to concerns that the rates, times, spatial patterns, or depths of and existing potential withdrawals of ground water are endangering the stability or optimum development of the ground water body. As these meetings took place, it became clear that good baseline ground water data was sparse and that major decisions were not made using a "complete data-set," but rather by incomplete knowledge of the resource. It was for this reason that CWRM started its ground water monitoring program in West Hawaiʻi.

From 1959 to 1978, average daily pumpage for the aquifer system increased from less than 1 to about 3.5 MGD. With the Kahaluʻu Shaft coming online in mid-1979, average pumpage increased to between 5 and 6 MGD. Prior to the development of the high-level wells, increasing water use demands were met by increasing pumpage from the Kahaluʻu wells and shaft, so by the mid-1980's to mid-1990's, average pumpage was averaging about 8 MGD. When the high-

[2] Bauer, G. R. A Study of Ground-Water Conditions in North and South Kona and South Kohala Districts, Island of Hawaii, 1991-2002. State of Hawaii Department of Land and Natural resources Commission on Water Resource Management. 2003. PR-2003-01

level wells were installed, the withdrawal rate increased. As noted by Oki, the mean monthly pumpage in 1997 was 11.1 MGD, and 9.8 MGD of that amount was pumped by the Hawaiʻi Department of Water Supply (DWS)[3]. Average withdrawal of ground water at the end of 2012 was 12.8 MGD and 1.1 MGD of that was reported private pumpage.

In summary, total pumpage from the Keauhou aquifer is small when compared to the estimated sustainable yield and total average daily recharge into the system. Nevertheless, individual basal wells are affected by pumpage because the static water levels in these wells are 5 feet above MSL or less, and the chloride concentration in the water is sensitive to pumpage. The high-level wells are not affected in this way.

Currently, CWRM monitors 15 wells (2 DMWs and 13 water level wells) in West Hawaiʻi. Major findings and conclusions listed below are based upon the individual water-level measurements in high-level wells, and water level measurements in the basal wells from 1991 through January 2014:

- The data strongly suggests a slow decline of water levels in some of the high-level wells, and an apparent relationship to water-level decline and climatic conditions as recorded in the Lanihau and Huʻehuʻe Ranch rain gages. Prior to pump installation, future wells drilled into this resource should be used as observation wells to verify the trends documented in the CWRM report.

- The data suggests that the high-level wells tap interconnected, though bounded, aquifers whose rate of water level decline is inversely proportional to its volume. Future well drilling for high-level potable sources must include accurate, well-designed aquifer tests that will aid in the determination of geologic boundaries to provide information on the geometry of the aquifer.

- The data suggests that there may be more than one geological mechanism that created the high-level aquifer and perched water above the high-level aquifer area may be significant.

- The data suggests that there is a water-level pattern observed in the high-level wells with Keōpū being the “drain” for the ground water flow system. The ground water flux south of Keōpū is to the north, and north of Keōpū, the ground water flow is to the south.

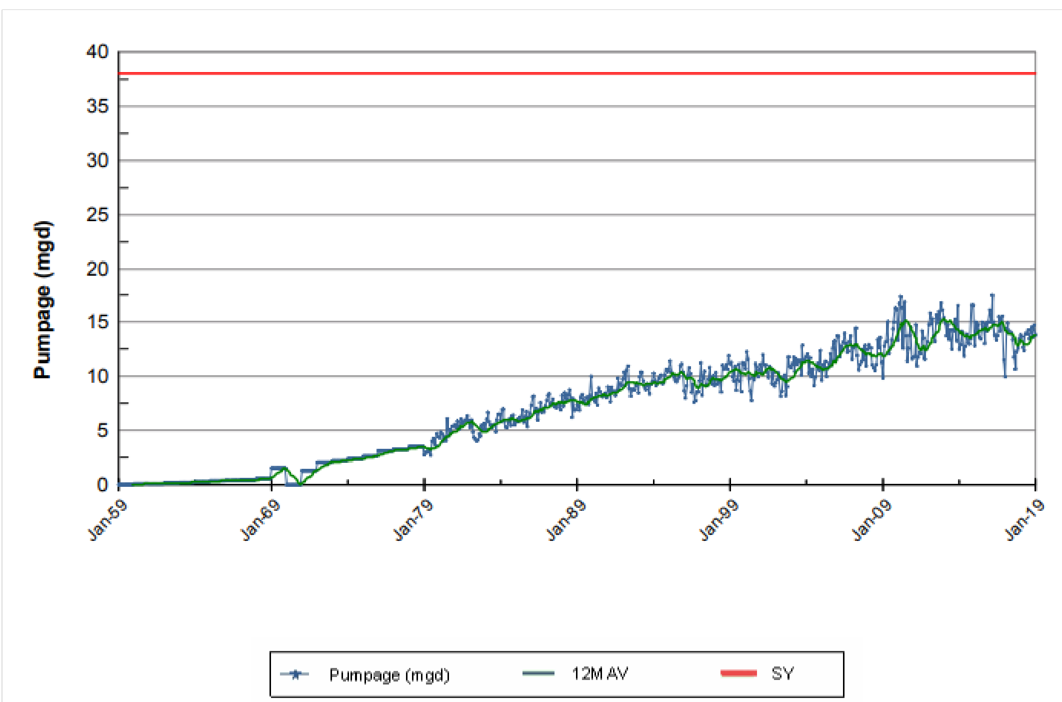
- Two deep monitoring well drilling projects, Keōpū DMW (8-3858-001), and Kamakana (8-3959-001), intercepted deep fresh water zones beneath the saltwater zone. Horizontal extent and capacity of this deep freshwater zone is unknown but may be a potential additional freshwater source for the Kona area.

[3] Oki, D. S., 1999, Geohydrology and numerical simulation of the ground-water flow system of Kona, Island of Hawaii: Water Resources Investigations Report 99-4073, prepared in cooperation with CWRM and NPS, 70 p.

- Some high-level wells do exhibit declining water levels over time. Long-term, continuous water-level monitoring should continue in these wells. Real-time correlation between water levels in the wells with climatic conditions measured at Lanihau Rain Gage will provide better insight into the behavior of the potable high-level aquifers.
- The data suggests the influence of climate over long-term trends in the basal aquifers.
- The strong correlation between well pairs will aid in predicting a water level, if only one of the wells can be measured.
- The data suggests that the variability of the ground water flow direction in a shallow basal lens system, as can be seen at the West Hawaiʻi Landfill, is translatable to other areas.
- The low ground water gradients suggest a highly permeable basal coastal aquifer where basaltic lavas comprise the aquifer, and this finding is supported by tidal analysis. The composition of the lava flows determines its permeability, and in turn, the ground water gradient.
- This data will become the calibration target for future numerical and analytical ground water models and will aid in the site selection for new wells.

CWRM review of reported water levels, temperatures and chlorides from production wells in the Keauhou ASA indicate that the data needs to be more comprehensively accurate and complete.

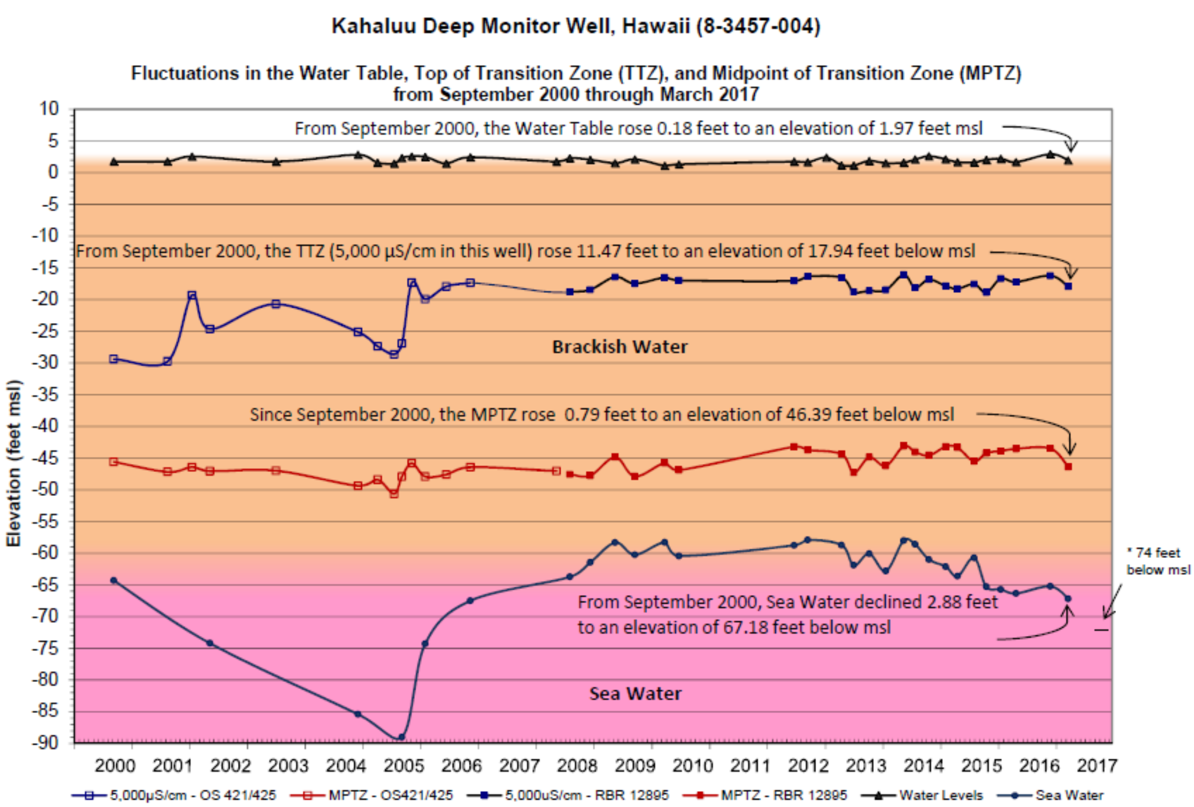
Figure G-5 Average Pumpage for Wells Within the Keauhou Aquifer System



Currently two deep monitoring wells in the Kona area are being monitored quarterly for conductivity and temperature. Presented below in **Figure G-6**, the fluctuations of the water table, top and midpoint of the transition zones, and the sea water interface at the Kahaluʻu Deep Monitoring Well are shown from September 2000 through January 2014.

The top of the transition zone (TTZ) is rising more quickly than both the MPTZ and sea water levels, indicating a thickening of the brackish water lens or localized upconing. This is likely due to the Hawaiʻi DWS supply wells skimming fresh water from the top of the thin basal lens directly upslope of this well. Given the 2.09 foot of head above MSL, the midpoint of the transition zone at equilibrium should be 83 feet thick using the Ghyben-Herzberg equation. The MPTZ was measured at 44 feet below MSL, or about half the equilibrium thickness of fresh water. This is due to the proximity of the monitoring well to a major pumping source for the Hawaiʻi DWS, which produces approximately 5 MGD from a thin basal freshwater lens. This also emphasizes the importance of placing monitor wells a significant distance from large pumping sources. **Figure G-7** below shows the relationship between pumpage and chlorides at the Kahaluʻu Shaft production well.

Figure G-6 Fluctuations in the Water Table, Transition Zones, and Sea Water in the Kahaluʻu Deep Monitoring Well

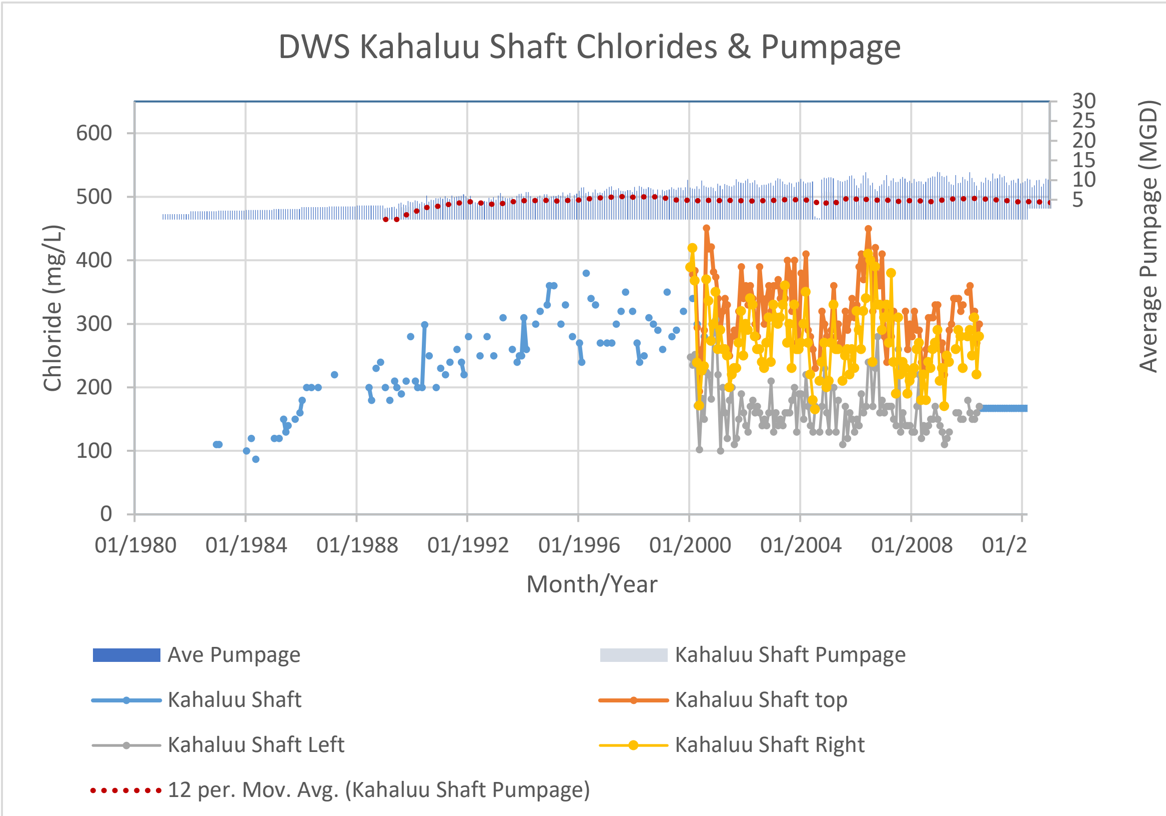


Notes: (1) Minimum conductivity in this well is greater than 1,000 µS/cm Therefore, TTZ = 5,000µS/cm; MPTZ = 25,000 µS/cm; (2) Fresh Water < 220 mg/L Cl^-, Brackish Water 220 mg/L CL^- to 16,999 mg/L Cl^-, Sea Water >= 17,000 mg/L Cl^-; (3) OS 421/425 = Ocean Sensors CTD (absolute conductivity); (4) RBR 12895 = RBR Global CTD (Specific Conductivity); (5) msl = mean sea level.

* Since the year 2000, the MPTZ rose 0.79 feet to an elevation of 46.39 feet below msl, where it is above a calculated Ghyben-Herzberg equilibrium elevation of 74 feet beow msl, relative to the Water Table measured at 1.97 feet above msl.

last updated 4/13/2017

Figure G-7 Pumpage and Chlorides at the DWS Kahalu‘u Shaft Production Well

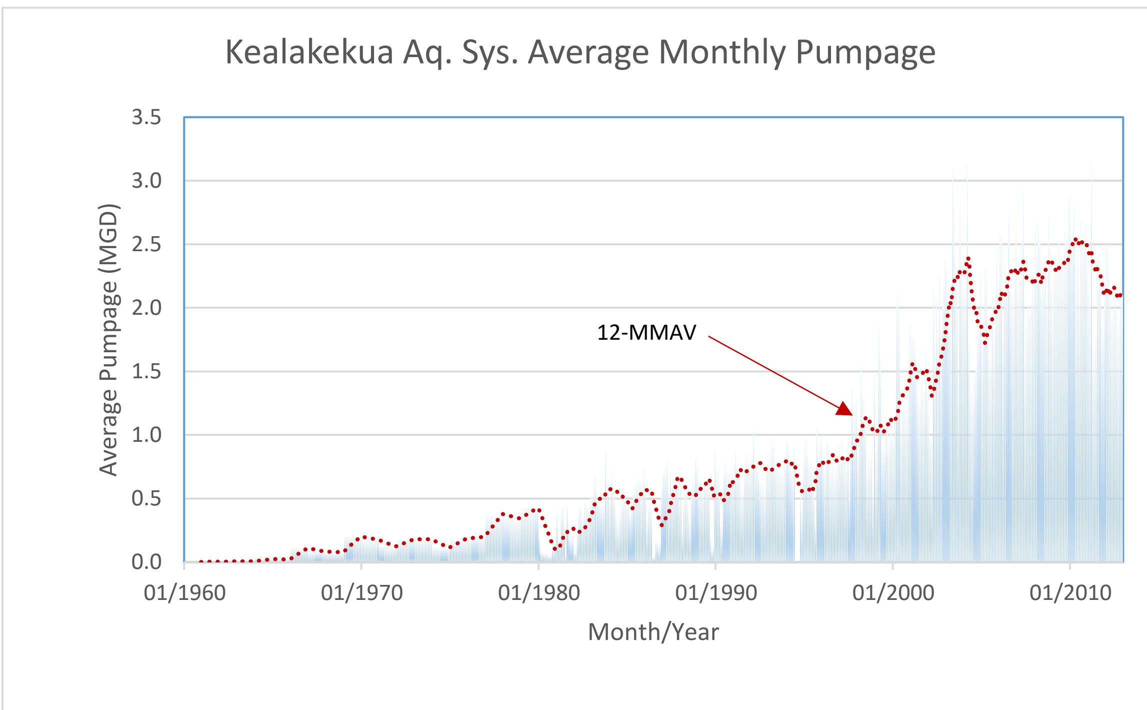


Kealakekua Aquifer System:
From 1960 to about the year 2000, average daily pumpage for the aquifer system remained below 2 MGD. Since 2000, the average daily pumpage has increased to between 2.5 and 3 MGD. Total pumpage is small when compared to the estimated sustainable yield and total average daily recharge into the system (see **Figure G-8**).

Individual wells with low basal heads are chloride-sensitive to pumping. The two high-level wells are not affected by pumping.

Long-term water levels for basal wells do not exist in the ground water database. Instantaneous water level measurements taken at the USGS high-level observation well since 1991 shows a steady decline in water level that is attributed to climate.

Figure G-8 Average Pumpage for Wells Within the Kealakekua Aquifer System

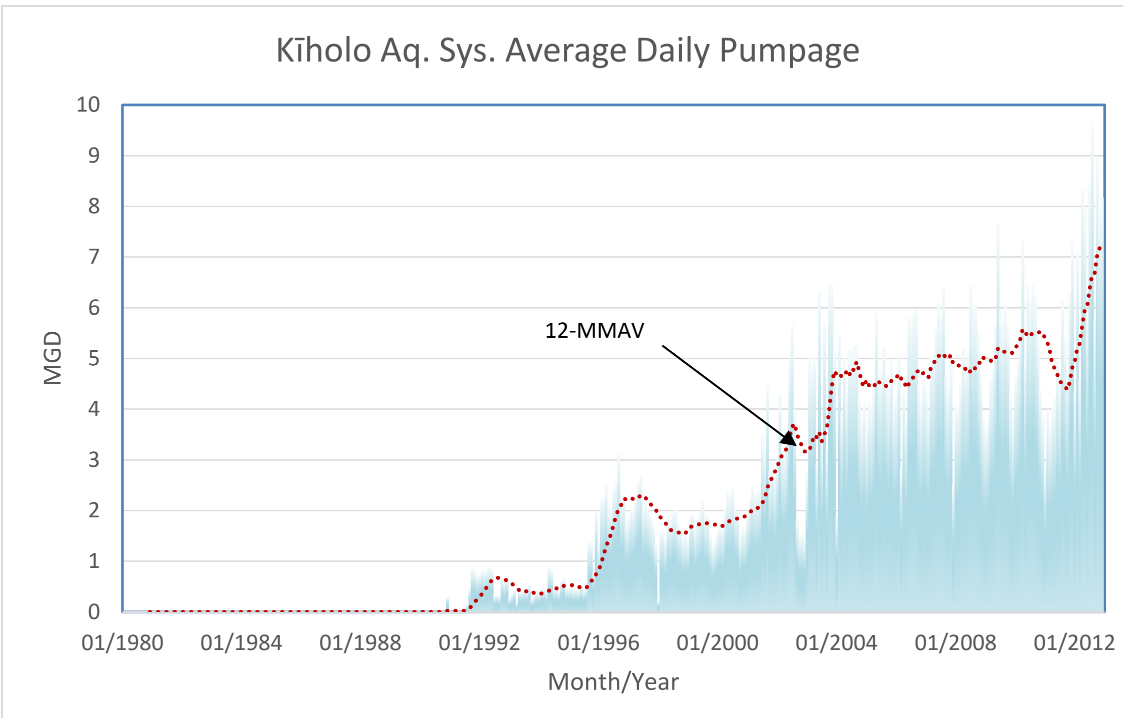


Kīholo Aquifer System:
Pumpage averages about 8 MGD in the aquifer system. This is less than 50 percent of the estimated sustainable yield. Irrigation and potable wells each produce about half of the total average pumpage.

The salinity in the basal potable and irrigation wells is marginal. Irrigation wells have lower water levels and are sensitive to pumping. The wells that have elevated water levels are much fresher.

Water levels in the basal sources seem to be loosely correlated to climatic conditions but are more related to ocean tidal signals transmitted through very permeable lava flows. The only elevated water level well with data, HR-5, responds to head changes differently due to a thick trachyte lava flow(s) overlying the aquifer.

Figure G-9 Average Daily Pumpage in the Kīholo Aquifer System Since 1991



Recommendations for the Kona Area include:

- Expand the network of basal and high-level monitoring wells.
- Coordinate with other ground water researchers to determine a prospective location, and design, core, and install a new DMW in the boundary zone between basal and high-level aquifers to better understand the hydrologic conditions of the boundary.
- Explore the origin, transport, and fate of perched water bodies and their relationship with the high level and basal aquifers.
- Long-term, continuous water-level monitoring should continue in high level wells, combined with correlating water levels in the wells with climatic conditions measured at Lanihau Rain Gage to provide better insight into the behavior of the potable high-level aquifers.
- Use information derived through USGS refinement of their numerical ground water model to better understand the relationship and connectivity between perched, basal, and high-level ground water.
- Conduct a geodetic survey and synoptic water level survey to determine current water levels.
- Continue to work with well owners and reporters to improve the quality and timeliness of their data reporting.

G.2.2.4 Maui Ground Water Monitoring Program

Three aquifer system areas on Maui are currently monitored quarterly by four deep monitoring wells: two wells in the ʻĪao ASA, one in the Waiheʻe ASA, and one in the Honokōwai ASA.

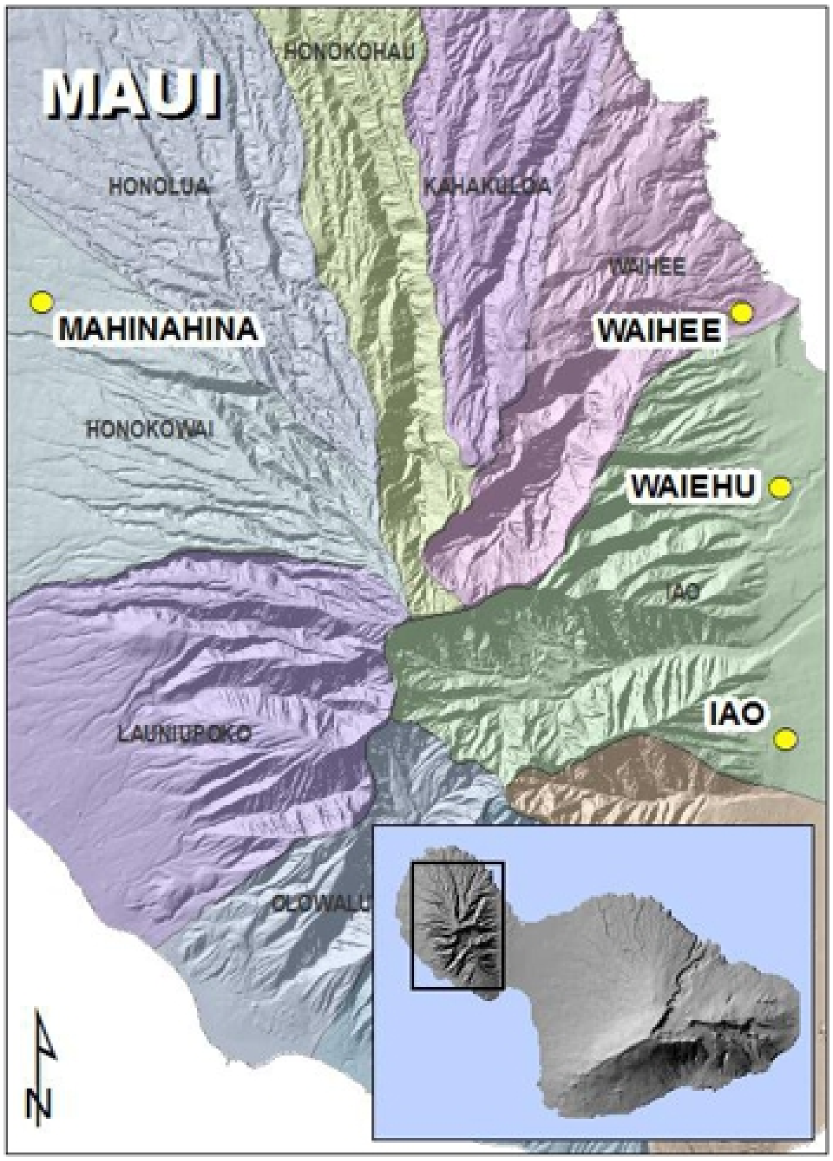
Measuring water levels in the ʻĪao ASA began before ground water development. The first test hole was drilled in 1940 and produced the first measured basal water level of 31.98 feet, MSL. Since 1940, 14 other test wells were drilled. Water levels have declined over time as a result of heavy pumping of DWS sources. However, after 1997 water levels started to rise as a direct result of lower pumping.

CWRM drilled two deep monitor wells in the ʻĪao Aquifer System. Waiehu Deep Monitor Well was constructed in 1982, and the ʻĪao Deep Monitor Well was completed in 2006. The USGS and CWRM continue to measure water levels in the test holes as well as instantaneous measurements in the deep monitor wells, respectively.

Currently, CWRM monitors 4 DMWs in West Maui, with locations shown on **Figure G-10.**

ʻĪao Aquifer System Area: The average pumpage has been reduced since designation of ʻĪao Aquifer System Area as a Water Management Area in 2003. The current 12-month moving average is about 15 MGD and appropriate for the basal portion of the aquifer. The high-level aquifer withdrawal rate (2.5 MGD) is small compared to the basal wells. Spreading the pumpage out to new sources drilled south of ʻĪao Stream will help alleviate the concentrated pumping north of ʻĪao Stream. The result may increase water levels and reduce chlorides in some wells.

Figure G-10 CWRM Monitored DMWs in West Maui

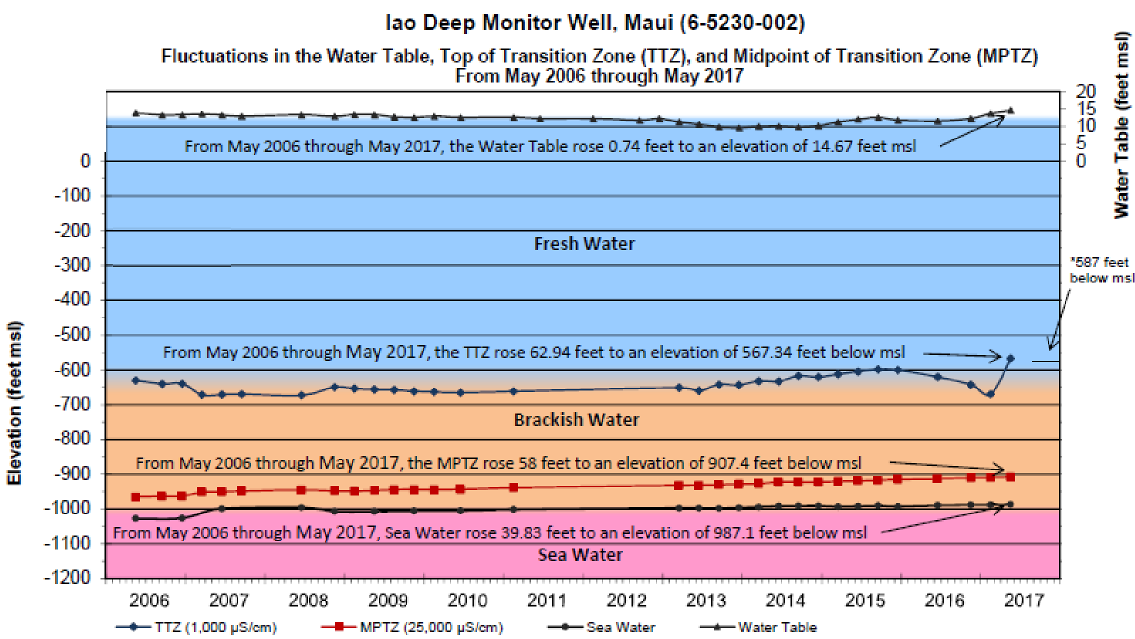


Chlorides in all DWS pumping wells north of ʻĪao Stream have risen over time, except for Kepaniwai which pumps dike-impounded ground water. New wells south of ʻĪao Stream will help reduce chlorides in existing sources.

Water levels have dropped significantly since 1940. After designation of ʻĪao as a water management area, pumping stabilized, although water levels at the ʻĪao DMW have continued to decline. Measured heads south of ʻĪao Stream are higher because pumpage is lower. Wet and dry periods also have an effect on heads as related to pumpage as an increase or reduction in recharge.

Chlorides in some wells are still problematic due to their depths. Backfilling may provide some relief from upconing. The large capacity pumps in other wells could be reduced as more water development occurs south of ʻĪao Stream to replace Shaft 33. Spreading out the pumpage will also help to reduce chlorides in some wells north of ʻĪao Stream and should cause water levels to rise at test holes that are near large pumping centers.

Figure G-11 Fluctuations in the Water Table, Transition Zones, and Sea Water in the ʻĪao Deep Monitoring Well



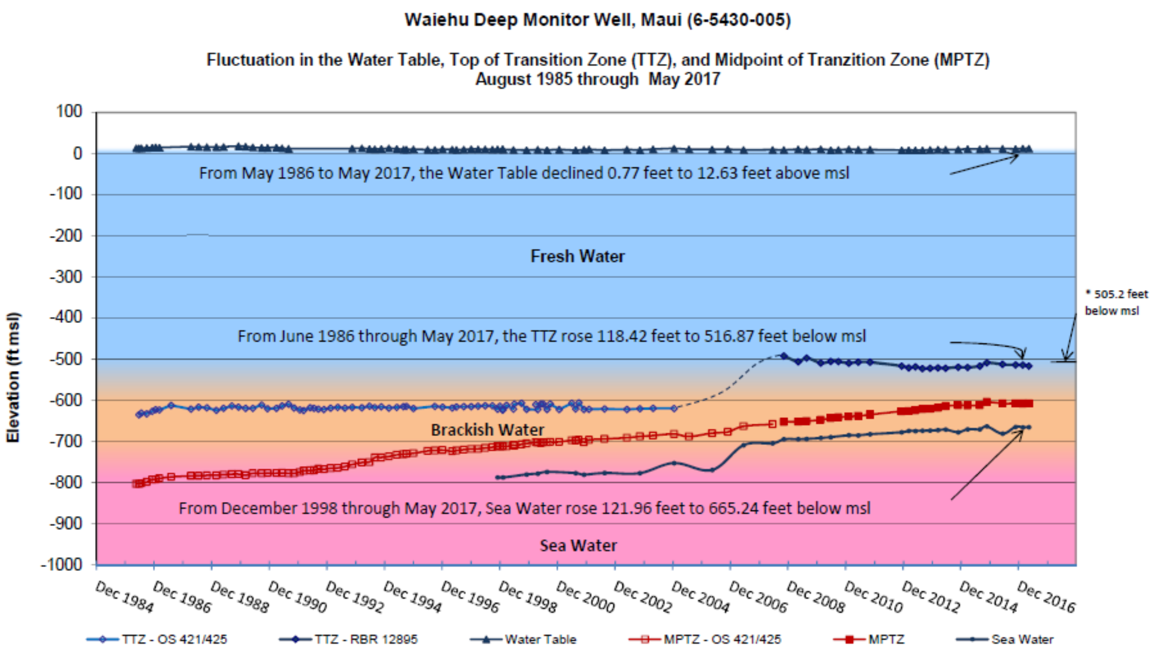
Notes: : (1) TTZ = 1,000 µS/cm (~ 220 mg/L Cl⁻); MPTZ = 25,000 µS/cm (~ 8,500 mg/L Cl⁻) (2) Fresh Water < 220 mg/L Cl¯, Brackish Water 220 mg/L CL¯ to 16,999 mg/L Cl¯, Sea Water >= 17,000 mg/L Cl¯; (3) OS 421/425 = Ocean Sensors CTD (absolute conductivity); (4) RBR 12895 = RBR Global CTD (Specific Conductivity); (5) msl = mean sea level.

* Since the year 2006, the MPTZ rose 58 feet, to near a calculated Ghyben-Herzberg equilibrium elevation of approximately 587 feet below msl, relative to the Water Table measured at 14.67 feet above msl.

last updated 5/26/2017

The water levels in the ʻĪao DMW have risen approximately 0.7 feet in the 11 years that it has been monitored. The TTZ has not changed substantially over that period, however, both MPTZ and sea water are rising towards a calculated Ghyben-Herzberg equilibrium elevation of 587 feet below MSL. Although the fresh water zone is currently much thicker than would be measured in an equilibrium condition, the declining head and rising MPTZ foreshadows a reduction in fresh water storage within the ʻĪao aquifer.

Figure G-12 Fluctuations in the Water Table, Transition Zones, and Sea Water in the Waiehu Deep Monitoring Well



Notes: (1) TTZ = 1,000 µS/cm (~ 220 mg/L Cl⁻); MPTZ = 25,000 µS/cm (~ 8,500 mg/L Cl⁻) (2) Fresh Water < 220 mg/L Cl⁻, Brackish Water 220 mg/L CL⁻ to 16,999 mg/L Cl⁻, Sea Water >= 17,000 mg/L Cl⁻; (3) OS 421/425 = Ocean Sensors CTD (absolute conductivity); (4) RBR 12895 = RBR Global CTD (Specific Conductivity); (5) msl = mean sea level

* Since the year 1985, the MPTZ has risen 196.14 feet, rising to near a calculated Ghyben-Herzberg equilibrium elevation of 505.2 feet below msl, relative to the Water Table measured at 12.63 feet above msl.

Updated 5/26/2017

Since monitoring began in 1985 in the Waiehu DMW, the position of the MPTZ has risen over time, while the TTZ has risen only slightly, and has been stable since 2008. From 1985 to 1999, the interpolated elevation of the MPTZ went from -803 ft., MSL to -713 ft., MSL or a rise of 90 feet. The TTZ during that same period went from -635 ft., MSL to -613 ft., MSL. The MPTZ seems to be rising linearly, but the position of TTZ changed dramatically in 2008.Chloride sampling by the USGS confirmed the sudden 90-foot rise of the TTZ. It is possible that borehole flow in the Waiehu Deep Monitor Well may be distorting actual chlorides at any given depth.[4]

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[4] Meyer, W. and T. K. Presley, 2001, The response of the Iao Aquifer to ground-water development, rainfall, and land-use practices between 1940 and 1998, Island of Maui, Hawaii: USGS Water Resources Investigations Report 00-4223, 60 p.

Waiheʻe Aquifer System Area: The first wells drilled this aquifer system were in 1981. The average ground water withdrawal at present is about 4 MGD, half of the estimated sustainable yield of 8 MGD, with most of the pumpage concentrated at the south end of the aquifer system. Pumpage needs to be spread out.

The salinity in the Waiheʻe Aquifer System Area is low, though at the Kānoa well field, chloride content is sensitive to pumping. The North Waiheʻe wells are stable.

Water level measurements by the USGS have been done in a number of Waiheʻe Aquifer System Area wells since 1988. However, the USGS working with the National Geodetic Survey (NGS) found discrepancies between the assumed benchmarks and measuring points for a number of wells. In some instances, the differences in the benchmark elevation caused the measured water levels to be lowered by as much as 1.66 ft. at the Kānoa Test Hole. In summary, water levels in the Waiheʻe Aquifer System are stabilizing, though remain low (see **Figure G-13**). Prior to 1997, climate, and perhaps pumping in ʻĪao, had an effect on the decline. The rise of 0.5 feet in the Waiheʻe Deep Monitor Well is an indication of stability (see Figure G-13 for water levels and pumpage, and

Figure G-14 for corresponding chloride concentrations).

Figure G-13 Water Levels and Pumpage in the Waiheʻe Aquifer System

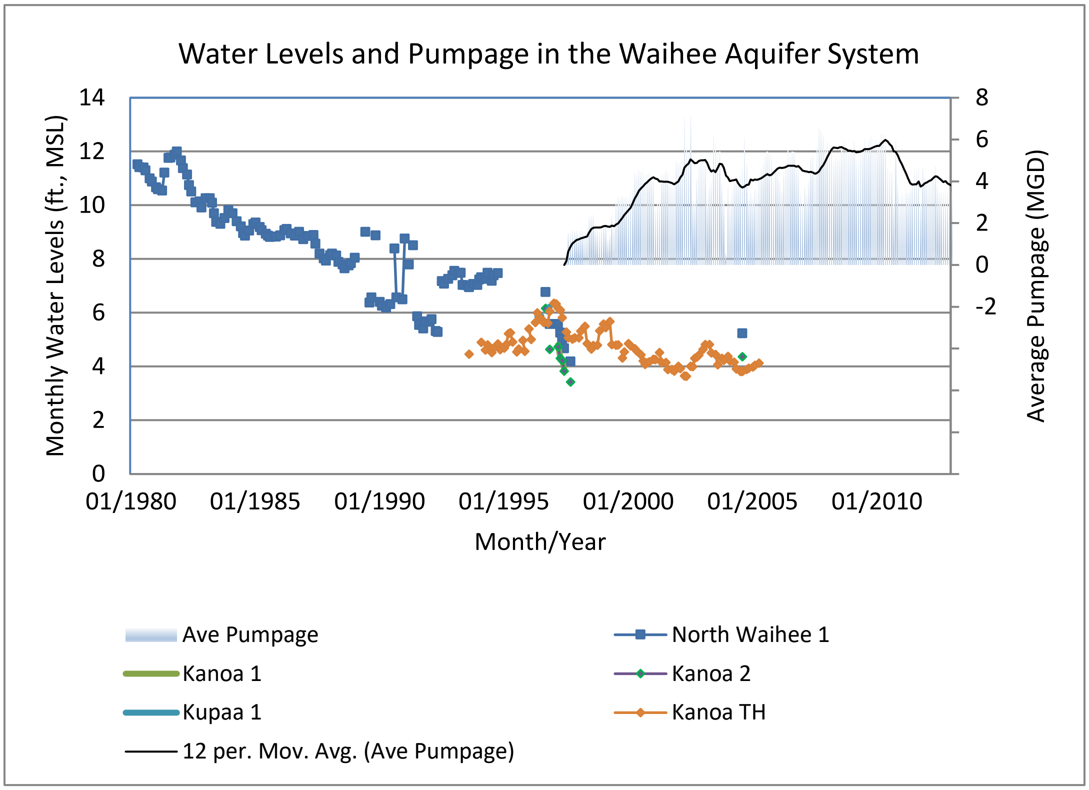


Figure G-14 Showing Relationship Between Pumpage and Chlorides in DWS Waihe‘e Wells

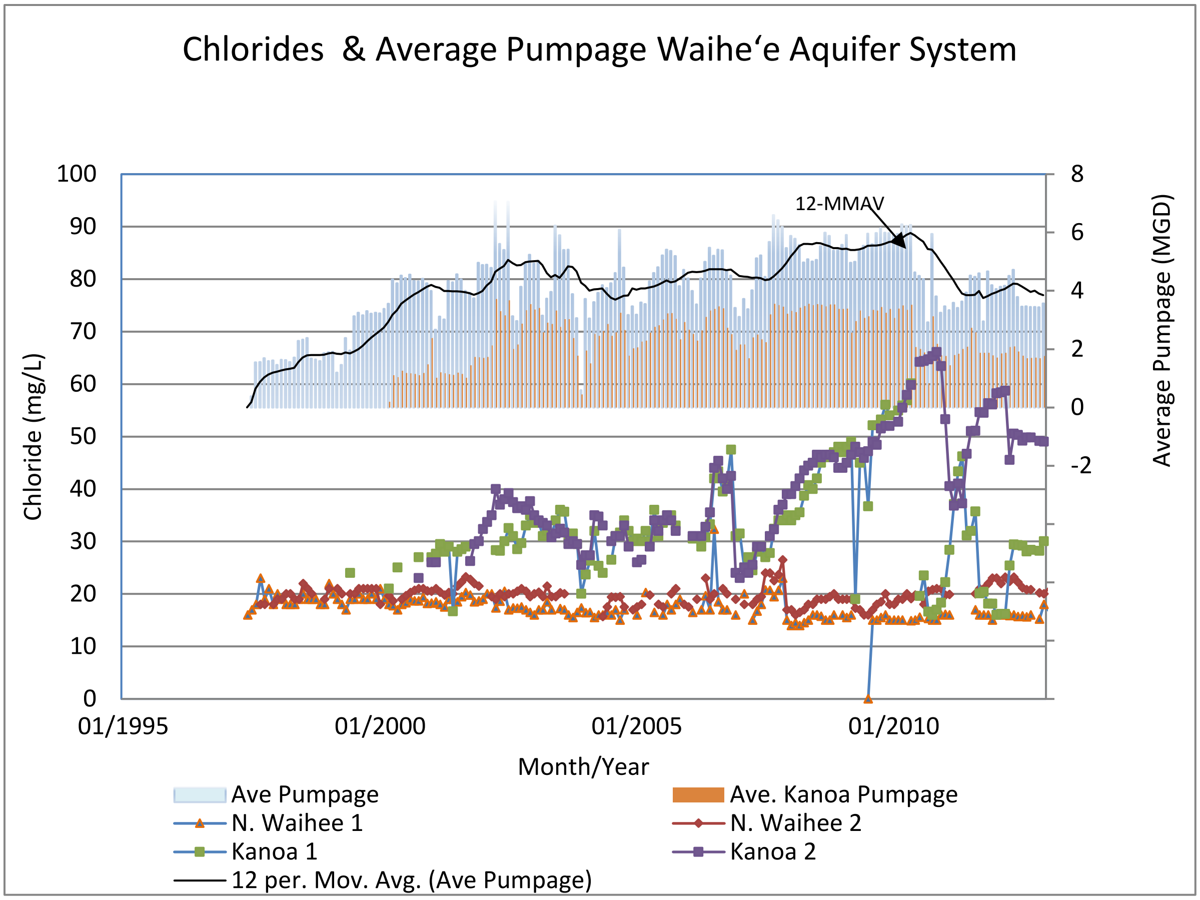
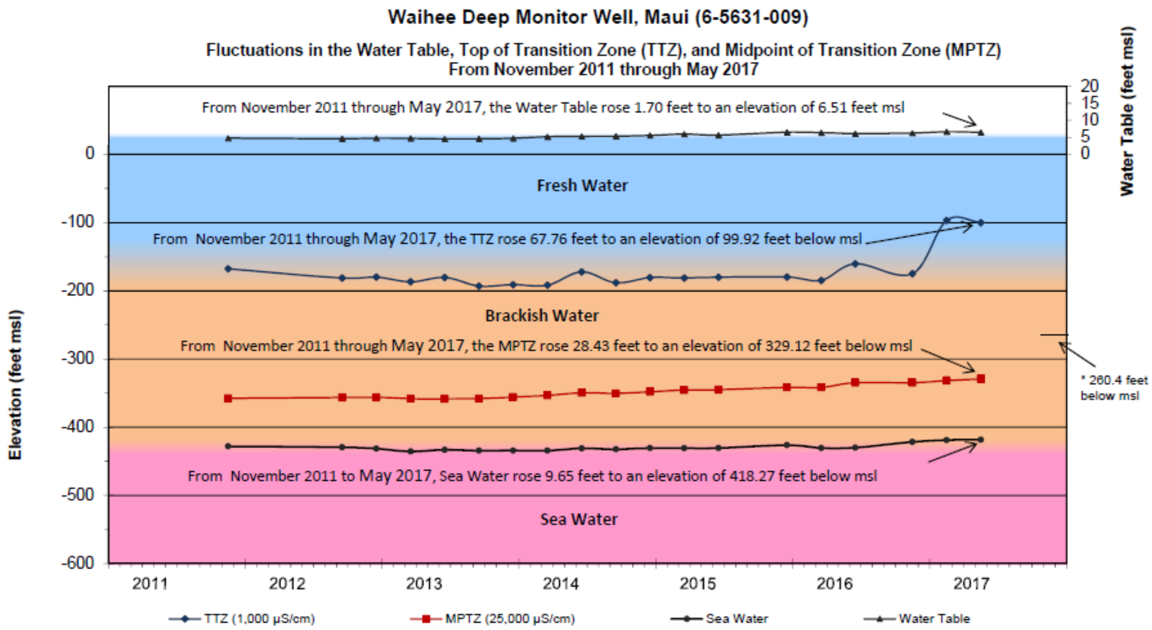


Figure G-15 Fluctuations in the Water Table, Transition Zones, and Sea Water in the Waihe‘e Deep Monitoring Well



Notes: : (1) TTZ = 1,000 µS/cm (~ 220 mg/L Cl⁻); MPTZ = 25,000 µS/cm (~ 8,500 mg/L Cl⁻) (2) Fresh Water < 220 mg/L Cl¯, Brackish Water 220 mg/L CL¯ to 16,999 mg/L Cl¯, Sea Water >= 17,000 mg/L Cl¯; (3) msl = mean sea level.

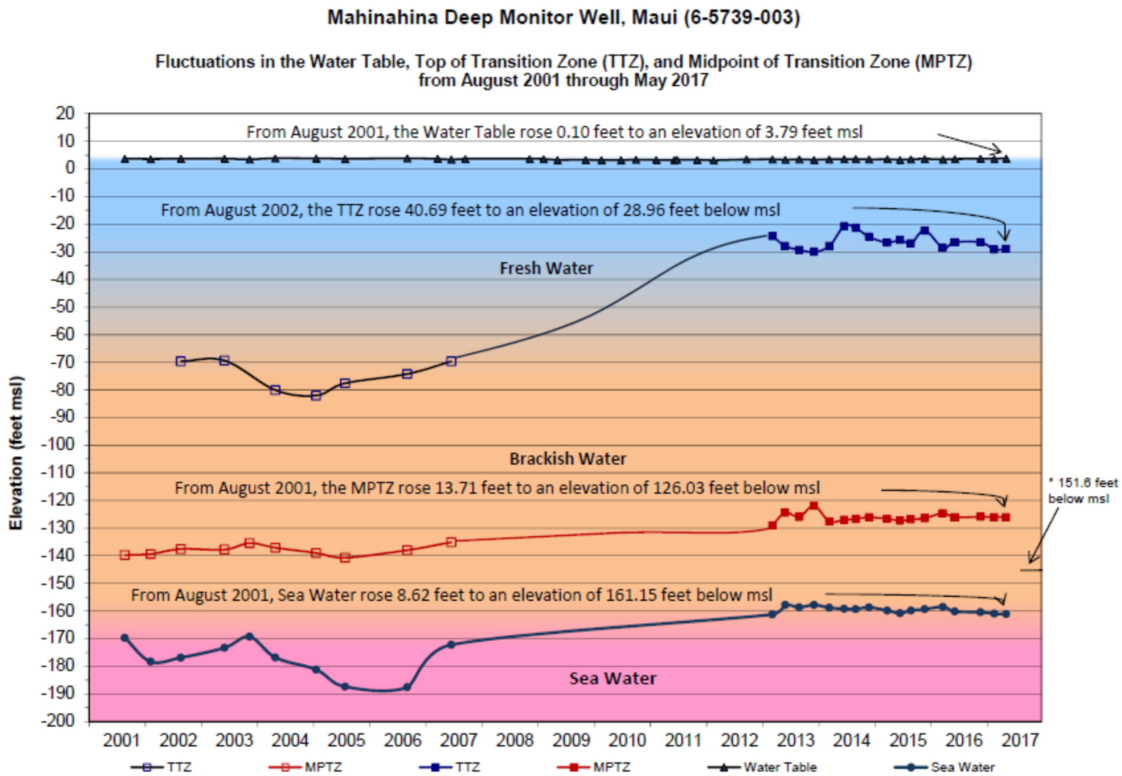
* Since the year 2011, the MPTZ rose 28.43 feet toward a calculated Ghyben-Herzberg equilibrium elevation of approximately 260 feet below msl, relative to the Water Table measured at 6.51 feet above msl.

last updated 5/26/2017

Honokōwai Aquifer System Area: Monitoring of the transition zone in this aquifer system began in 2001 with the installation on the Māhinahina Deep Monitoring Well, located at an elevation of 665 feet above MSL, upslope of the Kā‘anapali Airport.

The CTD profiles conducted since August 2001 indicate a thinning of the fresh water zone: the TTZ has risen nearly 50 feet, the MPTZ has risen 13 feet, and sea water rose 11 feet. The change in land use away from sugar cane, combined with the rise in construction and water demand in the Kā‘anapali and Honokōwai areas near the beach have imposed additional demands on the thin basal lens from wells installed upslope from the Māhinahina well, resulting in the upward trend of the top of the transition zone (TTZ), denoted the dramatic thinning of the fresh water lens in recent years.

Figure G-16 Fluctuations in the water table, transition zones, and sea water in the Māhinahina Deep Monitoring Well



Notes: : (1) TTZ = 1,000 µS/cm (~ 220 mg/L Cl⁻); MPTZ = 25,000 µS/cm (~ 8,500 mg/L Cl⁻) (2) Fresh Water < 220 mg/L Cl¯, Brackish Water 220 mg/L CL¯ to 16,999 mg/L Cl¯, Sea Water >= 17,000 mg/L Cl¯; (3) OS 421/425 = Ocean Sensors CTD (absolute conductivity); (4) RBR 12895 = RBR Global CTD (Specific Conductivity); (5) msl = mean sea level. Conditions inside the well prevented successful CTD deployment from 2006 through 2012, CTD profiling of this well was resumed 3-13-2013.

* Since the year 2001, the MPTZ rose 13.71 feet, to an elevation of 126.03 feet below mean sea level, where it is above the calculated Ghyben-Herzberg equilibrium elevation of 151.6 feet below msl, relative to the Water Table, measured at 3.79 feet above msl.

last updated 5/26/2017

Recommendations for Maui include:

- CWRM staff will deploy a vertical flow meter in the Waiehu DMW to detect measurable vertical borehole flow.
- Continue to monitor position of the TTZ and MPTZ and water levels quarterly
- Work with Maui DWS and USGS to determine validity of West Maui numerical model.

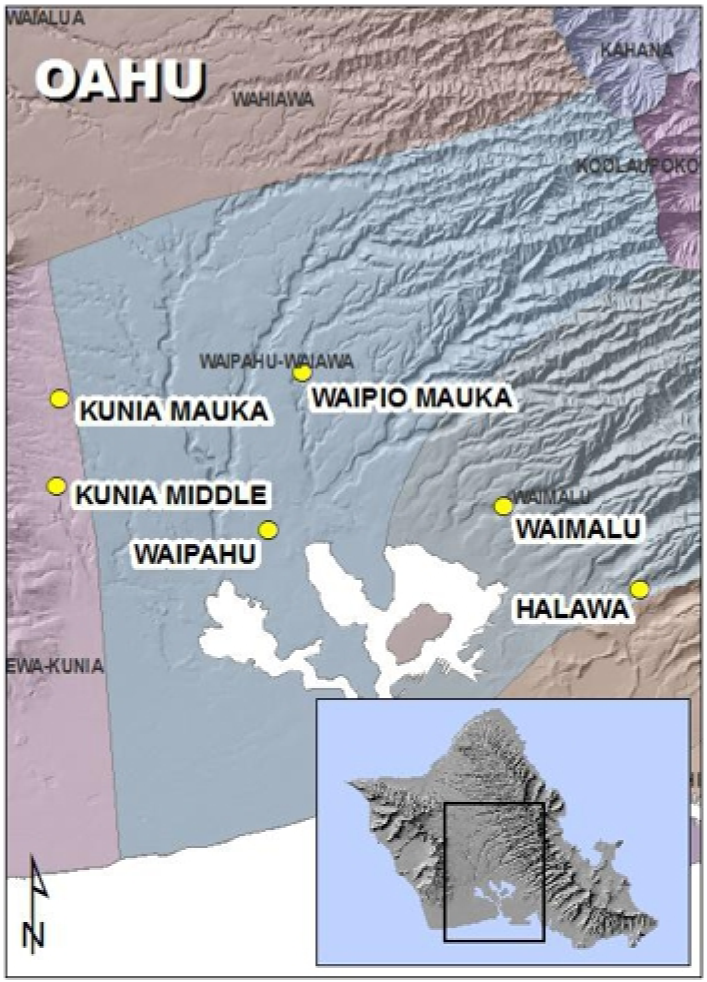
G.2.2.5 Pearl Harbor Ground Water Monitoring Program

The Pearl Harbor Aquifer Sector Area is comprised of the Waimalu, Waipahu-Waiawa, and ‘Ewa- Kunia Aquifer Systems. CWRM owns and monitors six deep monitoring wells in this Sector, two in the Waimalu Aquifer System and two in the ‘Ewa-Kunia Aquifer System.

Currently, CWRM monitors 6 DMWs in the Pearl Harbor ASA, with location shown on

Figure G-17.

Figure G-17 CWRM monitored DMWs in the Pearl Harbor ASA



Waimalu Aquifer System Area: Large scale ground water development in the Waimalu ASA began in 1899 with the development of Honolulu Plantation's Pump 2. Sugar cultivation created large withdrawal rates, but return irrigation water from furrow irrigation offset some the pumpage.

Although the average pumpage in the Waimalu ASA is near the estimated sustainable yield of 45 MGD, the average water use has declined slightly since the 1980's. This is in due to better management of the BWS integrated water system, increased monitoring of the resource though deep monitor wells, and by carefully monitoring chlorides in pumping wells that require action such as lowering pumpage, and/or "resting" of individual wells. Average total pumpage in the Waimalu ASA has been reduced 6.597 MGD since 1990.

Chlorides have risen over time for the larger BWS sources, even though the average pumpage has been slowly reduced. The small pumping stations remain relatively stable during the same period of time.

Water levels have declined in the Waimalu ASA since measurements were systematically collected starting in 1910. Return irrigation water kept the water levels higher than would be expected had no irrigation recharge input occurred. The war years saw a steep decline in area heads, but they recovered in the 1950's, only to decline again after the demise of sugar in this area. Since the late 1960's, water levels have remained relatively stable. Periods of dry or wet weather causes head variations of up to 6± feet.

There are six deep monitor wells in the Waimalu ASA (CWRM owns two of the six). From deep monitor well data, thicker zones of mixing are in the eastern part of Waimalu ASA where greater pumpage occurs. The Waimalu DMW shows a thickening of the fresh water zone, indicating stability within this area of the aquifer, with the TTZ and MPTZ declining towards a calculated Ghyben-Herzberg elevation of 753 feet below MSL, based upon a water level of 18.8 feet above MSL.

The January 2014 public disclosures of fuel releases from the Navy's Red Hill Fuel Facility (RHFF) prompted the Hawai‘i State Legislature to direct the HDOH to form and head a task force with members from the BWS, DOH, CWRM, U. S. Navy, Hawai‘i State Legislature, and the neighboring community representatives. The task force has met to address the issues facing the stakeholders and the community regarding the impacts to the drinking water aquifer beneath the RHFF. To date, the task force has assembled a draft report to the Legislature with recommendations to document the Navy's efforts to update the 70-year old facility, and to ensure Navy, BWS, and DOH participation in increased ground water and soil vapor monitoring, leak detection, and mitigation of releases to the environment.

Waipahu-Waiawa Aquifer System Area: The average daily pumpage for sugar cultivation between 1890 and 1960 was 92.1 MGD. Up until the early 1980's, sugar was irrigated using the furrow method. With the loss of agricultural lands tied with the increasing urbanization of the Pearl Harbor area, pumpage from BWS sources increased as new stations were added. During the decade from 1970 to 1979, the average pumpage was 155.4 MGD. Designation of the aquifer system in 1979 reduced pumpage. The demise of sugar cultivation in 1994, greatly reduced pumpage in the aquifer system. The average withdrawal rate from 1990 to 1999 was 69.2 MGD, from 2000 to end of 2012 the average pumpage dropped even further to 51.7 MGD.

High pumping rates and deep wells owned by the sugar companies contributed to the salting up of the Waipahu-Waiawa ASA below an elevation of 700 ft., MSL. Action by the state in adopting sustainable yields for state-wide aquifer systems, controlling the amount of pumpage, and limiting the depths of new wells allowed for the freshening of the potable sources since the mid-1990's.

Water levels in the Waipahu-Waiawa ASA are a function of pumpage, which is in turn influenced by climatic conditions. Since designation, water levels have continued to rise. There are eight deep monitor wells in Waipahu-Waiawa ASA (CWRM owns one of the eight). Deep monitor wells also show that the structure of the basal lens in Waipahu-Waiawa has been relatively stable over the last 20 years.

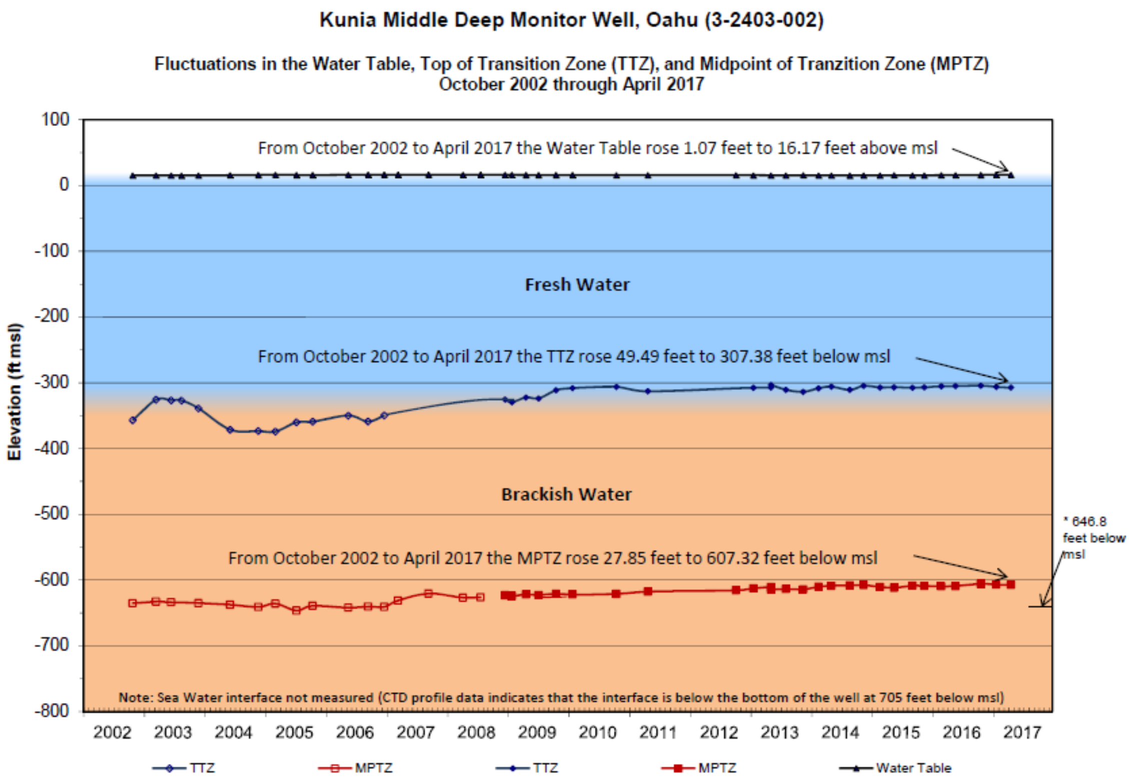
'Ewa-Kunia Aquifer System Area: For almost 90 years agricultural water use was high. In the 1970's and 80's agriculture combined with increasing urbanization led to a greater use of potable water provided by BWS and the Navy. Action by the state through the designation process to regulate pumpage, forced a decline in the average withdrawal rate. Pumpage is now 4 MGD less than sustainable yield.

Designation and the demise of sugar cultivation freshened up the 'Ewa-Kunia basal lens. Some BWS sources as well as the Navy Shaft have chloride concentrations that are sensitive to pumpage.

Water levels are several feet lower in the 'Ewa-Kunia ASA than in the Waipahu-Waiawa ASA. After designation and the cessation of sugar cultivation, water levels in observation wells stabilized. CWRM has two deep monitor wells in the aquifer system. The basal lens shows only a small rise in the MPTZ in both wells, otherwise the lens is stable.

The BWS and CWRM monitoring wells and data shows a stabilizing of water levels (refer to **Figure G-18** and **Figure G-19**). This indicates the current sustainable yield is greater than current pumping rates.

Figure G-18 Fluctuations in water level and transition zones in the Kunia Middle DMW

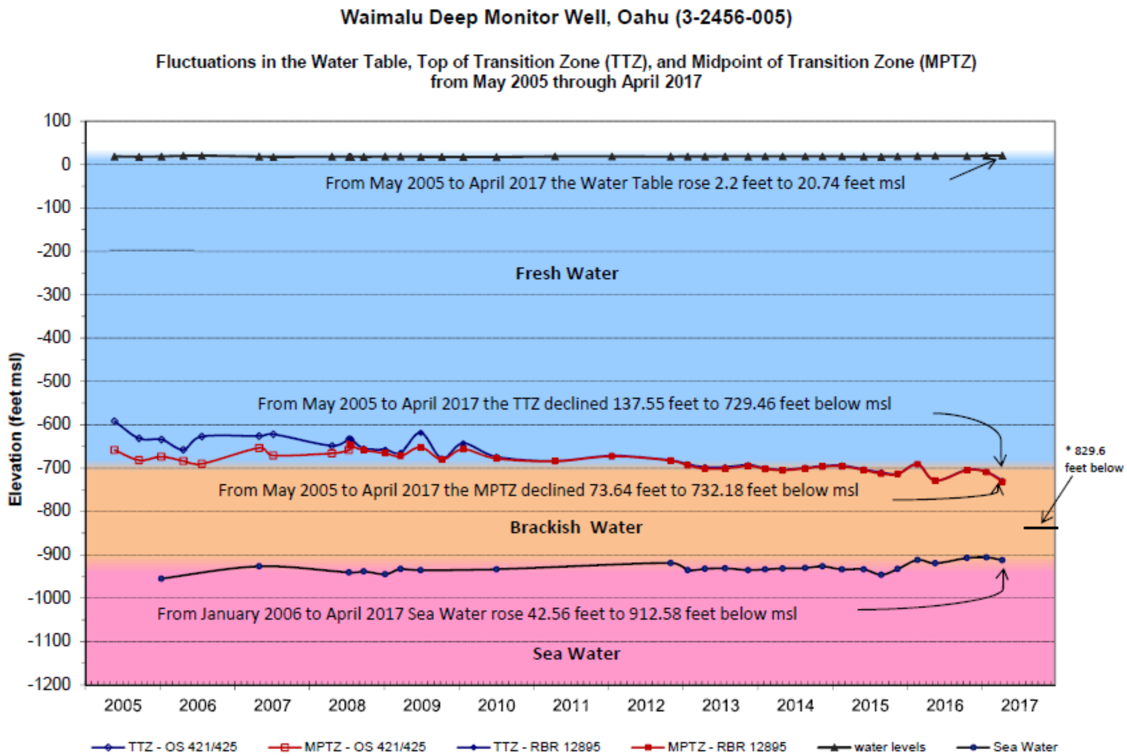


Notes: (1) TTZ = 1,000 µS/cm (~ 220 mg/L Cl⁻); MPTZ = 25,000 µS/cm (~ 8,500 mg/L Cl⁻) (2) Fresh Water < 220 mg/L Cl¯, Brackish Water 220 mg/L CL¯ to 16,999 mg/L Cl¯, Sea Water >= 17,000 mg/L Cl¯; (3) OS 421/425 = Ocean Sensors CTD (absolute conductivity); (4) RBR 12895 = RBR Global CTD (Specific Conductivity); (5) msl = mean sea level.

* Since the year 2002, the MPTZ has risen 27.85 feet to an elevation of 607.32 feet msl, where it is higher than the calculated Ghyben-Herzberg elevation of 646.8 feet below msl, relative to the Water Table measured at 16.17 feet above msl

last updated 4/27/2017

Figure G-19 Fluctuations in water level and transition zones in the Waimalu DMW



Notes: : (1) TTZ = 1,000 μS/cm (~ 220 mg/L Cl⁻); MPTZ = 25,000 μS/cm (~ 8,500 mg/L Cl⁻) (2) Fresh Water < 220 mg/L Cl⁻, Brackish Water 220 mg/L CL⁻ to 16,999 mg/L Cl⁻, Sea Water >= 17,000 mg/L Cl⁻; (3) OS 421/425 = Ocean Sensors CTD (absolute conductivity); (4) RBR 12895 = RBR Global CTD (Specific Conductivity); (5) msl = mean sea level.

* Since the year 2005, the MPTZ has declined 73.64 feet toward a calculated Ghyben-Herzberg equilibrium elevation of approximately 829.6 feet below msl, relative to the Water Table measured at 20.74 feet above msl.

last updated 4/27/2017

Recommendations for Pearl Harbor

- Continued monitoring of the DMWs for changes in the transition zones
- Continued participation in the RHFF Task Force
- Move the Waimalu/Moanalua ASA boundary to the northwest, so that the Moanalua ASA encompasses the South Hālawa Valley, and the new Moanalua/Waimalu boundary lies along the H-3 alignment in the North Hālawa Valley. Deeper sediments in the North Hālawa Valley provide a more natural geologic boundary than do the shallower sediments noted in the South Hālawa Valley, where heads are similar to those measured in the Moanalua aquifer.

G.2.2.6 CWRM-USGS Cooperative Ground Water Monitoring Program

CWRM-USGS cooperative monitoring program includes ground water, surface water, and rainfall monitoring activities on the Islands of Kauaʻi, Oʻahu, Molokaʻi, Maui, and Hawaiʻi. The objectives of the ground water data collection program in Hawaiʻi are to collect, analyze, and publish data on ground water levels and quality (chloride concentration) data from a network of springs, observation wells, pumping wells, and deep monitoring wells to allow assessment of regional ground water resources and to identify trends in response to natural climatic variations and induced stresses. Data is used by federal, State, local officials, and private parties to: assess the ground water resources, predict future conditions, detect and define saltwater intrusion problems, and manage water resources. Data is particularly useful in determining long-term trends in water levels, sustainable yields, climatic effects on water levels, and in the development of flow- and salt-transport models that allow prediction of future conditions and detection and definition of contaminant and water-supply problems.

Data from the cooperative monitoring program is published annually and is available online from the USGS at http://waterdata.usgs.gov/nwis.

The cooperative agreement between the USGS and the State officially began in 1909 when the USGS entered into an agreement with the Territory of Hawaiʻi to install and monitor gages on 12 streams. Ground water data collection was initiated in 1972 to gather baseline data throughout the state. The program began with 170 wells, where new knowledge of ground water conditions was needed. Currently, a regionally representative network of wells is maintained on the islands of Kauaʻi, Oʻahu, Molokaʻi, Maui, and Hawaiʻi to allow measurement of water levels and collection of water quality samples in most aquifers within the state. The ground water well networks are designed to meet the needs of the cooperators. New wells are added to the network as old wells are sealed or as other needs arrive.

Significant changes in the ground water monitoring network have occurred since 1995, when a total of 187 wells were included in the program. Program reductions induced by budgetary constraints reduced the number of wells to 160 for fiscal year 1996. By 2000, budget constraints caused monitoring activities to be discontinued at three more wells, bringing the total program well sites to 157. Fiscal Year (FY) 2001 saw another dramatic decrease, with the total number of program wells falling to 120. From 2002 to 2003, another 39 wells were cut, along with 10 more wells in 2004. Another well was discontinued in 2005 to bring the total well sites to 70. The budget for subsequent Fiscal Years resulted in decreased numbers of monitor wells. For FY 2014, the contract included 14 water-level monitor wells. Over a period of only 15 years, 173 of the 187 monitoring well sites that were active in 1999 have been discontinued; that translates to a 95% reduction in the number of monitoring locations statewide. Currently, the Survey Branch is expanding the network of CWRM monitored wells on Oʻahu, Maui, and Hawaiʻi to fill in the data gaps that have resulted from the discontinuation of the formerly USGS-monitored wells.

While the number of gages funded by CWRM has decreased over time, other agencies have taken on the responsibility as it is more directly related to their programs (e.g. crest stage gages) and redundancies in funding have been eliminated. In addition, the current network includes gages that the USGS has identified as a priority for long-term climate change monitoring and regulatory support. Organizations that participate (FY 14) as cooperators with the USGS are listed in **Table G-2** by government jurisdiction:

Table G-2 USGS Cooperative Monitoring Program Fiscal Year 2014 Cooperators

Agency/Entity	Abbreviation
Federal:	
U.S. Army Corps of Engineers	COE
U.S. Army Garrison Hawai‘i Directorate of Public Works	Army
USGS National Streamflow Information Program	NSIP
National Weather Service	NWS
State of Hawai‘i:	
Department of Land and Natural Resources, Commission on Water Resource Management	CWRM
Department of Land and Natural Resources, Engineering Division	DNLR-Eng. Div.
Department of Land and Natural Resources, Land Division	DLNR-Land Div.
Department of Land and Natural Resources, Division of Forestry and Wildlife	DLNR-DOFAW
Department of Transportation	DOT
Department of Health	DOH
Office of Hawaiian Affairs	OHA
Civil Defense Department	SCD
County of Kaua‘i:	
Department of Water	KDOW
City and County of Honolulu:	
Board of Water Supply	HBWS
Department of Planning and Permitting	DPP
County of Maui:	
Department of Water Supply	MDOW
County of Hawai‘i:	
Department of Water Supply	DWS
Department of Public Works	DPW
Other	
Dole Food Company Hawai‘i	Dole-Hawai‘i

A full list of the stations operated by the USGS in the Hawai‘i and more information about their mission can be found at https://hi.water.usgs.gov/.

G.2.3 Other Ground Water Monitoring Programs

G.2.3.1 Honolulu BWS Ground Water Monitoring Program

The Honolulu BWS has developed an extensive ground water monitoring program. The program includes 29 deep monitor wells and 11 water level monitor wells on Oʻahu. The Honolulu BWS utilizes data from these wells to operate and manage the integrated municipal water system serving the City and County of Honolulu. Kauaʻi County, Maui County, and Hawaiʻi County currently utilize data from wells included in the USGS Cooperative Monitoring Program.

Table G-3 BWS Deep Monitor Wells

Aquifer system	Well Number	Well Name
Waiʻalae-West	3-1747-004	Waiʻalae SH Deep Monitor
Pālolo	3-1748-014	Kaimukī Sta Deep Monitor
Pālolo	3-1749-022	Kaimukī HS Deep Monitor
Pālolo	3-1848-001	Waʻahila Deep Monitor
Nuʻuanu	3-1850-030	Punchbowl Deep Mon
Nuʻuanu	3-1851-057	Beretania Deep Monitor
Kalihi	3-1952-048	Kalihi Sta Deep Monitor
Kalihi	3-2052-012	Jonathan Springs
Moanalua	3-2052-015	Kalihi Sh Deep Monitor
Moanalua	3-2153-005	Moanalua Deep Monitor
Waipahu-Waiawa	3-2201-010	Kunia T41 Deep Monitor
Waimalu	3-2255-040	Hālawa-BWS Deep Monitor
Waipahu-Waiawa	3-2300-018	Waipahu Deep Monitor
Waimalu	3-2355-015	Kaamilo Deep Monitor
Waimalu	3-2456-004	Newtown Deep Monitor
Waimalu	3-2457-004	Punanani DMW
Waipahu-Waiawa	3-2458-006	Manana Deep Monitor
Waipahu-Waiawa	3-2459-026	Waiawa Deep Monitor
Waipahu-Waiawa	3-2500-003	Waiola Deep Monitor
Waipahu-Waiawa	3-2557-004	Waimano Deep Monitor
Waipahu-Waiawa	3-2602-002	Poliwai Deep Monitor
Waialua	3-3405-005	Helemano Deep Monitor
Koʻolauloa	3-3553-005	Punaluʻu Deep Monitor
Koʻolauloa	3-3554-005	Kaluanui 2 Monitor
Kawailoa	3-3604-001	Kawailoa Deep Monitor
Koʻolauloa	3-3755-010	Hauula Deep Monitor
Koʻolauloa	3-3956-008	Lāʻie Deep Monitor
Koʻolauloa	3-4057-017	Kahuku Deep Monitor
Waipahu-Waiawa	3-2659-001	Waipiʻo Mauka

Reported in 2017

Table G-3 lists the deep monitor wells included in the Honolulu BWS monitoring program. **Table G-4** lists the water level monitoring wells included in the Honolulu BWS Monitoring program. The BWS uses data from the deep monitor wells to identify changes in the freshwater lens, while data from the water level monitor wells are used to ensure operational safety and prevent water shortages.

Table G-4 BWS Water Level Well Network

Aquifer System	Well Number	Well Name
Pālolo	3-1748-011	Kaimukī Deep 1
Pālolo	3-1748-012	Keanu
Pālolo	3-1749-014	Kaimukī High School
Nuʻuanu	3-1849-011	Wilder Ave
Nuʻuanu	3-1849-012	Wilder Ave
Nuʻuanu	3-1851-002	Thomas Square
ʻEwa-Kunia	3-2006-012	Kahe Point
Nuʻuanu	3-2047-003	Mānoa
Nuʻuanu	3-2047-004	Mānoa
Kalihi	3-2052-010	Kapālama
Moanalua	3-2153-009	Moanalua-Manaiki
Moanalua	3-2253-002	Moanalua DH 43
Waimalu	3-2255-033	Hālawa Obs. T45
Nānākuli	3-2307-001	Nānākuli
Koʻolaupoko	3-2348-001	Kuou TH
Koʻolaupoko	3-2348-004	Kuou TH
Waimalu	3-2355-008	Kalauao
Waimalu	3-2356-053	ʻAiea T-75
Waimalu	3-2356-057	Waimalu
Waipahu-Waiawa	3-2358-020	Pearl City Obs T-27
Waimalu	3-2455-001	Upper Waimalu T52
Koʻolaupoko	3-2751-004	Waiheʻe Obs
Waiʻanae	3-2809-002	Waiʻanae Valley
Waialua	3-3406-004	Waialua

Currently provides Monthly levels

G.2.3.2 Public and Private Observation Wells

There are several federal, State, and county agencies that own and operate observation wells. Many private landowners and corporations also have wells permitted for observation purposes. These publicly and privately-owned wells are not included in the CWRM, USGS, or Honolulu BWS monitoring programs. **Table G-5** lists all observation wells registered with CWRM that are not part of the CWRM, USGS, or Honolulu BWS monitoring programs (the table does not include temporary monitor wells, such as the Kona area water level wells that are developed into production wells).

In 2014, CWRM affirmed its requirement for reporting of monthly water levels and salinity for all observation wells. CWRM also requires owners of unused wells to report monthly data on a case-by-case basis, as determined by staff[5]. Any water quality data from observation wells should be submitted to the DOH.

Table G-5 Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs

Island	Aquifer system	Well number	Well name	Well owner
Kauaʻi	Hanamāʻulu	2-0023-001	Pukaki Res Monitor	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Kauaʻi	Kekaha	2-0044-014	Kaunalewa Ks8	Kekaha Sugar Company, Ltd
Kauaʻi	Hanamāʻulu	2-0121-001	South Wailua	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Kauaʻi	Wailua	2-0123-001	Maalo Road Mon	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Kauaʻi	Wailua	2-0124-001	Ne Kilohana	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Kauaʻi	Wailua	2-0126-001	NW Kilohana Mon	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Kauaʻi	Wailua	2-0222-001	ʻAʻahoaka Mon	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Kauaʻi	Wailua	2-0327-001	Waikoko Mon	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Kauaʻi	Anahola	2-0518-002	Mahelona Hospital	State Dept. of Health, DOH

[5] January 22, 2014 CWRM Staff Submittal

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
Kauaʻi	Anahola	2-0523-002	Wailua Hmstds 3	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Kauaʻi	Anahola	2-1019-001	Aliomanu	LPC Corporation
Kauaʻi	Kōloa	2-5424-001	HDF-2	Hawaiʻi Dairy Farm LLC
Kauaʻi	Kōloa	2-5425-016	HDF-1	Hawaiʻi Dairy Farm LLC
Kauaʻi	Kōloa	2-5425-017	HDF-3	Hawaiʻi Dairy Farm LLC
Kauaʻi	Kōloa	2-5425-018	HDF-4	Hawaiʻi Dairy Farm LLC
Kauaʻi	Kōloa	2-5430-001	Lawai TH 3	McBryde Sugar Company, LLC
Kauaʻi	Kōloa	2-5529-002	Kalawai TH 5	McBryde Sugar Company, LLC
Kauaʻi	Kōloa	2-5534-006	Upper ʻEleʻele Mon	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Kauaʻi	Makaweli	2-5537-001	8-inch Mill Test	Olokele Sugar Co. Ltd.
Kauaʻi	Hanamāʻulu	2-5626-001	Puakukui Springs	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Kauaʻi	Hanamāʻulu	2-5723-001	MW-1	Department of Public Works Kauaʻi, KDPW, Engineering Division
Kauaʻi	Hanamāʻulu	2-5723-002	MW-2	Department of Public Works Kauaʻi, KDPW, Engineering Division
Kauaʻi	Hanamāʻulu	2-5723-003	MW-3	Department of Public Works Kauaʻi, KDPW, Engineering Division
Kauaʻi	Hanamāʻulu	2-5821-002	Kauaʻi Inn Tank	Department of Water Kauaʻi, KDW
Kauaʻi	Hanamāʻulu	2-5823-003	Garlinghouse Tunnel Observation Well	Department of Water Kauaʻi, KDW
Kauaʻi	Hanamāʻulu	2-5824-007	Puhi Obs 3	Neil Tagawa (Grove Farm Company, Inc.)
Kauaʻi	Hanamāʻulu	2-5825-002	Haʻikū Mauka Obs	Neil Tagawa (Grove Farm Company, Inc.)
Kauaʻi	Hanamāʻulu	2-5825-003	Haʻikū Mauka Obs	Neil Tagawa (Grove Farm Company, Inc.)
Kauaʻi	Hanamāʻulu	2-5923-008	Hanamāʻulu TZ	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Kauaʻi	Kekaha	2-5944-002	MW-II-7	State of Hawaiʻi

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
Oʻahu	Waiʻalae-West	3-1646-002	Waiʻalae Golf	Kamehameha Schools
Oʻahu	Waiʻalae-West	3-1647-001	Kahala	D. Cromwell
Oʻahu	Waiʻalae-West	3-1747-004	Waiʻalae SH Deep Monitor	Honolulu Board of Water Supply, BWS
Oʻahu	Pālolo	3-1748-001	Kanewai Park Obs	Kamehameha Schools
Oʻahu	Pālolo	3-1748-011	Kaimukī Deep 1	Honolulu Board of Water Supply, BWS
Oʻahu	Pālolo	3-1748-012	Keanu	Honolulu Board of Water Supply, BWS
Oʻahu	Pālolo	3-1748-014	Kaimukī Sta Deep Monitor	Honolulu Board of Water Supply, BWS
Oʻahu	Pālolo	3-1749-007	Kapahulu	City & County of Honolulu, C&CH
Oʻahu	Pālolo	3-1749-014	Kaimukī High School	Honolulu Board of Water Supply, BWS
Oʻahu	Pālolo	3-1749-022	Kaimukī HS Deep Monitor	Honolulu Board of Water Supply, BWS
Oʻahu	Waipahu-Waiawa	3-1800-001	ʻEwa Beach B	National Weather Service
Oʻahu	Malakole	3-1806-007	Conoco Ref Obs 2	Dill-Conoco
Oʻahu	Malakole	3-1806-008	Conoco Ref Obs 1	Dill-Conoco
Oʻahu	Pālolo	3-1848-001	Waahila Deep Monitor	Honolulu Board of Water Supply, BWS
Oʻahu	Nuʻuanu	3-1849-011	Wilder Ave	Honolulu Board of Water Supply, BWS
Oʻahu	Nuʻuanu	3-1849-012	Wilder Ave	Honolulu Board of Water Supply, BWS
Oʻahu	Nuʻuanu	3-1850-030	Punchbowl Deep Mon	Honolulu Board of Water Supply, BWS
Oʻahu	Nuʻuanu	3-1851-002	Thomas Square	Honolulu Board of Water Supply, BWS
Oʻahu	Nuʻuanu	3-1851-019	Halekauwila St	Harbor Square
Oʻahu	Nuʻuanu	3-1851-022	Ala Moana Blvd	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Oʻahu	Nuʻuanu	3-1851-057	Beretania Deep Monitor	Honolulu Board of Water Supply, BWS
Oʻahu	Puʻuloa	3-1900-012	ʻEwa Beach	Pacific Islands Water Science Center, USGS, U.S. Geological Survey

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
O‘ahu	Pu‘uloa	3-1900-014	‘Ewa Beach C	National Weather Service
O‘ahu	Pu‘uloa	3-1900-015	‘Ewa Beach D	National Weather Service
O‘ahu	Pu‘uloa	3-1902-005	Coral Creek 5	Coral Creek Golf, Inc.
O‘ahu	Malakole	3-1906-008	Barbers Pt. MW-1	State of Hawai‘i DOT, Harbors Division
O‘ahu	Malakole	3-1906-010	Barbers Pt. MW-3	State of Hawai‘i DOT, Harbors Division
O‘ahu	Kalihi	3-1952-004	Kapālama	Kapuna Apartments, LLC
O‘ahu	Kalihi	3-1952-046	HCC O-6	Honolulu Community College
O‘ahu	Kalihi	3-1952-048	Kalihi Sta Deep Monitor	Honolulu Board of Water Supply, BWS
O‘ahu	Waipahu-Waiawa	3-1959-005	Ft Weaver Rd	Department of the Navy, Navy Region Hawai‘i
O‘ahu	Waipahu-Waiawa	3-1959-006	Ft Weaver Rd	Department of the Navy, Navy Region Hawai‘i
O‘ahu	Waipahu-Waiawa	3-1959-007	‘Ewa Beach A	National Weather Service
O‘ahu	Pu‘uloa	3-2001-016	Coral Creek 3	Coral Creek Golf, Inc.
O‘ahu	‘Ewa-Kunia	3-2006-012	Kahe Point	Honolulu Board of Water Supply, BWS
O‘ahu	‘Ewa-Kunia	3-2006-016	Makaīwa Mon TH-1	James Campbell Company LLC
O‘ahu	Malakole	3-2006-018	Barbers Pt. MW-4	State of Hawai‘i DOT, Harbors Division
O‘ahu	‘Ewa-Kunia	3-2007-002	Makaīwa Mon TH-2	Makaīwa Hills, LLC
O‘ahu	Makaīwa	3-2007-003	Makaīwa Mon TH-3	Makaīwa Hills, LLC
O‘ahu	Waimānalo	3-2042-005	Waimānalo STP 1	Honolulu Sewers
O‘ahu	Waimānalo	3-2042-006	Waimānalo STP 2	Honolulu Sewers
O‘ahu	Waimānalo	3-2042-007	Waimānalo STP 3	Honolulu Sewers
O‘ahu	Waimānalo	3-2042-008	Waimānalo STP 4	Honolulu Sewers
O‘ahu	Waimānalo	3-2042-009	Waimānalo STP 5	Honolulu Sewers
O‘ahu	Waimānalo	3-2042-010	Waimānalo STP 6	Honolulu Sewers
O‘ahu	Waimānalo	3-2042-011	Waimānalo STP 7	Honolulu Sewers
O‘ahu	Waimānalo	3-2042-012	Waimānalo Stp 8	Honolulu Sewers
O‘ahu	Waimānalo	3-2042-013	Waimānalo	Pacific Concrete & Rock Co.
O‘ahu	Waimānalo	3-2044-001	Olomana Golf	State of Hawai‘i

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
O‘ahu	Nu‘uanu	3-2047-003	Mānoa	Honolulu Board of Water Supply, BWS
O‘ahu	Nu‘uanu	3-2047-004	Mānoa	Honolulu Board of Water Supply, BWS
O‘ahu	Kalihi	3-2052-010	Kapālama	Honolulu Board of Water Supply, BWS
O‘ahu	Kalihi	3-2052-012	Jonathan Springs	Honolulu Board of Water Supply, BWS
O‘ahu	Moanalua	3-2052-015	Kalihi Sh Deep Monitor	Honolulu Board of Water Supply, BWS
O‘ahu	Moanalua	3-2053-010	Fort Shafter Monitor	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
O‘ahu	Waipahu-Waiawa	3-2101-003	Honouliuli	State of Hawai‘i, Department of Transportation, Highways Division, DOT
O‘ahu	Waipahu-Waiawa	3-2101-009	Honouliuli F	‘Ewa Plantation
O‘ahu	‘Ewa-Kunia	3-2103-001	Pu‘u Makakilo	Naval Facilities Engineering Command Hawai‘i, Environmental, NAVFAC Hawaii
O‘ahu	‘Ewa-Kunia	3-2103-002	Pu‘u Makakilo	Naval Facilities Engineering Command Hawai‘i, Environmental, NAVFAC Hawaii
O‘ahu	‘Ewa-Kunia	3-2103-004	Barbers Pt. Mon	Naval Facilities Engineering Command Hwai‘i,, Environmental, NAVFAC Hawaii
O‘ahu	‘Ewa-Kunia	3-2103-005	Barbers Pt Shallow M	Naval Facilities Engineering Command Hawai‘i, Environmental, NAVFAC Hawaii
O‘ahu	Moanalua	3-2153-005	Moanalua Deep Monitor	Honolulu Board of Water Supply, BWS
O‘ahu	Moanalua	3-2153-009	Moanalua-Manaiki	Honolulu Board of Water Supply, BWS
O‘ahu	Moanalua	3-2153-013	TAMC MW-2	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
O‘ahu	Waipahu-Waiawa	3-2201-010	Kunia T41 Deep Monitor	Honolulu Board of Water Supply, BWS
O‘ahu	Moanalua	3-2253-002	Moanalua DH 43	Honolulu Board of Water Supply, BWS

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
O‘ahu	Waimalu	3-2253-003	Hālawa Deep Monitor	Commission on Water Resource Management, CWRM
O‘ahu	Waimalu	3-2253-004	RHMW06	Naval Facilities Engineering Command Hawai‘i, NAVFAC Hawai‘i
O‘ahu	Waimalu	3-2253-005	RHMW07	Naval Facilities Engineering Command Hawai‘i, NAVFAC Hawai‘i
O‘ahu	Moanalua	3-2253-007	RHMW08	Naval Facilities Engineering Command Hawai‘i, NAVFAC Hawai‘i
O‘ahu	Moanalua	3-2253-008	RHMW09	Naval Facilities Engineering Command Hawai‘i, NAVFAC Hawai‘i
O‘ahu	Waimalu	3-2255-021	Hālawa	State of Hawai‘i
O‘ahu	Waimalu	3-2255-022	Hālawa	State of Hawai‘i
O‘ahu	Waimalu	3-2255-026	Hālawa	State of Hawai‘i
O‘ahu	Waimalu	3-2255-027	Hālawa	State of Hawai‘i
O‘ahu	Waimalu	3-2255-033	Hālawa Obs. T45	Honolulu Board of Water Supply, BWS
O‘ahu	Waimalu	3-2255-040	Hālawa -BWS Deep Monitor	Honolulu Board of Water Supply, BWS
O‘ahu	Waimalu	3-2256-010	FW 1	State of Hawai‘i
O‘ahu	Waimalu	3-2256-012	FW 3	State of Hawai‘i
O‘ahu	Waipahu-Waiawa	3-2300-010	Waipahu P6	Kamehameha Schools
O‘ahu	Waipahu-Waiawa	3-2300-018	Waipahu Deep Monitor	Honolulu Board of Water Supply, BWS
O‘ahu	‘Ewa-Kunia	3-2303-007	Honouliuli Deep Monitor	Monsanto Company - O‘ahu
O‘ahu	Nānākuli	3-2307-001	Nānākuli	Honolulu Board of Water Supply, BWS
O‘ahu	Ko‘olaupoko	3-2348-001	Kuou TH	Honolulu Board of Water Supply, BWS
O‘ahu	Ko‘olaupoko	3-2348-004	Kuou TH	Honolulu Board of Water Supply, BWS
O‘ahu	Waimalu	3-2355-001	‘Aiea	Steven Ohata
O‘ahu	Waimalu	3-2355-008	Kalauao	Honolulu Board of Water Supply, BWS
O‘ahu	Waimalu	3-2355-015	Kaamilo Deep Monitor	Honolulu Board of Water Supply, BWS

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
Oʻahu	Waimalu	3-2356-053	ʻAiea T-75	Honolulu Board of Water Supply, BWS
Oʻahu	Waimalu	3-2356-057	Waimalu	Honolulu Board of Water Supply, BWS
Oʻahu	Waipahu-Waiawa	3-2358-020	Pearl City Obs T-27	Honolulu Board of Water Supply, BWS
Oʻahu	Waipahu-Waiawa	3-2400-007	Waikele Obs. D	Pacific Islands Water Science Center, USGS
Oʻahu	Waipahu-Waiawa	3-2401-002	Royal Kunia A-1	Royal Oʻahu Resorts, Inc.
Oʻahu	Waipahu-Waiawa	3-2401-003	Royal Kunia A-2	Royal Oʻahu Resorts, Inc.
Oʻahu	ʻEwa-Kunia	3-2403-002	Kunia Middle Deep Monitor	Commission on Water Resource Management, CWRM
Oʻahu	Waimalu	3-2455-001	Upper Waimalu T52	Honolulu Board of Water Supply, BWS
Oʻahu	Waimalu	3-2456-004	Newtown Deep Monitor	Honolulu Board of Water Supply, BWS
Oʻahu	Waimalu	3-2456-005	Waimalu Deep Monitor	Commission on Water Resource Management, CWRM
Oʻahu	Waimalu	3-2457-004	Punanani DMW	Honolulu Board of Water Supply, BWS
Oʻahu	Waipahu-Waiawa	3-2459-015	Waipahu	II Estate
Oʻahu	Waipahu-Waiawa	3-2459-026	Waiawa Deep Monitor	Honolulu Board of Water Supply, BWS
Oʻahu	Waipahu-Waiawa	3-2500-003	Waiola Deep Monitor	Honolulu Board of Water Supply, BWS
Oʻahu	ʻEwa-Kunia	3-2503-003	Kunia Mauka 2 Deep Monitor	Commission on Water Resource Management, CWRM
Oʻahu	ʻEwa-Kunia	3-2503-004	BMW 5	Edward Littleton (Del Monte Fresh Produce (Hawaiʻi), Inc)
Oʻahu	Waipahu-Waiawa	3-2557-004	Waimano Deep Monitor	Honolulu Board of Water Supply, BWS
Oʻahu	Waipahu-Waiawa	3-2558-008	Waiawa	Naval Facilities Engineering Command Hawaiʻi, Environmental, NAVFAC Hawaiʻi
Oʻahu	Waipahu-Waiawa	3-2600-005	Kipapa Mon MW-8	United States Air Force
Oʻahu	Waipahu-Waiawa	3-2600-006	Kipapa ST01MW05	United States Air Force

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
Oʻahu	Waipahu-Waiawa	3-2600-007	Kipapa ST01MW06	United States Air Force
Oʻahu	Waipahu-Waiawa	3-2600-008	Kipapa ST01MW07	United States Air Force
Oʻahu	Waipahu-Waiawa	3-2600-009	Kipapa ST01MW10	United States Air Force
Oʻahu	Waipahu-Waiawa	3-2602-002	Poliwai Deep Monitor	Honolulu Board of Water Supply, BWS
Oʻahu	Waipahu-Waiawa	3-2659-001	Waipio Mauka Deep Monitor	Commission on Water Resource Management, CWRM
Oʻahu	Waipahu-Waiawa	3-2702-001	Waikakalaua MW-6	United States Air Force
Oʻahu	Waipahu-Waiawa	3-2702-002	Waikakalaua MW-7	United States Air Force
Oʻahu	Waipahu-Waiawa	3-2702-006	Waikaka ST12MW03	United States Air Force
Oʻahu	Waipahu-Waiawa	3-2702-007	Waikaka ST12MW04	United States Air Force
Oʻahu	Waipahu-Waiawa	3-2702-008	Waikaka ST12MW05	United States Air Force
Oʻahu	Waipahu-Waiawa	3-2702-009	Waikaka ST12MW08	United States Air Force
Oʻahu	Waipahu-Waiawa	3-2702-010	Waikaka ST12MW09	United States Air Force
Oʻahu	Waipahu-Waiawa	3-2702-011	RW001	United States Air Force
Oʻahu	Waipahu-Waiawa	3-2703-003	BMW 2	Edward Littleton (Del Monte Fresh Produce (Hawaiʻi), Inc)
Oʻahu	Waipahu-Waiawa	3-2703-004	BMW 4	Edward Littleton (Del Monte Fresh Produce (Hawaiʻi), Inc)
Oʻahu	ʻEwa-Kunia	3-2703-005	BMW 6	Edward Littleton (Del Monte Fresh Produce (Hawaiʻi), Inc)
Oʻahu	ʻEwa-Kunia	3-2704-001	BMW 3	Edward Littleton (Del Monte Fresh Produce (Hawaiʻi), Inc)
Oʻahu	Koʻolaupoko	3-2751-004	Waihee Obs	Honolulu Board of Water Supply, BWS
Oʻahu	Wahiawā	3-2801-002	Schofield MW2-4	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Waipahu-Waiawa	3-2802-001	Schofield MW2-6	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
Oʻahu	Waiʻanae	3-2809-002	Waiʻanae Valley	Honolulu Board of Water Supply, BWS
Oʻahu	Wahiawā	3-2900-002	Schofield MW2-1	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Wahiawā	3-2901-001	Schofield Batt	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Wahiawā	3-2901-013	Schofield MW1-1	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Wahiawā	3-2902-003	Schofield MW2-3	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Wahiawā	3-2903-001	Schofield MW2-2	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Wahiawā	3-2959-001	Schofield MW2-5	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Wahiawā	3-3004-001	Schofield MW4-1	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Wahiawā	3-3004-002	Schofield MW4-2	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Wahiawā	3-3004-003	Schofield MW4-3	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Wahiawā	3-3004-004	Schofield MW4-4	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Wahiawā	3-3004-005	Schofield MW4-2A	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Keaʻau	3-3113-002	ERDC-MW-1	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Keaʻau	3-3113-003	ERDC-MW-4A	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
Oʻahu	Keaʻau	3-3113-004	ERDC-MW-4B	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Keaʻau	3-3113-005	ERDC-MW-4C	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Keaʻau	3-3113-006	ERDC-MW-5	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Waialua	3-3204-001	Kaheaka Obs.	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Oʻahu	Keaʻau	3-3213-008	ERDC-MW-2	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Keaʻau	3-3213-009	ERDC-MW-3A	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Keaʻau	3-3213-010	ERDC-MW-3B	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Keaʻau	3-3213-011	ERDC-MW-3C	Directorate of Public Works, Environmental Division, DPW, U.S. Army Garrison
Oʻahu	Mokulēʻia	3-3307-017	T-116	G Tree Ranch, LLC
Oʻahu	Mokulēʻia	3-3307-018	T-117	G Tree Ranch, LLC
Oʻahu	Waialua	3-3307-020	Thompson Corner 1	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Oʻahu	Waialua	3-3307-021	Thompson Corner 2	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Oʻahu	Mokulēʻia	3-3310-003	Mokulēʻia 3	Mokulēʻia Land Co.
Oʻahu	Waialua	3-3404-002	Waialua	Dole Food Company, Inc. Hawaiʻi
Oʻahu	Waialua	3-3405-005	Helemano Deep Monitor	Honolulu Board of Water Supply, BWS
Oʻahu	Waialua	3-3406-004	Waialua	Dole Food Company, Inc. Hawaiʻi

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
Oʻahu	Waialua	3-3406-012	Twin Bridge Deep	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Oʻahu	Waialua	3-3406-013	Kamooloa Obs.	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Oʻahu	Waialua	3-3406-014	Helemano Cap 1	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Oʻahu	Waialua	3-3406-015	Helemano Cap 2	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Oʻahu	Waialua	3-3407-029	Waialua	Dole Food Company, Inc. Hawaiʻi
Oʻahu	Waialua	3-3407-037	Kiikii Cap Mon 2	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Oʻahu	Mokulēʻia	3-3409-016	Mokulēʻia	Mokulēʻia Associates
Oʻahu	Mokulēʻia	3-3410-008	Mokulēʻia	Dole Food Company, Inc. Hawaiʻi
Oʻahu	Kahana	3-3453-012	Makalii 2	Koʻolau Agricultural Co., Ltd.
Oʻahu	Kawailoa	3-3503-001	N Upper Anahulu	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Oʻahu	Kawailoa	3-3505-025	N Lower Anahulu	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Oʻahu	Waialua	3-3505-026	Opaeula Obs	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Oʻahu	Koʻolauloa	3-3553-005	Punaluʻu Deep Monitor	Honolulu Board of Water Supply, BWS
Oʻahu	Koʻolauloa	3-3554-005	Kaluanui 2 Monitor	Honolulu Board of Water Supply, BWS
Oʻahu	Kawailoa	3-3604-001	Kawailoa Deep Monitor	Honolulu Board of Water Supply, BWS
Oʻahu	Kawailoa	3-3605-024	Kawailoa Pump 4	Waialua Sugar Company, Inc.
Oʻahu	Kawailoa	3-3605-025	Kawailoa Pump 4	Waialua Sugar Company, Inc.

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
O‘ahu	Ko‘olauloa	3-3755-010	Hauula Deep Monitor	Honolulu Board of Water Supply, BWS
O‘ahu	Ko‘olauloa	3-3956-008	Lā‘ie Deep Monitor	Honolulu Board of Water Supply, BWS
O‘ahu	Ko‘olauloa	3-4057-005	Kahuku	B. Tsukamoto
O‘ahu	Ko‘olauloa	3-4057-017	Kahuku Deep Monitor	Honolulu Board of Water Supply, BWS
O‘ahu	Kawailoa	3-4101-003	Waiale‘e	State of Hawai‘i
Moloka‘i	Kawela	4-0457-003	Kawela 2	Kawela Plantation Homeowners' Association
Moloka‘i	Kawela	4-0458-002	Kawela 3	Kawela Plantation Homeowners' Association
Moloka‘i	Kualapu‘u	4-0800-001	Kualapu‘u Deep Monitor	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Lāna‘i	Leeward	5-4954-001	Lāna‘i 3	Lāna‘i Holdings, Inc.
Maui	Kama‘ole	6-3925-001	Makena 68	State of Hawai‘i, DLNR Land Division O‘ahu, DLNR-LD
Maui	Kama‘ole	6-4026-005	Wailea 6	Wailea Golf LLC
Maui	Kama‘ole	6-4126-001	Wailea 1	Wailea Golf LLC
Maui	Kama‘ole	6-4327-008	Kalama Beach A1	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Maui	Kama‘ole	6-4327-009	Kalama Beach A2	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Maui	Kama‘ole	6-4327-010	Kalama Beach A3	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Maui	Kama‘ole	6-4422-001	Waiohuli	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Maui	Kama‘ole	6-4426-001	Kihei Inject TH	County of Maui Department of Environmental Management, Solid Waste Division

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
Maui	Kamaʻole	6-4427-006	Kihei Fire B1	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Maui	Kamaʻole	6-4427-007	Kihei Fire B2	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Maui	Kamaʻole	6-4427-008	Kihei Fire B3	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Maui	Waikapu	6-4831-001	Māʻalaea 272	State of Hawaii, DLNR Land Division Oʻahu, DLNR-LD
Maui	Pāʻia	6-5125-001	Wailuku MW-1	County of Maui Department of Environmental Management, Solid Waste Division
Maui	Pāʻia	6-5125-002	Wailuku MW-2	County of Maui Department of Environmental Management, Solid Waste Division
Maui	Pāʻia	6-5125-003	Wailuku MW-3	County of Maui Department of Environmental Management, Solid Waste Division
Maui	Pāʻia	6-5125-004	Wailuku MW-4	County of Maui Department of Environmental Management, Solid Waste Division
Maui	Pāʻia	6-5125-005	Wailuku MW-5	County of Maui Department of Environmental Management, Solid Waste Division
Maui	Pāʻia	6-5125-006	Wailuku MW-6	County of Maui Department of Environmental Management, Solid Waste Division
Maui	ʻĪao	6-5230-002	ʻĪao Deep Monitor	Commission on Water Resource Management, CWRM
Maui	Launiupoko	6-5237-001	Kauaula TH 1	State of Hawaiʻi, DLNR Land Division Oʻahu, DLNR-LD
Maui	Launiupoko	6-5237-002	Kauaula TH 2	State of Hawaiʻi, DLNR Land Division Oʻahu, DLNR-LD
Maui	Honopou	6-5313-001	EMI Kailua Mon	East Maui Irrigation Co., Ltd.
Maui	ʻĪao	6-5329-018	Waiale Obs	Astoria International Inc.
Maui	ʻĪao	6-5330-003	Field 63	Wailuku Sugar

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
Maui	ʻĪao	6-5330-004	Wailuku Mill TH	Wailuku Sugar
Maui	ʻĪao	6-5330-006	Mokuhau TH 1	Igarta, Bernard Trust
Maui	ʻĪao	6-5330-007	Mokuhau TH 2	Bernard Paet (Paet, Bernard Revoc TR/ETAL)
Maui	ʻĪao	6-5330-008	Mokuhau TH 3	Timothy Bachand
Maui	ʻĪao	6-5331-001	ʻĪao Valley TH	Wailuku Sugar
Maui	ʻĪao	6-5332-004	Kepaniwai TH	State of Hawaiʻi, DLNR Land Division Oʻahu, DLNR-LD
Maui	Launiupoko	6-5338-001	Kanaha TH 1	State of Hawaiʻi, DLNR Land Division Oʻahu, DLNR-LD
Maui	Launiupoko	6-5338-002	Kanaha TH 2	State of Hawaiʻi, DLNR Land Division Oʻahu, DLNR-LD
Maui	Haʻikū	6-5418-001	EMWDP Monitor	Maui Department of Water Supply, MDWS
Maui	Kahului	6-5425-002	Sprecklesville	Hawaiian Commercial & Sugar Co. (HC&S)
Maui	ʻĪao	6-5430-003	Waiehu TH-E	Wailuku Sugar
Maui	ʻĪao	6-5430-004	Waiehu TH-D	State of Hawaiʻi, DLNR Land Division Oʻahu, DLNR-LD
Maui	ʻĪao	6-5430-005	Waiehu Deep Monitor	Commission on Water Resource Management, CWRM
Maui	ʻĪao	6-5431-001	Waiehu TH-B	Wailuku Sugar
Maui	ʻĪao	6-5530-001	Waiehu Tunnel	Wailuku Sugar
Maui	ʻĪao	6-5631-001	Waiheʻe TH A1	Wailuku Sugar
Maui	Waiheʻe	6-5631-009	Waiheʻe DMW	Commission on Water Resource Management, CWRM
Maui	Honokōwai	6-5637-001	Honokōwai TH 1	AMFAC
Maui	Honokōwai	6-5637-002	Honokōwai TH 2	AMFAC
Maui	Honokōwai	6-5637-003	Honokōwai TH 3	AMFAC
Maui	Honokōwai	6-5637-004	Honokōwai	AMFAC

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
Maui	Honokōwai	6-5638-001	Honokōwai TH 6	AMFAC
Maui	Honokōwai	6-5638-002	Honokōwai TH 7	AMFAC
Maui	Honokōwai	6-5639-001	Honokōwai TH 5	AMFAC
Maui	Honokōwai	6-5639-002	Honokōwai TH 8	AMFAC
Maui	Waiheʻe	6-5731-005	Kanoa TH	Waiheʻe Sweetwater Farm LLC
Maui	Honokowai	6-5739-003	Mahinahina Deep Monitor	Commission on Water Resource Management, CWRM
Maui	Honolua	6-5840-001	ʻAlaeloa	State of Hawaiʻi, DLNR Land Division Oʻahu, DLNR-LD
Hawaiʻi	Kalae	8-0339-001	South Point Tank	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Hawaiʻi	Nāʻālehu	8-0437-001	Waiohinu Exploratory	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Hawaiʻi	Manuka	8-0445-001	HOVE Obs	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Hawaiʻi	Nāʻālehu	8-0831-001	Ninole Gulch TH-1	Hawaiiana Invest. Co., Inc
Hawaiʻi	Hilina	8-2317-001	Hawaiʻi Volcano National Park	U.S. National Park Service, Hawaiʻi Volcanoes, NPS
Hawaiʻi	ʻŌlaʻa	8-2714-001	Volcano TH-4	State of Hawaiʻi, DLNR Land Division Oʻahu, DLNR-LD
Hawaiʻi	ʻŌlaʻa	8-2714-002	Volcano TH5	State of Hawaiʻi, DLNR Land Division Oʻahu, DLNR-LD
Hawaiʻi	ʻŌlaʻa	8-2715-002	Volcano TH 3	State of Hawaiʻi, DLNR Land Division Oʻahu, DLNR-LD
Hawaiʻi	ʻŌlaʻa	8-2815-001	Volcano TH-1	State of Hawaiʻi, DLNR Land Division Oʻahu, DLNR-LD
Hawaiʻi	Kalapana	8-2883-007	Puna Geo MW2	Puna Geothermal Venture
Hawaiʻi	Kealakekua	8-3057-001	Hokukano Mon 2	Bob Stuit (Hokulia)
Hawaiʻi	Kealakekua	8-3155-001	Kealakekua Obs.	Pacific Islands Water Science Center, USGS, U.S. Geological Survey

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
Hawaiʻi	Kealakekua	8-3157-001	Hokukano Mon 1	Bob Stuit (Hokulia)
Hawaiʻi	ʻŌlaʻa	8-3207-004	ʻŌlaʻa -Mt. View	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Hawaiʻi	Keauhou	8-3255-001	Kainaliu Obs	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Hawaiʻi	Keauhou	8-3255-002	Kainaliu Test	Kona Research and Extension Center, CTAHR
Hawaiʻi	Keauhou	8-3457-002	Keauhou A	Kamehameha Schools
Hawaiʻi	Keauhou	8-3457-004	Kahaluu Deep Monitor	Commission on Water Resource Management, CWRM
Hawaiʻi	Keauhou	8-3858-001	Keopu Basal Monitor	Commission on Water Resource Management, CWRM
Hawaiʻi	Keauhou	8-3957-002	Komo Monitor	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Hawaiʻi	Keauhou	8-3959-001	Kamakana	Forest City Hawaiʻi Kona, LLC
Hawaiʻi	Hilo	8-4007-001	Waiakea Monitor	Okahara and Assoc., Inc.
Hawaiʻi	Hilo	8-4010-001	Kaumana	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Hawaiʻi	Keauhou	8-4060-002	Kaiser 1	Maryl Group, Inc.
Hawaiʻi	Keauhou	8-4060-003	Kaiser 2	Maryl Group, Inc.
Hawaiʻi	Keauhou	8-4061-001	Kaho 1	U.S. National Park Service, Kaloko-Honokohau Historical Park, NPS
Hawaiʻi	Keauhou	8-4161-001	Kaho 3	U.S. National Park Service, Kaloko-Honokohau Historical Park, NPS
Hawaiʻi	Keauhou	8-4161-002	Kaho 2	U.S. National Park Service, Kaloko-Honokohau Historical Park, NPS
Hawaiʻi	Keauhou	8-4161-010	MW 201	Kohanaiki Shores, LLC

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
Hawaiʻi	Keauhou	8-4161-011	MW 401	Kohanaiki Shores, LLC
Hawaiʻi	Keauhou	8-4161-012	MW 402	Kohanaiki Shores, LLC
Hawaiʻi	Keauhou	8-4162-004	MW 400	Kohanaiki Shores, LLC
Hawaiʻi	Keauhou	8-4162-005	MW 300a	Kohanaiki Shores, LLC
Hawaiʻi	Keauhou	8-4162-006	MW 300b	Kohanaiki Shores, LLC
Hawaiʻi	Keauhou	8-4162-007	MW 300c	Kohanaiki Shores, LLC
Hawaiʻi	Hilo	8-4203-016	HSDP 2 Deep	University of Hawaiʻi Hilo, UHH
Hawaiʻi	Keauhou	8-4262-003	MW 200	Kohanaiki Shores, LLC
Hawaiʻi	Keauhou	8-4262-004	Moana 9	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4262-005	Moana 9A	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4262-006	Moana 9B	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4262-007	W1	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4262-008	W-2	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4262-009	W2A	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4262-010	W2B	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4361-001	Queen K 13	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-014	Kona Blue 10	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-015	Kona Blue 10A	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-016	Kona Blue 10B	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-017	Mera 11	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-018	Mera 11A	Natural Energy Laboratory of Hawaiʻi Authority, NELHA

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
Hawaiʻi	Keauhou	8-4363-019	Mera 11B	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-021	W3	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-022	W3A	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-023	W3B	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-024	W4	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-025	W4A	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-026	W5	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-027	W5A	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-028	W5B	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-029	W6	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-030	W6A	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-031	W6B	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-032	W7	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-033	W7A	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-034	W7B	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-035	W8	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-036	W8A	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4363-037	W8B	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Hilo	8-4403-003	HSDP 1 Pilot	University of Hawaiʻi Mānoa, UHM
Hawaiʻi	Keauhou	8-4462-005	Keahole MW-11	State of Hawaiʻi, Department of Transportation, Airports Division, DOT

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
Hawaiʻi	Keauhou	8-4462-006	Keahole MW-13A	State of Hawaiʻi, Department of Transportation, Airports Division, DOT
Hawaiʻi	Keauhou	8-4462-007	Keahole MW-13B	State of Hawaiʻi Department of Transportation, Airports Division, DOT
Hawaiʻi	Keauhou	8-4463-001	Keahole MW-14A	State of Hawaiʻi, Department of Transportation, Airports Division, DOT
Hawaiʻi	Keauhou	8-4463-002	Keahole MW-14B	State of Hawaiʻi, Department of Transportation, Airports Division, DOT
Hawaiʻi	Keauhou	8-4463-003	Keahole MW-14C	State of Hawaiʻi, Department of Transportation, Airports Division, DOT
Hawaiʻi	Keauhou	8-4463-005	North Point 12	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4463-006	North Point 12A	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Keauhou	8-4463-007	North Point 12B	Natural Energy Laboratory of Hawaiʻi Authority, NELHA
Hawaiʻi	Waimea	8-4532-002	PTA Test Well 1	U.S. Army Garrison, Hawaii, Directorate of Public Works, DPW Army
Hawaiʻi	Onomea	8-4708-002	Kaieie Mauka	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Hawaiʻi	Kiholo	8-4959-010	Kukio Obs C	Kukio Community Association
Hawaiʻi	Kiholo	8-4959-011	Kukio Obs E	Kukio Community Association
Hawaiʻi	Kiholo	8-4959-012	Kukio Obs F	Kukio Community Association
Hawaiʻi	Kiholo	8-4960-001	Kukio Obs D	Kukio Community Association
Hawaiʻi	Kiholo	8-4960-003	Kukio Obs B	Huehue Ranch Associates, L.P.
Hawaiʻi	Kiholo	8-4960-004	Kukio Obs A	Huehue Ranch Associates, L.P.
Hawaiʻi	Mahukona	8-6141-001	Waiaka Tank	Pacific Islands Water Science Center, USGS, U.S. Geological Survey

Table G-5: Statewide Summary of Registered Observation Wells Not Included in the CWRM, CWRM-USGS, or Honolulu BWS Monitoring Programs (continued)

Island	Aquifer system	Well number	Well name	Well owner
Hawaiʻi	Mahukona	8-6144-001	Kanehoa	Pacific Islands Water Science Center, USGS, U.S. Geological Survey
Hawaiʻi	Waimea	8-6146-001	Ouli 2	Hale Wailani Partners LP
Hawaiʻi	Mahukona	8-6240-001	Waimea Obs.	Pacific Islands Water Science Center, U.S. Geological Survey
Hawaiʻi	Honokaa	8-6428-001	Honokaa (Hospital) Deepwell [NIU]	Department of Water Supply Hawaiʻi - Hilo, HDWS
Hawaiʻi	Mahukona	8-6652-001	Puanui 1	Kamehameha Schools
Hawaiʻi	Mahukona	8-7053-001	Mahukona MW 3	Wendell Brooks Jr.
Hawaiʻi	Mahukona	8-7154-002	Mahukona MW 2	Wendell Brooks Jr.
Hawaiʻi	Mahukona	8-7254-001	Mahukona MW 1	Wendell Brooks Jr.
Hawaiʻi	Hāwī	8-7345-003	Makapala Obs A	Pacific Islands Water Science Center, U.S. Geological Survey
Hawaiʻi	Hāwī	8-7347-003	Halaula Makai E	Pacific Islands Water Science Center, U.S. Geological Survey
Hawaiʻi	Hāwī	8-7347-004	Halaula Mauka B	Pacific Islands Water Science Center, U.S. Geological Survey
Hawaiʻi	Hāwī	8-7347-005	Halaula B	Pacific Islands Water Science Center, U.S. Geological Survey
Hawaiʻi	Hāwī	8-7445-001	Hapuu Bay D	Pacific Islands Water Science Center, U.S. Geological Survey
Hawaiʻi	Hāwī	8-7448-006	Kohala Obs F	Pacific Islands Water Science Center, U.S. Geological Survey
Hawaiʻi	Hāwī	8-7449-003	Hāwī Obs H	Pacific Islands Water Science Center, U.S. Geological Survey
Hawaiʻi	Hāwī	8-7451-001	Upolu Obs J-A	Pacific Islands Water Science Center, U.S. Geological Survey
Hawaiʻi	Hāwī	8-7451-002	Upolu Obs J-B	Pacific Islands Water Science Center, U.S. Geological Survey
Hawaiʻi	Hāwī	8-7549-003	Hāwī Makai I	Pacific Islands Water Science Center, U.S. Geological Survey
Hawaiʻi	Kalae	8-8836-001	Kaalualu TH 1	Kawaihae Ranch
Hawaiʻi	Kalae	8-8837-001	Kaalualu TH 2	Kawaihae Ranch

G.2.4 CWRM Management of Ground Water Data

CWRM utilizes four tools to manage information on ground water: a well index database, verifications of ground water well sources, a digital library of published Hawaiʻi related hydrologic reports, and water use reports submitted by individual well owners or operators. These tools are described below.

G.2.4.1 CWRM Well Index Database

CWRM maintains a well index database to track specific information pertaining to the construction and installation of production wells in Hawaiʻi and assists CWRM staff in protecting ground water resources from excessive withdrawals. The database contains information on well location, ownership, operation, well construction, pump type and capacity, and contractor information. The well index also contains aquifer properties and geologic information from well-drilling logs and pump-test reports.

G.2.4.2 Ground Water Well Verification

In 1988, CWRM initiated a program for well registration and declaration of existing water uses and began requiring well owners and operators to report water use to CWRM (see **Section H.3** for more information on water use reporting requirements). To date, CWRM has completed field verifications of all registered wells located in ground water management areas on Oʻahu, Molokaʻi, and Maui. In non-water management areas, CWRM has not completed field verification of many wells drilled prior to 1988.

Verification of wells since 1988 has been accomplished via 1) field investigations through the registration program for Oʻahu, Molokaʻi, and parts of Hawaiʻi, Maui, and Kauaʻi; 2) field investigations in existing ground water management areas related to the statutory 20-year review (§174C-56) in 2008, and 3) well & pump completion report correspondence and photo documentation provided by the drilling contractors as part of their permit requirements. Well construction and pump installation permits require the contractor to file completion reports as a condition of the permits and pump maintenance restorations. On occasion, staff will make a field visit to an existing or new well, but for the most part, day to day well verification is based on information provided by the drilling contractor.

CWRM can indirectly verify information on a well by examining ground water use reports submitted by the owner or operator. Water-use reports must identify the volume of ground water withdrawn over specific intervals, the water level in the well referenced to mean sea level, and the temperature of well water. Until the Hawaiʻi Well Construction and Pump Installation Standards were adopted by CWRM in 1997, CWRM did not consistently require pumpage metering and elevation benchmark references on all new wells. CWRM has not revised water use reporting policies to require the installation of meters and benchmarks at wells located outside water management areas that were drilled before 1988. Such requirements would better enable CWRM to indirectly verify reported well data.

G.2.4.3 Digital Library

CWRM staff maintains a digital library of all known hydrologic reports related to establishing ground water quantity in Hawaiʻi. Documents are searchable and provide a valuable research tool when analyzing permits, plans, organization, establishing the sustainability, etc., of ground water resources.

G.2.4.4 CWRM Water Use Reports

Ground water withdrawal data is obtained through reports submitted to CWRM by well operators/owners. Report submittals are inconsistent, with some users diligently reporting on a monthly basis, and others filing no reports until enforcement actions are taken against them. A monthly ground water use reporting form is available for use by well operators/owners on the CWRM website. The form asks for the following information:

- Well identification information;
- Start date and end date of reporting period;
- Quantity pumped (gallons);
- Method of quantity measurement;
- Chloride concentration (milligrams per liter) (or conductivity [µSeimens]);
- Water temperature; and
- Non-pumping water level (elevation in feet above mean sea level).

To improve data collection from well operators/owners, CWRM has developed a database for tracking water use reports and has enhanced the database to include an automated system for issuing notices of reporting delinquencies to permittees. An important feature is a web-based reporting program that enables water users to more efficiently report water usage to CWRM.

G.2.5 Gaps in Ground Water Monitoring Activities

G.2.5.1 Statewide Ground Water Monitoring Plan

There is a need for a statewide plan to coordinate and implement monitoring activities, and to direct the expansion of monitoring networks. There is also the associated need to increase funding for data collection networks.

G.2.5.2 Deep-Monitor Wells

There are 45 deep-monitor wells in the state (see **Figure G-2** and **Table G-5**). All but seven of them are on Oʻahu. Although Oʻahu has the most deep-monitor wells, there is still a need for more wells in inland locations. Also, development is proceeding rapidly on Kauaʻi, Maui and Hawaiʻi, and basal aquifers are often developed to supply these developments. Deep-monitor wells should be drilled on the neighbor islands to provide baseline data and to provide data on the influence of pumpage and climate change on ground water.

Aquifer-wide monitoring is severely limited throughout most of the state. Useful data on the behavior and status of ground water resources is lacking. This data gap may be especially dangerous in aquifers that are critical municipal sources. The coverage of water level and deep monitor wells should be increased. The State, in cooperation with the USGS, counties, and private entities should plan for idealized well placement in each aquifer sector area and create maps showing the ideal well locations, existing wells, funded wells, and planned wells.

Considerations for locating future deep monitor wells include:

- Providing the necessary *mauka*-to-*makai* spatial coverage within each aquifer system area;
- Enhancing hydrologic knowledge of the ground water system;
- Locating wells in areas that are not directly influenced by pumping centers and replacing those that are;
- Where feasible, identifying and converting former production and/or existing water-level observation wells into deep monitor wells; and
- Minimizing site requirements to obtain well easements, rights-of-entry, and property ownership.

Primary locations for deep monitor wells are areas where:

- The aquifer is a major potable resource and/or is being heavily pumped; and
- There is uncertainty about the sustainable yield and/or the conceptual hydrogeologic model and concern about the relationship between pumpage and saltwater intrusion.

Secondary locations for deep monitor wells should be chosen in light of the following considerations:

- Collecting baseline data from an aquifer system area before it is developed to capacity (e.g., Kailua-Kona and Lahaina);
- Planning an additional well in an aquifer to provide greater understanding of the ground water hydrology (e.g., Pearl Harbor); and
- Minimizing cost by converting unused wells to deep monitor wells.

G.2.5.3 Water-Level Observation Wells

The statewide water-level observation well network is inadequate. In most areas of the state, the present water-level observation network lacks wells that continuously measure water levels from interior sites within aquifer system areas. There are also not enough wells in the high-level aquifers, which are important in measuring the effects of pumpage on streamflow. Also, high-level aquifers are often relatively small and need to be monitored for resource depletion. Interior water-level observation wells are important in defining the inland extent of basal aquifers.

Additionally, wells used to measure water levels are not tied into the same datum. It is essential to have well measuring points tied to the same datum; otherwise, the measured water levels may not be comparable.

Elevations in Hawaiʻi are related using geodetic control points. The geodetic control in Hawaiʻi was last updated by the National Geodetic Survey in the 1970s. Construction and land development over the last 30 years has resulted in the destruction or disturbance of many of the control benchmarks. In addition, land subsidence, changes in sea level, and other natural causes have also altered these controls. The Hawaiʻi Department of Transportation is leading an effort to modernize elevations in Hawaiʻi by obtaining funding and assistance from the National Geodetic Survey. Once a new geodetic control is in place it will be possible to link elevations at the current and future monitor well networks. Recent work reestablishing benchmarks in Central Maui and in the Pearl Harbor Aquifer Sector Area, Oʻahu by the National Geodetic Survey (NGS), using global positioning satellite (GPS) technology, has shown benchmark elevations can be rapidly and accurately reestablished (vertical accuracy with the NGS survey is about 2 cm). With these benchmarks established it is possible to then perform synoptic water levels that help establish and compare water levels throughout an aquifer at a single moment in time.

G.2.5.4 Spring Discharge and Chemistry Measurements

Although spring discharge and chemistry data are collected in some areas (e.g., the Pearl Harbor Aquifer Sector Area), there has been minimal progress toward using the data in a meaningful way. Little has been done to correlate spring chemistry and flow quantities with land use changes over time, and the following opportunities should be explored:

- Because basal spring discharge essentially occurs at the coast, the challenge is to use coastal and submarine springs to monitor changes within the basal lens and impacts to nearshore environments. Springs can provide information on the impacts of past land use activities and other changes to recharge.

- Continued sampling and discharge measurements are imperative, but other chemical constituents or measurable parameters (e.g., completing an annual mineral analysis of selected spring sampling points) should be measured to present a more complete understanding of the dynamics of ground water flow.

- The effect of spring data on the calibration of numerical ground water models should be further studied, as such data may provide additional insight.

- Databases on spring information are kept by multiple agencies; however, these databases are generally not integrated. Although jurisdictional issues must be addressed, the integration and sharing of data would be useful in understanding flow dynamics and would allow for better application of shared resources and information.

G.2.5.5 Pumpage, Water-Level, Temperature, and Chloride (or Conductivity) Information

Currently, all reported well pumpage data is entered into CWRM's water use reporting database. It is CWRM's priority to update and maintain ground water pumpage information. Pumpage data is updated on a regular basis, however, other functions of the database are still undergoing beta testing.

Due to staff constraints, CWRM has prioritized pumpage data collection to focus on designated water management areas and large users in non-designated areas. Once CWRM achieves a greater level of compliance with the reporting of pumpage data, CWRM intends to improve compliance with chloride (or conductivity) data reporting, followed by water-level reporting.

The following issues and concerns are associated with pumpage, water-level, and chloride (conductivity) data collection:

- Immediate correlation between pumpage, chloride (or conductivity), and water levels cannot be achieved. Time lags exist between pumping activities and aquifer response. Changes in water levels and chlorides (or conductivity) may not manifest immediately and lag periods may be several months long. In addition, water levels in coastal monitoring wells may be overwhelmingly governed by ocean level and tidal signals and may completely mask changes due to recharge or withdrawal.

- It is difficult to correlate water uses with the associated changes in chloride concentrations (or conductivity) and water levels; the effects of additional variables such as subsurface geology are also difficult to correlate.

- It is difficult to execute analyses of small-user data versus large-user data.

- Presently, pumpage, water-level, and chloride (or conductivity) data is not shared between agencies through integrated databases. As is the case with spring discharge information, agency jurisdictional issues must be addressed before the integration and sharing of data can occur.

CWRM anticipates that the issues listed above can be addressed by the agency when the water use reporting database is fully operational and updated with current water use reports. It is a priority to obtain more ground water pumpage, chloride (or conductivity), and water level information. Without this data, comprehensive, accurate and timely hydrologic analysis cannot be executed; CWRM will be unable to asses all stresses placed on ground water and the resulting individual well reaction to such stresses. Water use reporting (large and small users) in a generally uniform and timely fashion is a major goal of the water use database, as is the capability of having online reporting. This will greatly speed up correlations between pumpage, chloride concentrations (or conductivity), and water levels. CWRM enforcement of water use reporting requirements is essential to improving the quality and timeliness of the CWRM database, which will in turn provide a quicker and more accurate picture of aquifer health.

G.2.6 Recommendations for Monitoring Ground Water Resources

Recommendations for the improvement and expansion of ground water monitoring activities in the State of Hawaiʻi are listed below and are categorized by activity type.

G.2.6.1 General Recommendations

The recommendations listed below apply to statewide activities for maintaining current programs and planning for future monitoring activities.

- **Maintain/increase USGS co-op funding:** The number of wells monitored by the USGS in the UGSG-CWRM cooperative agreement has declined by 95 percent since 1995. Water-level monitoring on the neighbor islands is not adequate and must be expanded. Federal and State funding for the cooperative program should be increased. The increased funding would reflect inflationary costs as well as expanding the data collection network to monitor new centers of water development.

- **Conduct Regular Analysis of Aquifer Health**: As the Survey Branch collects water use and aquifer data through its monitoring programs, regular analysis should occur to identify potential threats to aquifer sustainability. Water data is critical to support current management policies regarding the sustainability of ground water resources.

- **Planning a Statewide Ground Water Monitoring Network:** It is recommended that a statewide plan be developed to implement monitoring activities and to direct the expansion of monitoring networks, especially for deep monitoring wells. This plan should also project funding requirements for data collection activities and improvements to the monitoring networks.

- **Develop Comprehensive Monitoring Plans for Aquifer System Areas of Concern:** It is recommended that comprehensive monitoring plans be developed for aquifer system areas under threat or there is uncertainty about the hydrogeologic conditions.

Deep Monitor Wells

The items below summarize the recommendations for the Deep Monitor Well Program. Included in this listing are planned near-term improvements, as well as other projects that require the approval and appropriation of funds.

- **Drill new deep monitor and water level monitor wells:** Deep monitor wells should be drilled in most of the basal aquifers in Hawaiʻi. Also, dedicated water-level monitor wells should be located or drilled in all of the aquifers in Hawaiʻi.

- **Better Spatial Coverage:** Ideally, deep monitor wells within an aquifer should be located to provide coverage from an inland or mauka site, a middle site near withdrawal areas, and a makai site to monitor changes in the distal portion of the basal lens. Locating wells in this fashion provides a cross-section of the basal aquifer.

- **Review Monitoring Well Network:** The monitoring well network should be reviewed to: 1) identify wells located in large pumping batteries, that are directly influenced by pumpage, and should be considered for replacement; and 2) identify former production and/or existing water-level observation wells where it may be feasible to convert existing wells to deep monitoring wells.

- **New Data Collection:** Existing wells or new wells should be outfitted with nested piezometers or multiple piezometers to observe vertical flow in the aquifer system areas where such information is important. In addition, conductivity data loggers could be lowered to depths identified in the conductivity profile logs that suggest vertical flow and left to monitor changes in conductivity over time. Where available, calibrated dispersion coefficients from deep monitor well data should be included in new 3-D solute transport ground water flow models.

- **Graphical Mapping of Data**: Conduct geospatial mapping of top of TZ, MPTZ, and water-level elevations. These maps would show actual water levels and expected water levels from the deep monitor well data.

- **Borehole Flow Analysis**: Recent data collected by the USGS and CWRM has shown that borehole flow does occur under certain natural and induced (anthropogenic) conditions in deep monitor wells[1] (Rotzoll USGS, 2010). As a result, CTD profiles may not accurately reflect the transition zone elevations within the aquifer. CWRM will evaluate the influence of vertical borehole flow on a well by well basis and develop recommendations for future DMW design and installation details (and consider existing DMW retrofits) to mitigate the influence of vertical flow within the DMWs.

Water-Level Observation Wells

The items below summarize the recommendations for water-level observation wells. Included in this listing are planned near-term improvements, as well as other projects that require the approval and appropriation of funds.

- **Upgrade Data Collection System:** 1) All new CWRM deep monitor wells will be fitted with transducers or other devices that will collect water-level data on a continuous basis. 2) Add transducers (or other devices) to provide continuous water-level data collection at existing BWS and USGS deep monitor wells in the network throughout the Pearl Harbor Aquifer Sector Area. 3) Eliminate redundant data collection from some monitoring sites.

- **Drill New Water-Level Observation Wells**: The primary considerations for drilling new observation wells is to better delineate the basal aquifer boundaries, and to locate geological boundaries and/or structures that would affect ground water flow. In general, even with the addition of water-level measuring devices in the existing deep monitor and water-level observation wells, coverage is lacking toward the interior of aquifer sector areas. New water-level observation wells or test holes should be drilled or developed in interior areas following a mauka-to-makai orientation.

- **Resurvey All Measuring Points for Water-level Observation Wells, Including Deep Monitor Wells:** In addition to new water-level monitoring, a priority goal is to resurvey all measuring points (benchmarks) related to water-level data. This action would include all new wells and existing wells. Because many of the observation wells were drilled over a timespan of several years, it is uncertain whether the elevation of measuring points located on the wells (from which the water-level elevations are derived) are referenced to the same datum. Therefore, synoptic water-level maps may not provide an accurate representation of water-level gradients. Geodetic-control benchmarks in the State of Hawaiʻi should be resurveyed to ensure consistent and accurate water level measurements.

- **Conduct More Synoptic Water-level Surveys:** In a cooperative effort, the USGS, Honolulu BWS, and CWRM completed two synoptic water-level surveys of the Pearl Harbor Aquifer Sector Area (August 17, 2011 and April 26, 2012). The most recent synoptic survey of the ʻĪao and Waiheʻe Aquifer System Areas was on September 15, 2015. Water-level measuring tapes owned by the three agencies were calibrated against a USGS reference steel tape. Correction factors to the individual tapes were applied to each measurement. All measurements within the Pearl Harbor Aquifer Sector Area were completed within a four-hour period on each day.

Synoptic water level surveys should be conducted at least twice a year in all important areas. All water-level tapes should be calibrated against the USGS reference steel tape at least once every two years and correction factors updated. With the height modernization of measuring point benchmarks, the synoptic water levels will provide an accurate “snapshot” into the direction of ground water movement.

- **Reinstate Water Level Measurement in Discontinued Observation Wells:** CWRM should evaluate the list of 173 discontinued observation wells and prioritize important wells that should be monitored. Once this is done, arrangements should be made with well owner to begin quarterly measurement of water levels in selected wells. CWRM should also coordinate with USGS on monitor well details, e.g., benchmarks, reference points, site access, etc.

- **Monitor Water Levels in High-Level Wells:** There is insufficient coverage in the high-level aquifers, and water level monitoring is crucial in order to assess the effects of pumpage from these systems. High-level aquifers are often relatively small and need to be monitored for resource depletion.

Spring Discharge and Chemistry Measurements

The items below summarize the recommendations regarding spring discharge and chemistry data collection, information management, and data analyses. Included in this listing are planned near-term improvements, as well as other projects that require the approval and appropriation of funds.

- **Integration of Databases:** Secure commitments from agencies who collect spring data, to further the use and integration of the spring discharge and chemistry databases, and to explore options for data application/studies to help understand flow dynamics of basal lenses.

- **Additional Analyses**: Analyze spring data for parameters, such as nitrate, and compare with data analyses performed in well water. This may provide insight on the velocity of ground water flux over time.

- **Additional Monitoring:** Use data loggers to monitor temperature and conductance at spring orifices, logging daily changes. Temperature and conductance data may provide greater insight into the movement of the lens.

Pumpage, Water-Level, and Chloride Data Management

The items below summarize the recommendations for well pumpage, water-level, and chloride (or conductivity) data management and dissemination. Included in this listing are planned near-term improvements, as well as other projects that require the approval and appropriation of funds.

- **Updating and Maintaining CWRM's Water Use Reporting Database**: In the effort to become more efficient at managing all its water resource information, CWRM's Water Resource Management Information System (WRIMS) was launched in July 2012. This system enables Water Use Reporters to file their Water Use Reports on-line and monitor their historical use from each source via the internet. The updating and maintenance of the WRIMS database is paramount for timely analysis and reporting of pumpage, water-level, and chloride (or conductivity) data statewide. CWRM is currently focused on obtaining pumpage reports from all users in designated water management areas and from large users in non-designated areas. Subsequently, CWRM will pursue statewide reporting of pumpage, water-level, and chloride (or conductivity) data from all water use reporters.

- **Integration of Databases and Public Access**: Honolulu BWS historical pumpage and chloride data should be integrated with CWRM and USGS information in an appropriately managed database. Assuming that security and sensitivity of the data can be preserved, there should be limited public access via the Internet. Based on the success of this effort, the database should be expanded to include information from other county water departments.

- **Design and Implement Quality Assurance / Quality Control Protocols:** Data voluntarily submitted to CWRM may have quality and accuracy issues – particularly well pumping reports. Site visits with well operators to verify measurement equipment and methods and to provide training and outreach would improve confidence in data submitted to CWRM.

G.3 Surface Water Monitoring

Similar to ground water resources, long-term monitoring information is critical to developing appropriate management scenarios for surface water resources. There is a long history of surface water monitoring in Hawai‘i; however, much of the historic record is focused on large, agricultural irrigation systems that were active throughout the state for much of the 20th Century. Surface water management has grown in complexity, due largely to recent closures of sugar and pineapple plantations and the potential for restoration of stream ecosystems. These changes are further complicated by the demands of a burgeoning population that requires high-quality ground water for drinking purposes, as well increasing amounts of surface water for irrigation needs (e.g., diversified agriculture, golf courses, landscaping, etc.) and for the perpetuation of cultural gathering rights.

Monitoring various stream characteristics, along with appropriate climate and physical data, can provide valuable information on stream health and integrity. Important considerations for surface water monitoring are described below.

Streamflow: Streamflow is the primary surface water characteristic measured during surface water monitoring activities. Most often, streamflow is measured at continuous-record gaging stations, which are permanent structures constructed on the bank of a stream. These stations typically remain in operation for a number of years, provided that funding is available. The stations provide annual flow values and allow for long-term trend analysis. The USGS maintains numerous stations throughout Hawai‘i. These stations collect data with sufficient frequency to identify daily mean values and daily variations in flow. Streamflow may also be measured at specific sites intermittently or as necessary for a specific study. The USGS refers to these sites as partial-record stations. While flow is often not measured with sufficient frequency to provide daily statistics, these measurements may aid in trend analysis and provide a snapshot of flow at a specific period in time.

Rainfall: Rainfall data represents the “input” to surface water systems and provides basic information to complete the water balance equation. Surface water runoff models rely on rainfall, landcover, soil, geology, and land use information to determine how much rainfall percolates into subsurface layers, and how much water runs off the land as surface water. Ideally, rainfall data should be complemented with fog drip and evapotranspiration data to provide for more accurate modeling conditions. Rainfall and precipitation monitoring are discussed further in **Section G.4**.

Diversions: There are approximately 1,380 registered and permitted stream diversions statewide. A considerable number of these diversions have been verified in the field, but much of the information is outdated as landowners change and systems deteriorate. In 2007, CWRM initiated a statewide field investigations project to verify registered stream diversions. CWRM recognized early that available funding would not be sufficient, so a prioritized list was developed that first looked at areas with issues pending before the Commission followed by regions that contained large irrigation systems. The resulting study covered much of Maui and Kauaʻi, but not Oʻahu and Hawaiʻi. Portions of Koʻolaupoko on the island of Oʻahu were also verified with the assistance of the Honolulu Board of Water Supply. CWRM continues to refine its Water Resource Information Management System and update diversion information as field investigations are conducted statewide.

One of the difficulties in assessing surface water diversions is the wide range of methods that are employed to divert stream water. Diversion structures may consist of various materials and installations, including PVC pipes, hoses, concrete intakes, or hand-built rock walls. Water can be moved from the stream channel into the diversion by pump or by gravity flow. It is difficult to quantify the amount of diverted stream flow statewide, as most diversions are not equipped with gages, and access to diversion sites may be restricted or require special arrangements. Often, particularly for irrigation systems associated with former plantation lands, intake structures are located high in the mauka sections of the watershed and are only accessible by four-wheel drive or on foot. The quantification of diverted flow, whether estimated or measured directly, is a key component in streamflow analysis, allowing investigators to estimate natural streamflow and identify diversion impacts to instream uses. Continuous, long-term measurement of diverted streamflow is ideal.

A long-term monitoring program must be supported by an initial verification of each registered and permitted diversion structure and the amount of flow diverted at each site. This is a critical first step towards comprehensive management of surface water and is being executed by CWRM. Long-term monitoring programs and improved regulation of stream diversion structures will be facilitated by field verification activities.

Irrigation Systems: Throughout Hawai‘i, large irrigation systems are responsible for the majority of the annual volume of diverted surface water flow. While this water was traditionally used for irrigation of sugarcane and pineapple, the closure of these industries has made both land and irrigation water available for diversified agriculture, stream restoration, and other applications. Due to the complex nature of large irrigation systems, it is difficult for irrigation managers to measure flow diverted at all surface water intakes. Instead, water flow through irrigation systems is usually measured at a handful of key locations along the system alignment. As a result of the September 1992 Commission action exempting surface water users from reporting requirements until standard methods are approved (see **Appendix H, Section H.3 CWRM Water Use Reporting Requirements**), few irrigation system managers provided CWRM with water use reports. In January 2014, the Commission repealed this policy as CWRM staff sought to develop greater surface water use reporting. CWRM's Stream Protection and Management (SPAM) Branch has compiled an inventory of stream diversion measurement methods, developed a water user reporting database, implemented a web-based water use reporting function, and continues to seek out and work with new surface water use reporters. Workshops for large and small irrigation system operators were conducted to provide education and onsite training for measuring and reporting diverted surface water as part of CWRM's water conservation plan implementation. These water use reports are the primary information source for CWRM's monitoring and regulating of stream diversions and surface water use by irrigation systems.

End Uses: End use primarily refers to the diversion of water from large irrigation systems. Reporting water use amounts for end uses is not required by CWRM, except in designated surface water management areas. However, via the registration of stream diversion works process (circa 1989), CWRM received a large number of applications by end users reporting their water use. In addition, CWRM may often request end use amounts when addressing surface water issues for a specific area. End use information is critical to determine system efficiency and reasonable and beneficial water use.

Biology: Stream biology is an important factor in determining CWRM's regulatory authority for a stream channel and in the setting of instream flow standards. CWRM relies heavily on biological information provided by the DLNR Division of Aquatic Resources (DAR), along with data collected by other agencies such as USGS and DOH. The point-quadrat study method preferred by DAR is a combined survey of macrofauna and microhabitat, often performed randomly along the length of a stream segment. Biological surveys generally provide information on species composition (native v. exotic), distribution, flow type, substrate, and basic water quality parameters.

Water Quality: Water quality monitoring falls under the jurisdiction of the DOH. However, the State Water Code provides that CWRM consider surface water quality in determining instream flow standards, in the issuance of stream channel alteration permits, and in permitting stream diversion works. Stream channel alterations, such as channel hardening, ford crossings, culverts, and diversion structures, may have a direct impact upon water quality. Conversely, CWRM must weigh the impact of existing alterations and diversions in its determination of appropriate instream flow standards. Relationships between water quality, aquatic species habitat, biodiversity, and land use may be taken into consideration when determining water availability for instream and offstream uses.

G.3.1 Existing CWRM Surface Water Monitoring Programs in Hawaiʻi

The Hawaiʻi Administrative Rules, Chapter 13-169-20 (2), recognizes that, “a systematic program of baseline research is…a vital part of the effort to describe and evaluate stream systems, to identify instream uses, and to provide for the protection and enhancement of such stream systems and uses.” CWRM’s SPAM Branch is currently developing an independent, long-term monitoring program, and continues to work closely with the USGS to operate and maintain a statewide network of surface water gaging stations (see **Figure G-21** to **Figure G-25**[6]). The data collected through the CWRM-USGS cooperative monitoring program serves as the backbone of CWRM’s SPAM Program. The long-term record provided by the gaging station network supports a wide range of statewide studies (e.g., flood analysis, water quality, ground/surface water interaction, biology, etc.).

G.3.1.1 CWRM-USGS Cooperative Monitoring Program

Similar to the cooperative groundwater monitoring program described in the previous sections, CWRM and the USGS work together to collect surface water data throughout the State. Of the 376 perennial streams in Hawaiʻi, over 140 have been gaged since the inception of the cooperative agreement. Stream gage data is collected and analyzed as part of the overall hydrologic data-collection network. CWRM staff continuously reviews and evaluates the data-collection network for duplication of effort, usefulness of information, and for monitoring deficiencies in a particular geographic area. USGS data collection and analysis methods are described below.

Data Collection

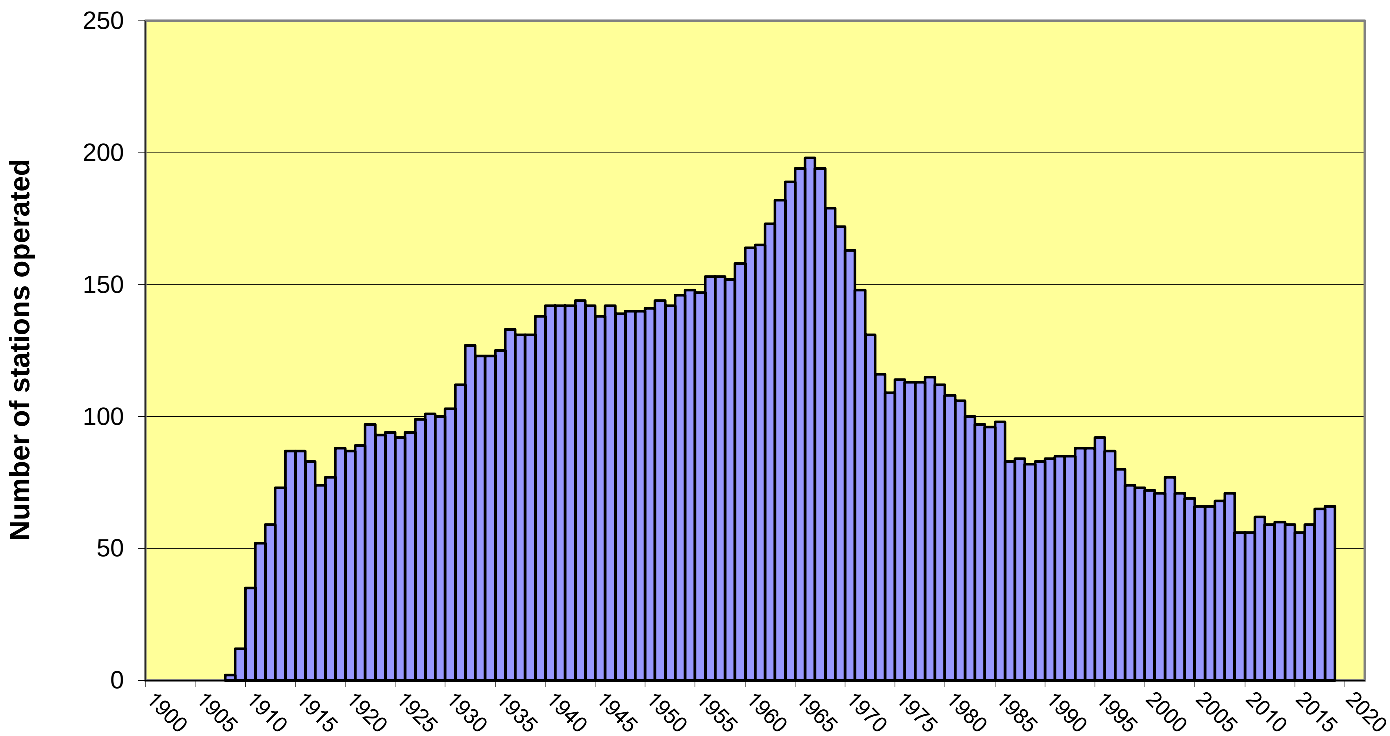
Continuous-Record Gaging Stations: The Hawaiʻi surface water data collection program operated by the USGS officially began in 1909, with the establishment of 12 continuous-record gaging stations. The program quickly expanded so by 1914, there were 87 continuous-record gages in operation, however most gages were installed to evaluate potential sources of irrigation water for agriculture. The program continued to grow and peaked in 1966 with a total of 197 continuous-record gages. Over the years, gages were discontinued for a variety of reasons. The primary reasons have been either economic and/or because a gage has fulfilled its data collection requirements. **Figure G-20** shows the number of continuous-record gaging stations in operation from 1909 to 2008. The CWRM funded surface water data-collection stations in operation for Fiscal Year 2017 are listed in **Table G-6**.

[6] Fontaine, R.A., 2006, Water Resources Data, Hawaii and other Pacific Islands, Water Year 2005, Volume 1. Hawaii, U.S. Geological Survey Water-Data Report HI-05-1, 344p.

Continuous-record gaging stations are gages that record some type of data, generally water-surface elevation, on a continuous basis. This data can be used to compute streamflow for any instantaneous period or for selected periods of time (e.g., day, month, year). These stations collect long-term baseline data, in order to provide a series of consistent streamflow observations. Streamflow data is used to identify trends in streamflow over time, analyze the statistical structure of hydrologic time series, and to evaluate flow regime trends in response to various local, regional, or global changes.

Some continuous-record gaging stations have been designated as long-term trend stations. These stations provide data used analyzing the statistical structure of hydrologic time series and can be used as a baseline for evaluating the flow regimes of other streams or for climate change monitoring purposes. For a gage to be considered a long-term trend station, it must be on a stream in a drainage basin that has undergone no significant human alterations and is expected to remain that way into the future.[7]

Figure G-20 History of USGS continuous-recording stream gage operation



[7] Fontaine, R.A., 1996, *Evaluation of the surface-water quantity, surface-water quality, and rainfall data-collection programs in Hawaii, 1994*: U.S. Geological Survey Water-Resources Investigations Report 95-4212, 125 p.

Table G-6 CWRM Funded USGS Surface Water Data-Collection Stations in Operation for Water Year 2017

USGS Station No.	Island	USGS Station Name	Station Type	Frequency
16031000	Kauai	Waimea River at Waimea	SW RT-Cont	Continuous - RT
16049000	Kauai	Hanapepe Riv blw Manuahi Str near	SW RT-Cont	Continuous - RT
16060000	Kauai	SF Wailua River near Lihue	SW RT-Cont	Continuous - RT
16068000	Kauai	EB of NF Wailua River near Lihue	SW RT-Cont	Continuous - RT
16071500	Kauai	Left Branch Opaekaa Str near Kapaa	SW RT-Cont	Continuous - RT
16097500	Kauai	Halaulani Str at alt 400 ft near Kilauea	SW RT-Cont	Continuous - RT
16103000	Kauai	Hanalei River near Hanalei	SW RT-Cont	Continuous - RT
16208000	Oahu	SF Kaukonahua at E. Pump nr	SW RT-Cont	Continuous - RT
16227500	Oahu	Moanalua Stream near Kaneohe	SW RT-Cont	Continuous - RT
16229000	Oahu	Kalihi Str near Honolulu	SW RT-Cont	Continuous - RT
16240500	Oahu	Waiakeakua Str at Honolulu	SW RT-Cont	Continuous - RT
16294900	Oahu	Waikane Str at alt. 75 ft at Waikane	SW RT-Cont	Continuous - RT
16345000	Oahu	Opaeula Str near Wahiawa	SW RT-Cont	Continuous - RT
16294100	Oahu	Waiahole Stream above Kamehameha	SW RT-Cont	Continuous - RT
16296500	Oahu	Kahana Str at alt 30 ft near Kahana	SW RT-Cont	Continuous - RT
16301050	Oahu	Punaluu Str above Diversion near	SW RT-Cont	Continuous - RT
16508000	Maui	Hanawi Stream near Nahiku	SW RT-Cont	Continuous - RT
16604500	Maui	Iao Stream at Kepaniwai Park near	SW RT-Cont	Continuous - RT
16614000	Maui	Waihee Rv above Waihee Dtch Intake	SW RT-Cont	Continuous - RT
16620000	Maui	Honokohau Stream near Honokohau	SW RT-Cont	Continuous - RT
16518000	Maui	West Wailuaiki Stream near Keanae**	SW RT-Cont	Continuous - RT
16587000	Maui	Honopou Stream near Huelo	SW RT-Cont	Continuous - RT
16704000	Hawaii	Wailuku River at Piihonua	SW RT-Cont	Continuous - RT
16720000	Hawaii	Kawainui Stream near Kamuela	SW RT-Cont	Continuous - RT
16770500	Hawaii	Paauau Gulch at Pahala	SW RT-Cont	Continuous - RT
16717000	Hawaii	Honolii Stream near Papaikou	SW RT-Cont	Continuous - RT
16725000	Hawaii	Alakahi Stream near Kamuela	SW RT-Cont	Continuous - RT

Figure G-21 Locations of Streamflow gaging stations on Kaua‘i (Water Year 2017)

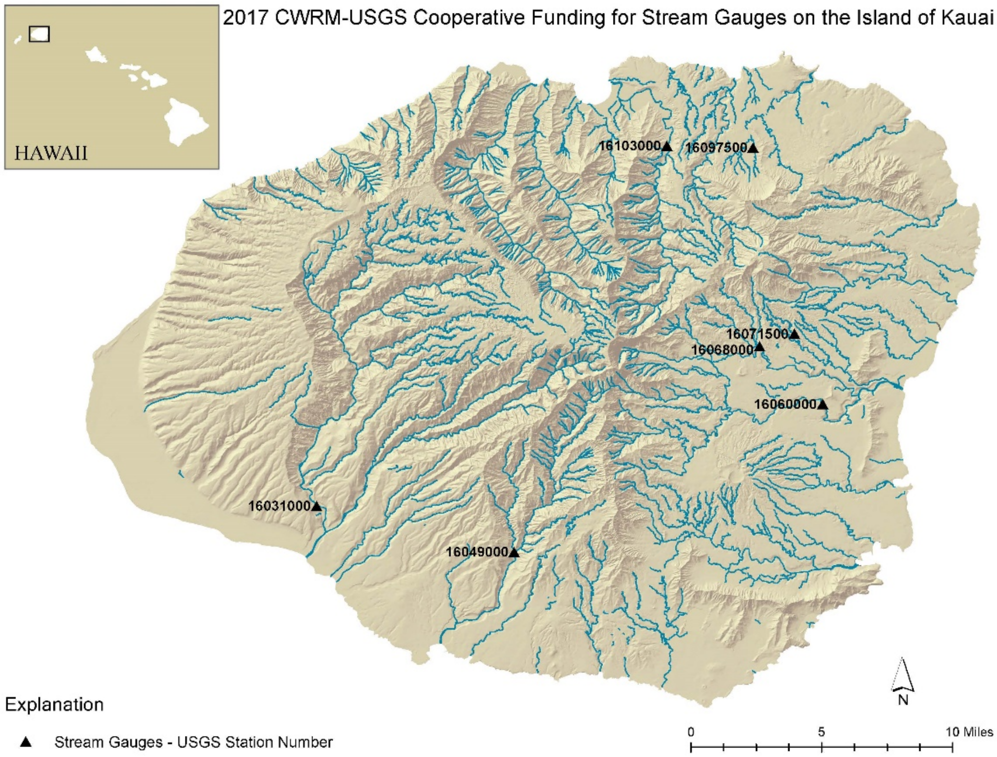


Figure G-22 Locations of Streamflow gaging stations on O‘ahu (Water Year 2017)

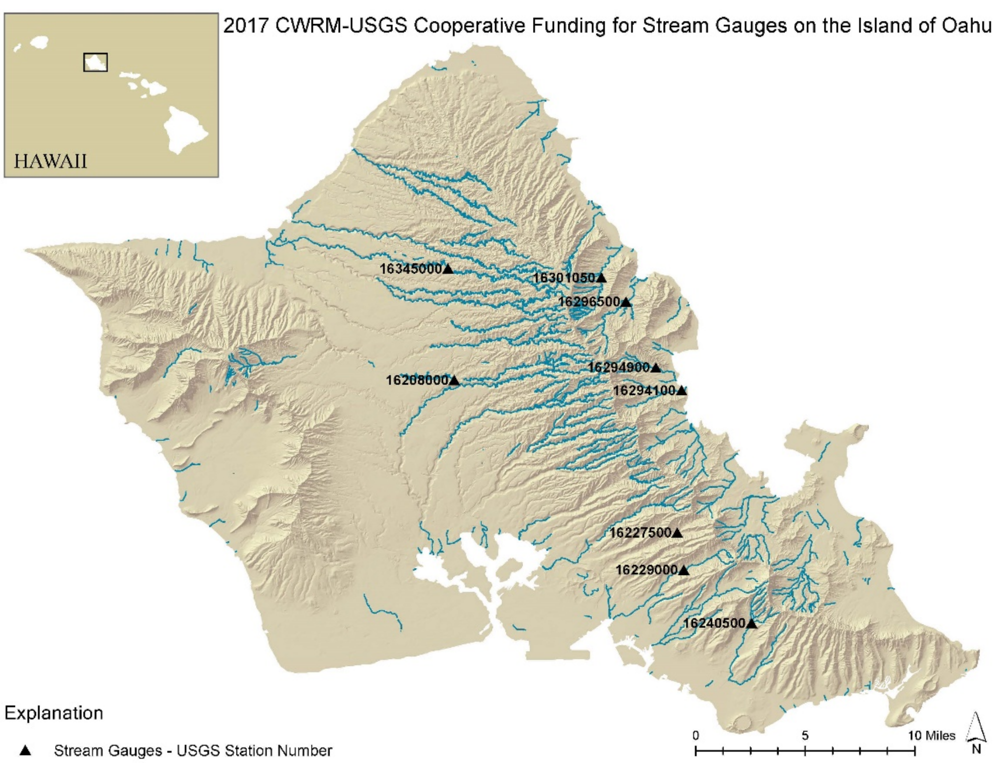
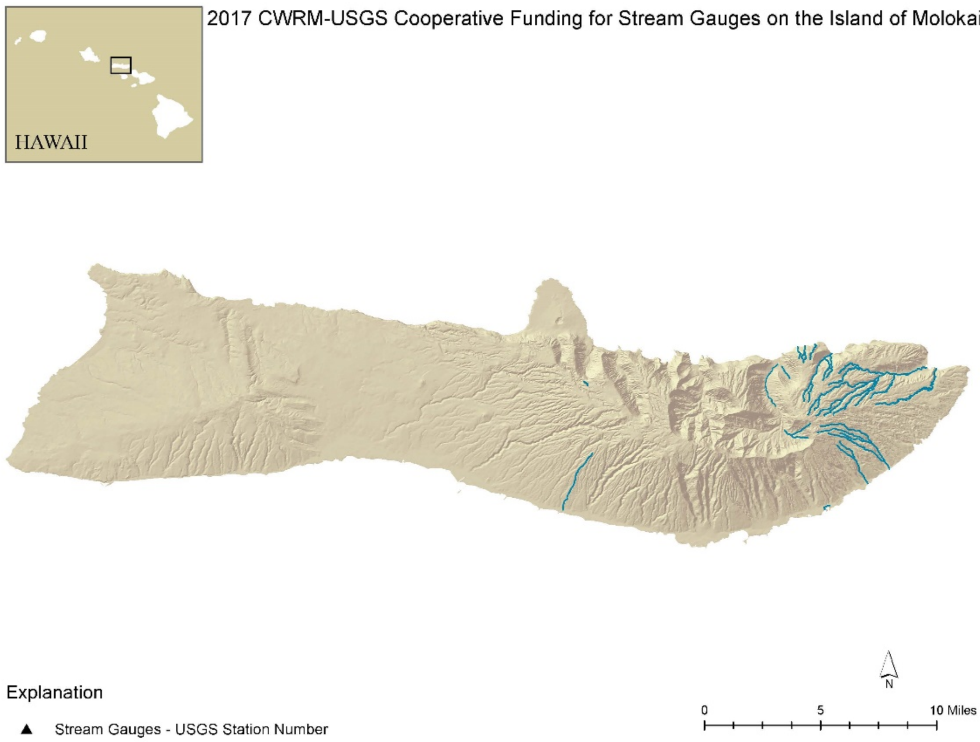


Figure G-23 Locations of Streamflow gaging stations on Moloka‘i (Water Year 2017*)



*No CWRM Funded USGS streamflow gaging stations on Moloka‘i for Water Year 2017

Figure G-24 Locations of Streamflow gaging stations on Maui (Water Year 2017)

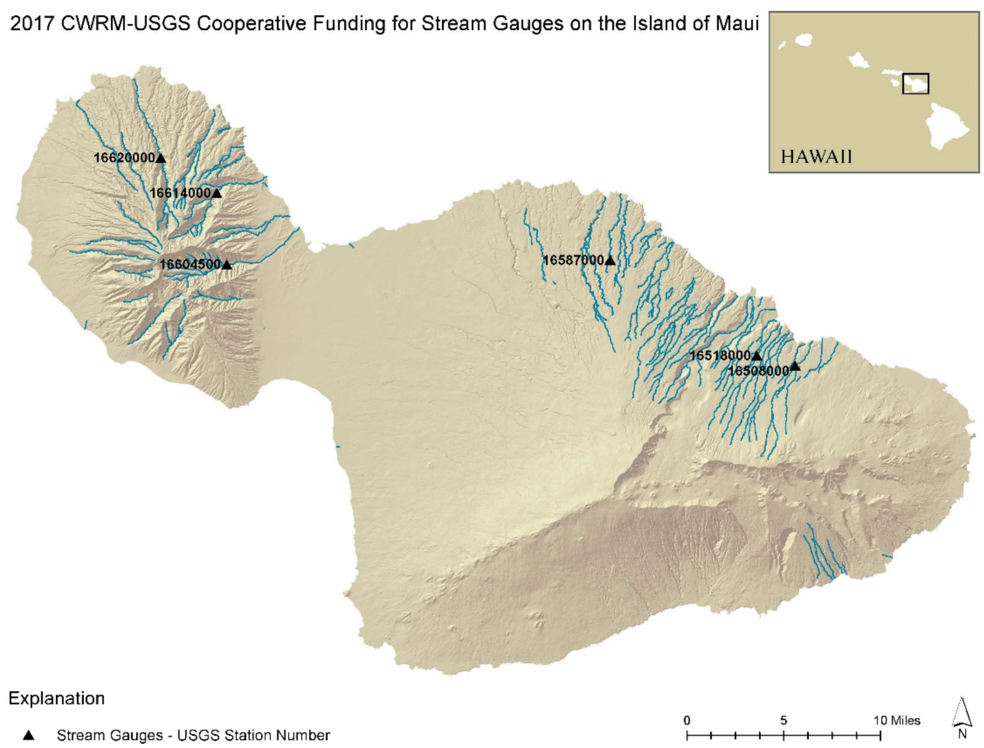
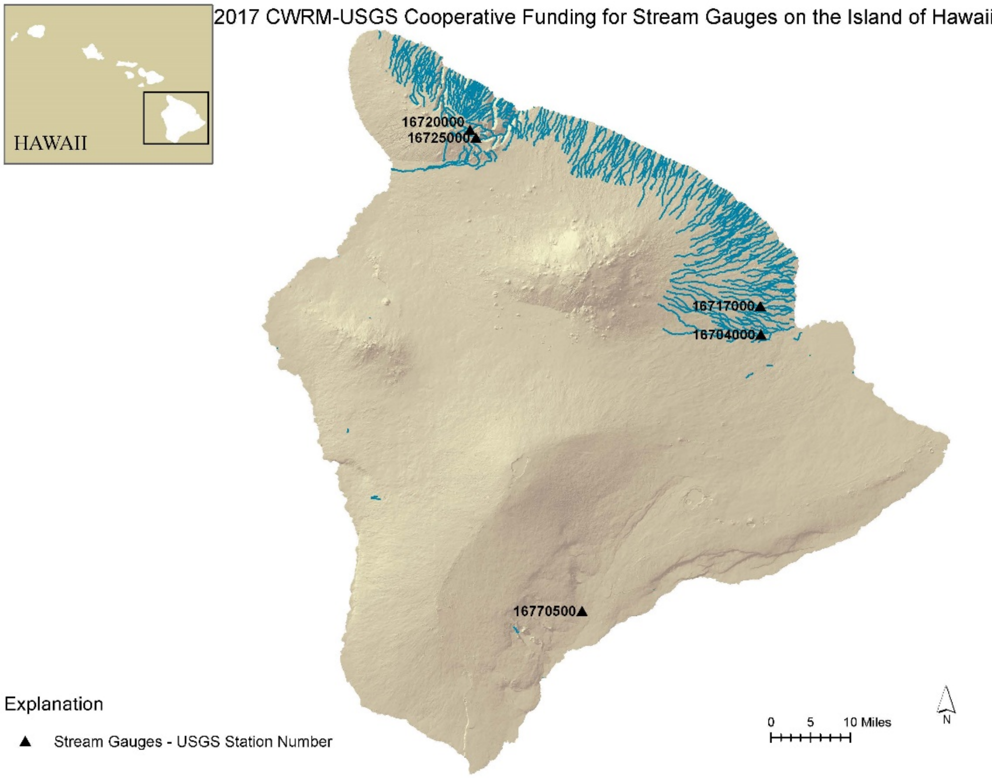


Figure G-25 Locations of Streamflow gaging stations on Hawai‘i (Water Year 2017)



Crest-Stage Gaging Stations: Crest-stage gages provide only the peak surface water elevation that occurred between servicing visits to the gages. Peak elevation data is often used to compute discharges for selected flood peaks, and only the maximum flood peak for each water year is typically published.

Data from crest-stage gaging stations can be incorporated into a regional flood frequency analysis, by determining the magnitude and frequency of peak flow data for a period of at least ten years. This is especially important in areas where continuous-record gaging stations do not exist, as crest-stage gages are an efficient and cost-effective means of collecting flood stage data.

Low-Flow Partial Record Stations: For streams that lack an extensive or comprehensive long-term gaging station record, alternative methods that are both timely and cost-effective may be required. Low-flow partial records stations have been demonstrated to be a viable alternative in Hawai‘i for use in estimating base flow at sites without long-term gaging stations.[8]

[8] Fontaine, R.A., Wong, M.F., and Matsuoka, Iwao, 1992, *Estimation of median streamflows at perennial stream sites in Hawaii*: U.S. Geological Survey Water-Resources Investigations Report 92-4099, 37 p.

Low-flow, partial records stations require a minimum of ten discharge measurements during periods of base flow. Measurements should be made over a variety of baseflow conditions and during independent recessions, following periods of direct runoff. The discharge measurements are then correlated with the concurrent daily discharges recorded at an index station (a nearby gaging station with long-term data available) to accurately estimate streamflow statistics.[9]

Seepage Runs: With the complex nature of ground and surface water interactions, it is often necessary to conduct seepage runs to identify gaining stream reaches (where base flow increases due to ground water discharge) and losing stream reaches (where base flow decreases due to outflow through the streambed into the underlying ground water body). Seepage runs are particularly important when conducting hydrologic investigations on streams that have been altered by diversions and return-flow practices. Seepage runs can accurately identify stream flow losses and gains throughout the system.

A seepage run is an intensive data collection effort, in which discharge measurements are made at several locations along a stream reach. Measurements are made during periods of base flow when flow rates at any given location in the stream are relatively constant. The time between the first and last measurement in the seepage runs are minimized to reduce the effects of temporal variability.

Data Analysis

Similar to the data collection efforts identified above, CWRM depends on the data analysis efforts of the USGS. These analyses are based on the data compiled from USGS' extensive network and historical records of surface water gaging stations. Data analysis is important in characterizing past and present streamflow conditions, identifying short-term and long-term trends, and understanding the interaction of ground and surface water. In turn, this information is applied to a wide range issues, such as stream biology, water quality, flooding, agriculture, and ultimately water resource management and planning. The basic analyses identified below are essential to understanding the general nature and occurrence of surface water. More detailed analyses are conducted by USGS on a project-specific basis.

Streamflow Hydrograph: A streamflow hydrograph is a graphical representation illustrating changes in flow or water-level elevation over time. This is the simplest analysis of data obtained from continuous-record gaging stations. At a glance, the hydrograph is useful in identifying periods of high- and low-flows and making general observations of streamflow characteristics.

[9] Fontaine, R.A., 2003, *Availability and distribution of base flow in lower Honokohau Stream, Island of Maui, Hawaii*: U.S. Geological Survey Water-Resources Investigations Report 03-4060, 37 p.

Summary Statistics: Under the cooperative agreement between the USGS, CWRM, and various other agencies, the USGS previously produced an annual hydrologic data report for Hawai‘i, documenting the information gathered from its surface and ground water data collection network. The data was analyzed and published in summary tables that are useful in understanding basic streamflow characteristics. Such data is also valuable for infrastructure design and water resources planning and management. A description of the summary statistics and the most recent data (by water year) is available for download from the USGS website (http://hi.water.usgs.gov). Current and historical water data is now provided by USGS' National Water Information System Web Interface (NWISWeb). NWISWeb is the online tool to search, display, and download a gaging station's entire record and general station information.

Flow Duration Curves: Flow duration curves provide a simple and useful way of representing streamflow data by illustrating the flow characteristics of a stream throughout the range of discharge.[10] By definition, a flow duration curve is a cumulative frequency curve that shows the percentage of time that specified discharges are equaled or exceeded. For example, one of the most frequently used points on a flow duration curve is the 50th percentile, or median discharge. This is the discharge that is equaled or exceeded 50 percent of the time.

Generally, a smooth flow duration curve indicates that there are no flow manipulations of significance affecting the discharge recorded. A curve with a steep slope denotes a highly variable stream that receives flow volumes largely from direct runoff, whereas a curve with a flat slope that levels out at the higher percentiles is indicative of a significant, sustained source of base flow.

Hydrograph Separation: Identifying a stream's base flow component is important for water resource planning and management, as base flow indicates the long-term flow volume that can be sustained by the stream. Streamflow data recorded from a gaging station is frequently divided into two basic components, base flow and direct runoff. Base flow is that part of stream flow, derived from ground water, while direct runoff is the remainder of stream flow, derived from surface and subsurface flow occurring in response to excess rainfall.[11]

The USGS commonly uses an automated hydrograph separation method.[12] This computerized base flow separation program, or Base Flow Index (BFI), is a FORTRAN program based on a set of procedures developed by the Institute of Hydrology (United Kingdom). The method requires the input of two variables, *N* (number of days) and *f* (turning-point test factor). The separation method divides the daily streamflow data into non-overlapping periods, each *N*-days

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[10] Searcy, J.K., 1959, *Flow-duration curves: U.S. Geological Survey Water-Supply Paper 1542-A*, 33p.

[11] Fontaine, R.A., 2003.

[12] Wahl, K.L., and Wahl, T.L., 1995, *Determining the flow of Comal Springs at New Braunfels, Texas: Proceedings of Texas Water '95, A Component Conference of the First International Conference on Water Resources Engineering, American Society of Civil Engineers, August 16-17, 1995*, San Antonio, Tex., 77-86.

long, and determines the minimum flow in each period. If the minimum flow within a period is less than *f* times the minimums of the adjacent periods, then the central period minimum is made a pivot (or turning point) on the base-flow hydrograph. Conceptually, the variable *N* represents the number of days following a storm before direct runoff generally ceases.[13]

G.3.2 Other Surface Water Monitoring Programs

G.3.2.1 USGS Cooperative Agreements with Other Entities

The cooperative agreement between USGS and CWRM is one component of a larger gaging network that is cost-shared by several cooperators, including county water departments, State and federal agencies, DLNR divisions, and private landowners (for a complete list, see **Table G-2 USGS Cooperative Monitoring Program Fiscal Year 2014 Cooperators**). The aggregate of data collected through these various agreements is available online via the USGS' NWISWeb. The online tool includes the entire range of data collected through the USGS's extensive network: discharge at surface water gaging stations, crest-stage partial record stations, low-flow partial record stations, water surface elevation for ground water wells, rainfall records, and water quality for both surface and ground water stations. All USGS hydrologic data is available online at https://waterdata.usgs.gov/nwis.

G.3.2.2 Division of Aquatic Resources Aquatic Survey Database

As noted earlier in **Section G.3**, CWRM works closely with the DLNR Division of Aquatic Resources in collecting and managing biological data related to streams. This data is necessary to evaluate applications for Stream Channel Alteration Permits (SCAP) and Stream Diversion Works Permits (SDWP), and anticipated impacts to instream uses. Biological data is also a key consideration in the establishment of measurable instream flow standards.

DAR utilizes a fairly comprehensive aquatic survey database to store and maintain information on a wide range of biological data. The database was originally intended to update the information from the 1990 Hawaiʻi Stream Assessment, and to store data obtained through DAR's point-quadrat survey method. In the course of database development, DAR discovered and incorporated into the database historic records from the early Hawaiʻi Division of Fish and Game. The database is constantly being updated as new sources of information, including various independent biological studies, are encountered and reviewed. Most recently, new data has been added pertaining to macroinvertebrates (e.g., damselflies). By evaluating the information in the DAR database, CWRM will be able to identify biological resources associated with each stream, as well as to identify those streams which have little or no data.

[13] Fontaine, R.A., 2003.

G.3.2.3 DOH Water Quality Data

The Department of Health is the agency responsible for the collection of water quality data statewide. Specifically, the DOH's Clean Water Branch, Monitoring Section oversees the collection, assessment, and reporting of numerous water quality parameters in three high priority categories as follows:

- Possible presence of water-borne human pathogens;
- Long-term physical and chemical characteristics of coastal waters; and
- Watershed assessments, including the integrity of natural aquatic environments.[14]

DOH plays an integral role in the review process for all of CWRM's surface water related permits, as DOH's water quality data and assessments are vital to instream use considerations.

Under the federal Clean Water Act, DOH is required to prepare and submit lists biennially of waterbodies not expected to meet State water quality standards. This list is referred to as the 303(d) List of Impaired Waters (303(d) List), which was most recently prepared and approved in 2004. The DOH Environmental Planning Office has developed a methodology for preparation of the 303(d) List. Part of this methodology involves the review of various sources of water quality data including:

- DOH Clean Water Branch data;
- USGS North American Water Quality Assessment Program data;
- AECOS, Inc. stream survey data (surveys conducted using the National Resource Conservation Service Visual Assessment Protocol); and
- Biological Assessments and various other studies and reports.[15]

The 303(d) List for Hawai‘i serves to contribute to the assessment of instream flow standards.

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[14] Department of Business, Economic Development and Tourism's Office of Planning–Coastal Zone Management and Department of Health's Clean Water Branch Polluted Runoff Control Program, 2000, *Hawaii's Implementation Plan for Polluted Runoff Control*.

[15] Koch, Linda, Harrigan-Lum, June, and Henderson, Katina, 2004, *Final 2004 List of Impaired Waters in Hawaii*, *Prepared Under Clean Water Act §303 (d):* Hawaii State Department of Health, Environmental Planning Office.

G.3.3 CWRM Management of Surface Water Data

CWRM has a comprehensive database to manage surface water use and stream permitting information statewide. Similar to CWRM's Ground Water Regulation program, the SPAM program requires an information management system to track and maintain data for water use reports, stream channel alterations, and stream diversion works. Labeled the Surface Water Information Management System, this database has been integrated into CWRM's Water Resource Information Management System (WRIMS) and will ultimately facilitate the setting of instream flow standards by helping CWRM to track and manage water use data, location and type of alterations to stream channels, and water use for various offstream purposes. This information will allow CWRM to assess impacts upon instream uses and to develop appropriate management scenarios at the watershed level.

G.3.3.1 Surface Water Information Management System

The Surface Water Information Management (SWIM) System addresses CWRM's need for a single, comprehensive database to store and manage all stream-related CWRM activities. This includes requests for determination, permits, petitions, complaints and disputes, and emergency authorizations. CWRM staff continues to input data into the SWIM System and improve the database design.

The SWIM System was primarily developed as a means of storing and managing data. The database will contribute to improved surface water use reporting statewide as the SPAM Branch increases staffing. The SWIM System also provides CWRM with another tool to improve CWRM operations and the agency's ability to manage surface water resources. For example, the database enables CWRM to generate reports identifying pending activities and follow-up actions. Geographic location data from the SWIM System allows staff to perform geospatial analyses of stream diversions and CWRM regulatory actions.

The SWIM System's ultimate utility is as a tool for developing measurable instream flow standards. Issues related to permitted stream channel alterations and diversions, determinations, and complaints provide information regarding on-the-ground activities occurring within watersheds. CWRM plans to expand the SWIM System to include information on stream channel alterations (e.g., channelizations, bridges, culverts, etc.) constructed prior to the establishment of CWRM; and reference materials (e.g., bibliographical information on published reports and studies) for various watersheds. The compilation of these resources into a single system will further CWRM's efforts to establish instream flow standards throughout Hawai‘i.

G.3.3.2 Stream Diversion Verification

In 1988, CWRM began registering declarations of water use (see **Appendix H Existing and Future Demands**). At the time, staffing and funding constraints largely prevented CWRM from completing field verifications for the majority of stream diversions statewide. Policy developments placed an emphasis on ground water protection, while the statewide decline of plantations raised questions about the continued diversion of water to plantation irrigation systems. As a result, there is a deficit of surface water use data and increasing concerns regarding watershed health, stream and riparian ecosystems, and surface water resource protection.

In 2007, CWRM attempted to undertake a statewide verification of stream diversions, but due to a lack of funding was only able to complete verifications for a considerable number of areas on Maui and Kauaʻi. Subsequent assistance from the Honolulu Board of Water Supply also provided verifications for a number of diversions in the Koʻolaupoko region, Oʻahu. The data collected from these efforts will contribute to the assessment of instream uses and the establishment of instream flow standards statewide. Updated diversion information is also critical to the development of appropriate surface water monitoring programs and will identify water users that should be included in a surface water use reporting program. CWRM is continually working to verify and update diversion information and increase water use reporting.

G.3.4 Gaps in Surface Water Monitoring Activities

Surface Water Monitoring: Since the inception of the CWRM-USGS cooperative monitoring program, the USGS cost of operating a continuous-record stream gaging station has steadily increased, while CWRM funding available for monitoring has declined. The resulting gaps in the statewide monitoring network could potentially affect the integrity of hydrologic studies and investigations, as well as increase risk to public safety. Public safety is impacted where the monitoring network maintained by USGS serves the additional purpose of alerting the public of potential flood hazards. This is true particularly in large watersheds where real-time gaging stations provide government agencies and the public with up-to-date streamflow data via the Internet. Also, public agencies rely heavily on surface water discharge data for streams serving municipal water systems and for consideration in the design of highway culverts, bridges, flood structures, and other infrastructure. Maintenance of the current surface water monitoring network will require greater funding commitments in light of rising costs, along with the need for additional partner agencies that rely on the network to share in overall operating expenses.

Water Use Data: Surface water use data for the State of Hawaiʻi is inadequate. For certain areas, water use studies have been conducted either by the USGS or other government agencies. However, comprehensive watershed-wide studies are important to understanding processes within the entire drainage area, and most studies only assess a small portion of the watershed. Therefore, the extent and intensity of surface water use remains unknown in many areas of the state. Increased surface water use data is critical to the protection and management of surface water resources.

G.3.5 Recommendations for Monitoring Surface Water Resources

In light of the gaps in surface water-monitoring activities summarized in **Section G.3.4**, CWRM has identified the following recommendations for the improvement and expansion of surface water monitoring activities in the State of Hawaiʻi:

- **Increase surface water use reporting:** The SPAM Branch has completed the development and integration of its surface water use reporting system into CWRM's Water Resource Information Management System, but some enhancements still remain to be implemented. This includes necessary improvements to querying, reporting, and graphing functions. These improvements are underway as the SPAM Branch is actively reaching out to water users to begin reporting.

- **Adopt guidelines for surface water monitoring**: CWRM currently faces difficulties in regulating the amount of water diverted via registered and permitted stream diversion works. This problem stems from the lack of guidelines for surface water monitoring and the wide range of methods for diverting water. Additionally, technical knowledge among water users varies considerably. Public understanding of water use regulations must be encouraged, especially among water users and diversion works operators. Users should be educated on the correct application of water use metering and gaging methods that are appropriate for each end use. A small user, who may divert water for landscaping and small water features, has very different water metering needs compared to that of a large irrigation system operator diverting millions of gallons daily over large expanses of agricultural land. These issues offer considerable challenges, and CWRM must continue its work to develop a standardized set of methods for measuring diverted flow and water use, in accordance with CWRM's policy directive. CWRM's first effort towards this objective was to compile an inventory of surface water measurement methods in 2008. The result was a handbook of methods designed to educate and inform water users with little to no knowledge of measuring surface water flow. In 2014, CWRM conducted workshops for large and small irrigation system operators to provide education and training on measuring diverted water flow. Despite these efforts, challenges remain in developing the surface water use reporting program further. CWRM will continue to reach out to all surface water users to determine which measurement methods would best suit them and how water use reporting could be made more convenient.

- **Estimates of Streamflow Characteristics:** The lack of information on the availability of water during low-flow conditions has been particularly difficult for the development of instream flow standards. Currently, there are equations to estimate median flow in streams across the state and similar equations for high-flows have been developed to assist in flood frequency planning. In 2013, CWRM entered into a cooperative agreement with USGS for the first of two phases to apply regionalization techniques to estimate low-flow duration discharges (between the 50 and 95 flow-duration percentiles) for streams that have limited streamflow data. The study will focus on the islands of Kauaʻi, Oʻahu, Molokaʻi, Maui, and Hawaiʻi. Phase 1 consisted of extensive data entry, fieldwork, and analysis, and was completed in August 2016 with results provided in USGS' Scientific Investigations Report 2016-5103. Phase 2 was initiated in January 2017 and will involve the integration of regionalized low-flow equations into the USGS' StreamStats web-based geographic information system. Phase 2 is expected to be completed in September 2021. Upon implementation, StreamStats will allow users to interactively calculate low-flow statistics for selected streams and watersheds.

- **Maintain/increase funding for the CWRM-USGS cooperative monitoring program:** The number of continuous surface water gages maintained by the USGS has declined roughly 30 percent since 2000. Continuous monitoring in various areas throughout the state is currently inadequate to appropriately measure and monitor surface water resources and must be expanded. Both federal and state funding for the cooperative program should be increased concomitantly. Funding increases should reflect inflationary costs, as well as the need to expand the data collection network in areas where competition for surface water resources is greatest.

- **Instream flow standard monitoring**: As part of setting measurable instream flow standards statewide, CWRM must continue to plan for and develop a streamflow monitoring program. This program should include appropriate staff training, establishing protocols, assessing the existing USGS stream-gaging network, and developing a schedule to measure streams at regular time intervals on a regional scale. Monitoring efforts have been implemented for streams in Na Wai ʻEhā (Central), East Maui, and West Kauaʻi, but challenges remain including staffing turnover, changing stream conditions, maintenance of gages, and the development of technical systems to store and process collected stream data.

- **Increase collaboration to achieve goals**: The involvement of public agencies, private entities, and community organizations in watershed partnerships, alliances, and other collaborative efforts is critical in identifying water uses and assessing watershed conditions. Such partnerships foster relationships and build trust within the communities ultimately impacted by surface water management decisions. Partnerships also contribute to sound planning and can help in obtaining funding for local implementation of stream-related studies and programs.

- **Outreach and Education on Stream Diversion Measurement Methods:** In order to improve stream diversion water measurement and reporting compliance, it is important to communicate with stream diverters on what is required and expected for their water use reporting. Training workshops in the community would help to disseminate this information and assist stream diverters in meeting their water use reporting obligation.

- **Design and Implement Quality Assurance / Quality Control Protocols:** Data voluntarily submitted to CWRM may have quality and accuracy issues – particularly surface water diversion reports. Site visits with stream diversion operators to verify measurement equipment and methods and to provide training and outreach would improve confidence in data submitted to CWRM.

G.4 Rainfall Monitoring Activities

G.4.1 Overview

Rainfall data collection is fundamental to monitoring hydrologic conditions and water resources in Hawaiʻi. Rainfall is the ultimate natural source of freshwater for streams, springs, and underground aquifers. Studies have shown fog drip may be a significant contribution,[16] and melting snow (to a much lesser degree) may also contribute to ground water recharge and baseflow in some areas.

Long-term rainfall data is also important in analyzing the effects of long-term climate changes, as well as decadal and shorter-term atmospheric fluctuations, such as the Pacific Decadal Oscillation, El Niño, and La Niña events, on Hawaiian water resources. This data is also important when analyzing the effects of extreme weather events, such as floods and droughts, on water resources.

Rain gages are grouped into two categories: non-recording and recording rain gages. Non-recording instruments are manually read rain gages, which are typically sampled daily. Recording instruments are typically tipping-bucket rain gages, which can be programmed to sample at different intervals, usually 15 minutes or one hour. Some recording rain gages are telemetered to provide real-time data.

G.4.2 Rainfall Data Collection Networks

Rainfall data has been collected in Hawaiʻi since the mid-1800s. Sugar and pineapple plantations and ranches established and operated the majority of rain gages across the state. There have been over 2,000 rain gages operating at some time or another since rainfall data collection began in Hawaiʻi. In many instances, however, data quality is uncertain, due to the lack of data quality control and standardized collection methods.

Hawaiʻi had one of the densest rainfall monitoring networks in the world, due in part to the large gradient in average rainfall over very short distances and the varied microclimates across the state. There are several principal rainfall data collection networks in Hawaiʻi operated by the NWS, USGS, University of Hawaiʻi, and private entities. **Figure G-26** to **Figure G-30** show the locations of all the historic and active raingages as of 2013.

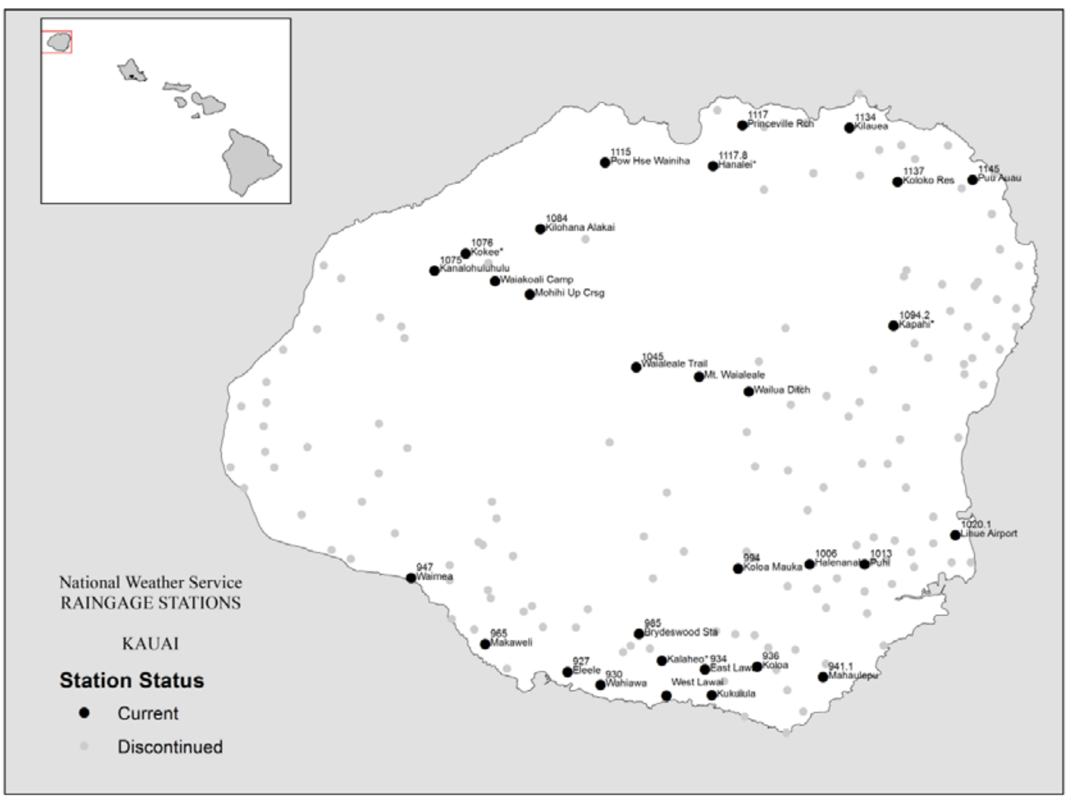
[16] Hardy, R. (1996). *A Numerical Ground-Water Model for the Island of Lanai, Hawaii*. Commission on Water Resource Management Report No. CWRM-1.

G.4.3 Rainfall Data Availability

Over the years there have been numerous data summaries published on rainfall in Hawai‘i, and many of these are available in the public or University of Hawai‘i libraries' reference section. Monthly summaries of data collected through the NWS cooperative observer program are published and available in hard copy or electronically from the National Climatic Data Center (NCDC). Individual NWS station data is also available electronically and on hard copy through NCDC for a fee. Data is available in daily, monthly, and annual formats. In some cases, 15-minute and one-hour data is available. This data is also available from the Western Regional Climate Center for a fee. Some USGS rainfall data is made available on their website and annual summaries are published in their Annual Water Data report. Specialized data requests can be accommodated for a fee.

To develop the 2011 *Rainfall Atlas of Hawai‘i* the University of Hawai‘i compiled several datasets from DLNR, the Office of the State Climatologist, the USGS, the NCDC, and data from other smaller raingage networks, thereby creating the most comprehensive raingage database to date.[17] The data however is only available as monthly totals.

Figure G-26 Raingage Stations on Kaua‘i



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17 Giambelluca TW, Chen Q, Frazier AG, Price JP, Chen Y-L, Chu P-S, Eischeid J., and Delparte, D. 2011. The *Rainfall Atlas of Hawai‘i*. Available online at: http://rainfall.geography.hawaii.edu.

Figure G-27 Raingage Stations on O‘ahu

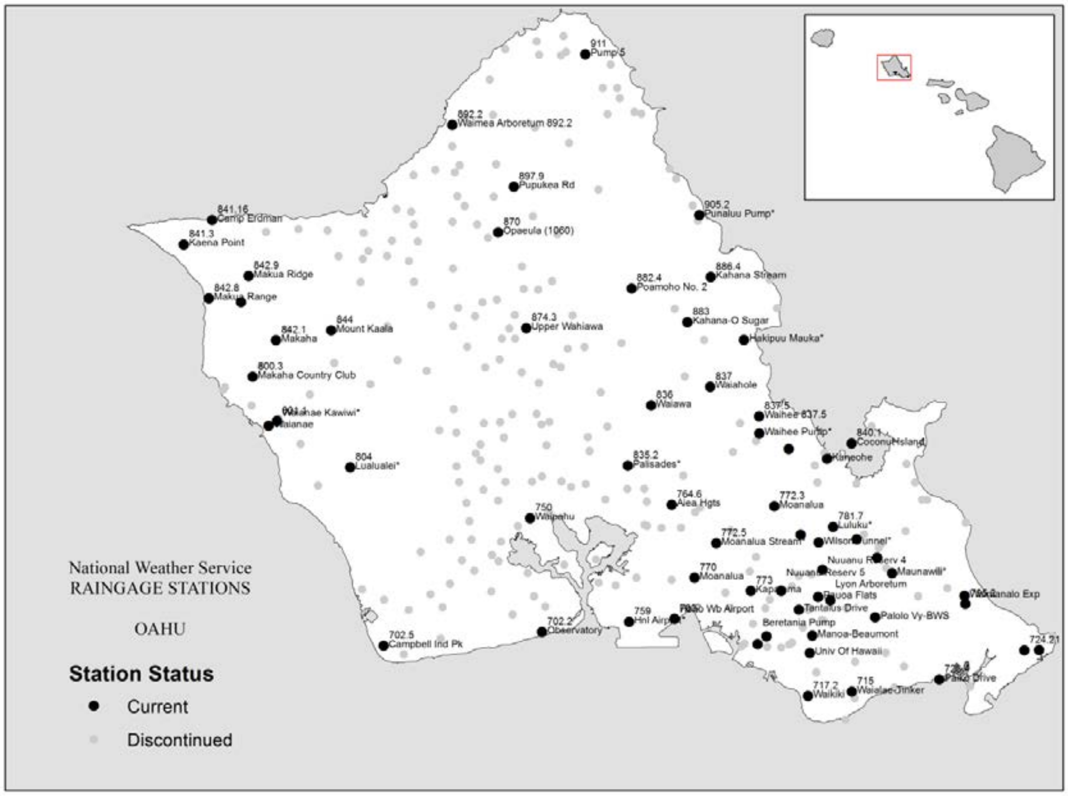


Figure G-28 Raingage Stations on Moloka‘i and Lāna‘i

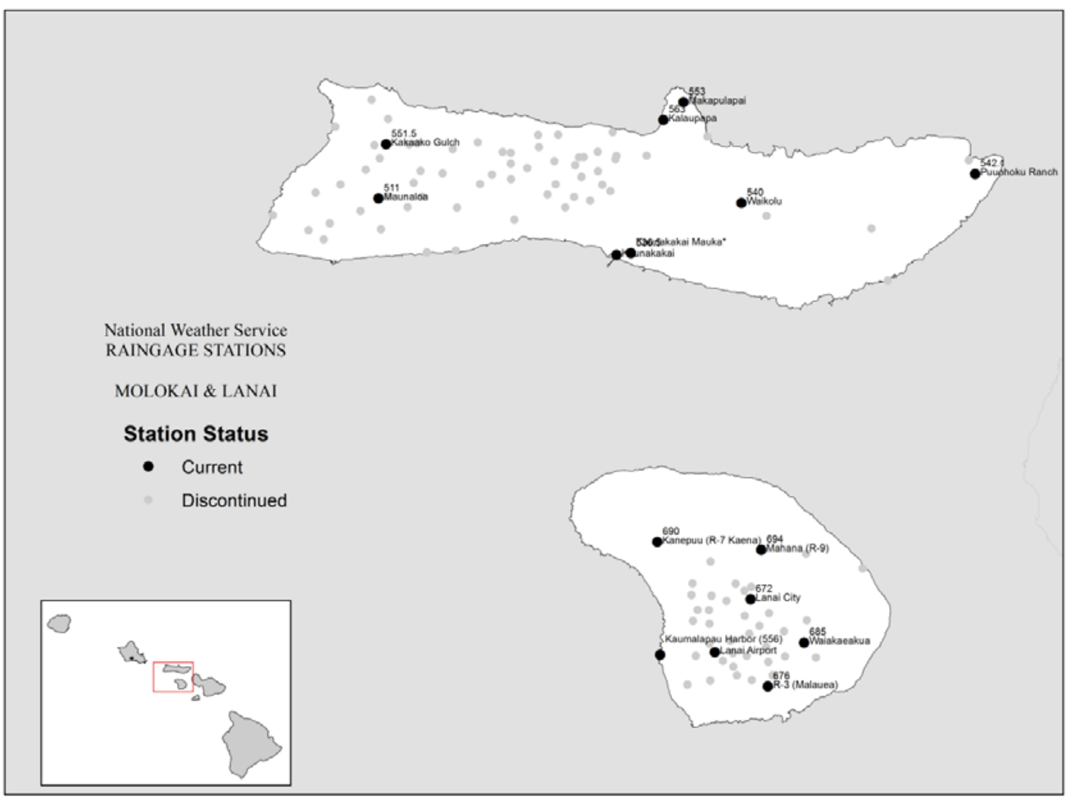


Figure G-29 Raingage Stations on Maui and Kahoolawe

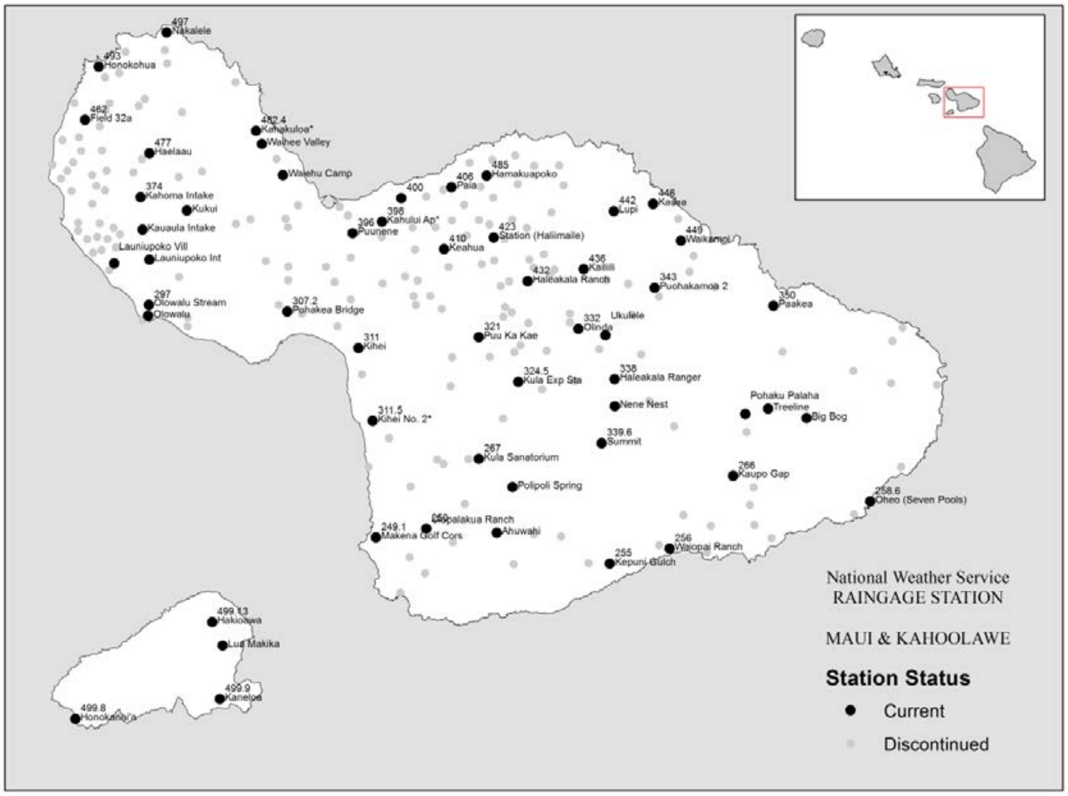
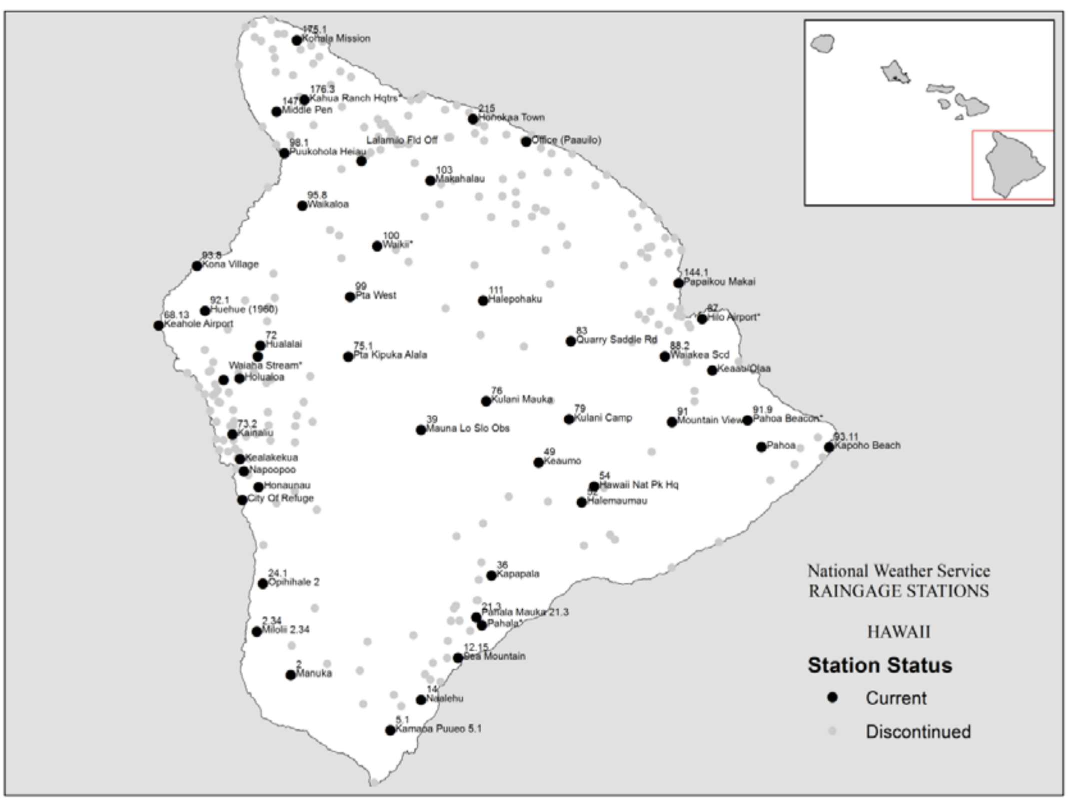


Figure G-30 Raingage Stations on Hawai‘i



G.4.4 Rainfall Data Analysis

There have been several analyses done of mean and median rainfall for monthly and annual data for Hawaiʻi. The most recent report, *Rainfall Atlas of Hawaii* (2011), has resulted in maps of the spatial patterns of rainfall for each of the islands. Developed by the University of Hawaiʻi and available online, the maps provided in the *Rainfall Atlas of Hawaii* serve as the standard isohyet maps for use in hydrologic studies and represent the best estimates of the mean rainfall for the 30-yr base period 1978-2007.[18] CWRM supports the consistent use of these maps to ensure consistent assumptions in data analyses. It should be noted, however, that there are other data sources available that may not be controlled to the data standards of the NWS. The results of studies that use such data are difficult to compare with the results of investigations that use standardized data.

G.4.5 Gaps in Rainfall Data

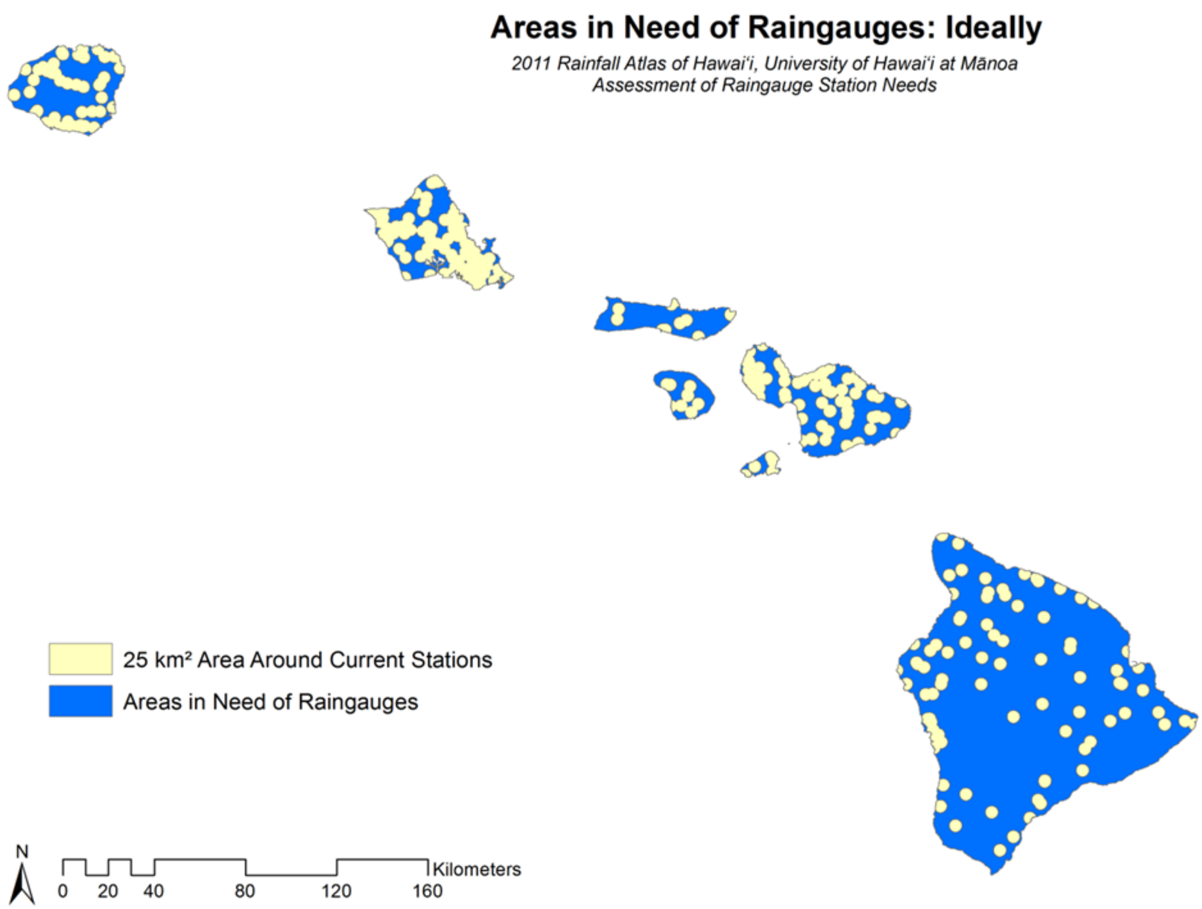
Due to the closing of sugar and pineapple plantations across the state beginning around 1990, there has been a drastic decrease in rain gage sites in the former plantation areas. This has resulted in the discontinuation of monitoring activities at many rainfall stations with long periods (50-100 years) of record. On Kauaʻi, Oʻahu, Maui, and Molokaʻi, there is a lack of rain gages located in high rainfall areas (areas receiving more than 80 inches of rain annually), which often correspond to forest reserve, watershed, and ground water recharge areas. There is also insufficient rain gage coverage in many agricultural areas across the state.

The lack of coverage is further exacerbated by Hawai'i's topography. Rainfall patterns can be very diverse over small distances, thereby requiring a dense network of rain gage sites to improve the accuracy of rainfall estimations. The World Meteorological Organization (WMO) recommends that small islands should have a minimum gage density of 1 gage per 25 km^2. Through the development of the current *Rainfall Atlas of Hawai'i*, the University of Hawai'i determined that an ideal raingage network would contain 667 gages to adequately provide the spatial coverage needed to account for Hawaiʻi's complex terrain (**Figure G-31**).[18] This would require adding 327 stations to 340 currently in operation. However, due to the financial and logistical challenges associated with establishing such a large number of stations, researchers at the University of Hawai'i prioritized locations based on the following criteria:

1) Areas where people live and work (residential and agricultural lands);
2) High rainfall areas (areas that receive at least 3000mm annually, as these are important ecological recharge areas);
3) High rainfall gradient areas (500mm/km rate of change or greater, areas where the rainfall changes drastically over a short area – it is important to have high station density for accuracy); and
4) Areas within the typical trade wind inversion (TWI) band (between 1800 and 2600 m in elevation – these are areas that are extremely sensitive to climate change).

[19]Frazier A., Special Report: Assessment of Raingauge Network Needs for Hawai'i

Figure G-31 Areas in Need of Raingauges



CWRM has also been considering the use of radar data to estimate rainfall in areas with no raingages. The NWS uses high resolution doppler weather radar stations called NEXRAD to detect rainfall and thunderstorms. NEXRAD can detect atmospheric movement and precipitation. NEXRAD is used to estimate rainfall intensities and issue flood warnings and special weather statements. In areas without rain gage coverage, NEXRAD can estimate rainfall accumulations. However, there are limitations to this approach and the data must be vetted prior to its use. The University of Hawaiʻi extensively reviewed the NEXRAD data prior to incorporating it into the *Rainfall Atlas of Hawaiʻi*.

G.4.6 Gaps in Rainfall Analysis

The 2011 *Rainfall Atlas of Hawai'i* was the first time a manual analysis of rainfall values was not used. In other words, past analysis of rainfall required manually creating lines of equal value (isohyets) based on data from a well distributed network of rainfall stations. As the number of reliable rainfall stations has decreased greatly over the years another approach was required to develop a good estimate of rainfall values for the entire state. The *Rainfall Atlas of Hawai'i* used an innovated approach of supplementing raingage data with other predictors such as rainfall maps from NEXRAD data, global climate models, and vegetation maps. Despite this thorough approach, uncertainties do exist, and more research is needed to understand the discrepancies between the rainfall maps and data recorded at rainfall stations.

The assessment by the researchers at the University of Hawai'i was an important first step to address the gaps in climate data collection in Hawai'i. There will be a further refinement and analysis of data needs in the aforementioned USGS report on hydrologic data monitoring needs in Hawai'i. This project is expected to conclude sometime in 2018.

G.4.7 Recommendations for Rainfall Monitoring

As discussed in the previous sections, the loss of rainfall stations due to the closure of sugar and pineapple plantations have reduced rain gage coverage and ended many stations with long periods of record. The historic rainfall record should be properly maintained and easy access to this data should be provided. Reports of rainfall analysis of all types need to be updated, and the effects of climate change on Hawaiian rainfall should be studied. The following recommendations hope to address these concerns:

- Increase rainfall data collection, especially in the watershed, agricultural, and high-precipitation areas.
- Explore partnerships and identify potential funding sources to increase the coverage of rain gages in high priority areas.
- Incorporate the recommendations of the *Special Report: Assessment of Raingauge Network Needs in Hawai'i* and continue or reestablish long-term rainfall stations.
- Better coordinate rainfall data sharing between major data collection networks and improve delivery of data for public consumption (including the acquisition and review of historic plantation data kept by the Hawai'i Agricultural Research Center).
- Continue to investigate the effects of climate change on precipitation in Hawai'i through collaborative studies with partners such as the University of Hawai'i and the USGS.
- Study newer technologies and tools for rainfall estimation in Hawai'i.

G.5 Cloud Water Interception and Fog Drip Monitoring Activities

G.5.1 Overview

Cloud water interception or fog drip is the direct interception of water, from clouds or fog, by vegetation. Some of this water makes its way into the ground. Fog drip is likely an important contribution to the hydrologic budget in Hawaiʻi's forested areas frequently enveloped in clouds. This is especially true when there is little or no precipitation occurring. Although this subject has been studied to some degree in Hawaiʻi and other locations around the world, there are still uncertainties as to what contributions cloud interception and fog drip make to the hydrologic cycle, and specifically to ground water recharge.

G.5.2 Measuring Fog Drip

The interception of cloud water, or fog drip, can be measured by fog collectors, which use screens, strings, or some other surface to capture cloud or fog droplets, which is then collected by receptacles or tipping bucket gages. Another method of measuring fog beneath vegetative canopies is by using throughfall collectors, which capture fog drip and precipitation using gutter-like troughs situated beneath the forest canopy. A rain gage is usually positioned nearby to account for the precipitation's contribution.

G.5.3 Existing Programs

There is no systematic, long-term cloud water/fog drip collection network in Hawaiʻi. There have been several fog drip studies conducted on Lānaʻi, Maui, and Hawaiʻi, which yielded site-specific fog collection data of various periods of record. These sites have typically been in the cloud covered mountainous regions of these islands, ranging from approximately the 1,500-foot to 10,000-foot elevation.

G.5.4 Analyses and Reports

There are few analyses and reports done on the subject of cloud water interception / fog drip in Hawai‘i. The University of Hawai‘i Water Resource Research Center published two technical reports, *Methodical Approaches in Hawaiian Fog Research,*[19] and *A Climatology of Mountain Fog on Mauna Loa Hawaii Island.*[20] Other researchers have conducted studies and investigations[21] on this subject. It should be noted that due to the lack of data on cloud water interception, there is uncertainty of the contribution of cloud water to the overall water budget of our forested watersheds.

G.5.5 Gaps

Since there is no fog drip data collection network, almost all of the islands' mountainous regions within the cloud belt have no data. Most of these areas have no vehicular access, and the difficult and often steep terrain prevents easy access for installation and maintenance of the fog drip data collection instruments.

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[19] McKnight, J. H. and Juvik, J. O., 1975, Methodological approaches in Hawaiian fog research, Technical Report No. 85, Project Completion Report for fog precipitation along topo-climatic gradients on the Island of Hawaii, OWRT Project No. A-041-HI, Grant Agreement No. 14-31-0001-4011, Project Period: July 1, 1972 to June 30, 1975.

[20] Juvik, J. O. and Ekern, P. C., 1978, A climatology of mountain fog on Mauna Loa, Hawaii Island, Technical Report No. 118, Project Completion Report for fog precipitation along topo-climatic gradients on the Island of Hawaii, OWRT Project No. A-041-HI, Grant Agreement No. 14-34-0001-5011, Project Period: 1 July 1974 to 31 December 1975.

[21] Juvik, J. O, and Nullet, D., 1994, A climate transect through tropical montane rain forest in Hawaii: Journal of Applied Meteorology, v. 33, No.11, p. 1304.

Juvik, J. O, and Nullet, D., 1995, Comments on "A Proposed Standard Fog Collector for Use in High Elevation Regions": Journal of Applied Meteorology, v. 34, No.9, p. 2108-2110.

Scholl, M., T. W. Giambelluca, S. B. Gingerich, M. A. Nullett, and L. L. Loope (2007), Cloud water in windward and leeward mountain forests: The stable isotope signature of orographic cloud water, Water Resour. Res., doi:10.1029/2007WR006011, in press. http://www.agu.org/journals/pip/wr/2007WR006011-pip.pdf" (accepted 31 August 2007).

Scholl, M.A., Gingerich, S.B., and Tribble, G.W., 2002, The influence of microclimates and fog on stable isotope signatures used in interpretation of regional hydrology: East Maui, Hawaii: Journal of Hydrology, v. 264, p. 170-184.

Giambelluca, T.W., DeLay, J.K., Nullet, M.A., Scholl, M.A., and Gingerich, S.B. Interpreting canopy water balance and fog screen observations: Separating cloud water from wind-blown rainfall at two contrasting forest sites in Bruijnzeel, L.A., Juvik, J., Scatena, F.N., Hamilton, L.S., and Bubb, P., Mountains in the Mist: Science for Conserving and Managing Tropical Montane Cloud Forests, Honolulu, HI, University of Hawaii Press.

G.5.6 Recommendations for Cloud Water Interception and Fog Drip Monitoring

As mentioned above, there is no long-term or widespread data collection network that gathers cloud water interception information in Hawaiʻi. The amount of research and study on this subject is sparse compared to those of other hydrologic elements, especially rainfall. The following recommendations aim to increase the knowledge of cloud water interception and its contribution to watershed hydrology and water balance:

- Increase cloud water interception data collection in important watersheds;
- Explore partnerships and identify potential funding sources to increase the collection of cloud water interception data;
- Increase research into cloud water interception and its contribution to the hydrologic budget and aquifer sustainable yield;
- Develop methods to estimate cloud water interception over large areas; and
- Assess impacts of climate change on cloud water interception.

G.6 Evaporation Data

G.6.1 Overview

The most common way of determining evaporation is direct measurement from an instrument called an evaporation pan. Factors that influence evaporation include temperature, humidity, wind speed, and solar radiation. Other instruments, such as evaporimeters, can measure evaporation indirectly. Other empirical and psuedo-physical models can be used to estimate evaporation, based on other observed weather elements.

Evaporation data was used extensively in Hawaiʻi to assist in crop irrigation and to assess the amount of water used by crops. Evaporation is also an important tool in determining an area's hydrologic budget, since evaporation can be used to estimate evapotranspiration, which is an important component of the hydrologic budget. Evapotranspiration (ET) equals the water evaporated from the soil and other surfaces combined with the transpiration from plants in a vegetated area. It can be directly measured, computed from meteorological data, or estimated from pan evaporation data. In Hawaiʻi, pan evaporation data is relied upon heavily when estimating ET, since there are few direct measurements of ET and the meteorological data to compute evapotranspiration is sparse.

G.6.2 Data Collection

In Hawaiʻi, pan evaporation data collection began in the late 19th century, with the majority of stations beginning in the mid-1950s. The proliferation of pan evaporation stations was directly influenced by the expanse of sugar and pineapple cultivation, and the vast majority of this network was comprised of sugar and pineapple plantation stations. Some of these stations were co-located with the NWS cooperative observer program rainfall stations. However, since the closure of these plantations, most of these pan evaporation stations have been discontinued. Many of these stations were located in the areas where sugar was grown, which were usually lower elevation areas with relatively low rainfall, although there are some data from higher elevations in wetter areas.

The University of Hawaiʻi currently operates two eddy covariance measurement stations on the Island of Hawaiʻi that allow researchers to directly measure energy balance changes.[22] As these stations are positioned directly above the forest canopy very accurate measurements of evaporation can be made.

G.6.3 Existing Programs

As described above, the network of pan evaporation stations has almost disappeared due to the plantation closures. The NWS currently maintains two evaporation stations, one in Lihue, Kauaʻi, and the other in ʻEwa, Oʻahu. Former plantation areas on Maui and Kauaʻi may still be collecting pan evaporation data; however, this data is not published or reported to the State Climate Office. The University of Hawaiʻi operates two stations on the Island of Hawaiʻi that allows them to directly measure or compute evapotranspiration. Historic data can be found in the reports mentioned below. Evaporation data from the Lihue and ʻEwa stations are available from the National Climatic Data Center.

G.6.4 Analyses and Reports

The Department of Land and Natural Resources published three pan evaporation reports. *Pan Evaporation Data, State of Hawaii* (1961) and *Pan Evaporation in Hawaii 1894-1970* (1973) described the pan evaporation data collection network in Hawaiʻi, presented data from these stations, and discussed data analysis. *Pan Evaporation: State of Hawaii 1894-1983* (1985) is a similar report with in-depth technical discussion of pan evaporation methods and analysis, as well as maps of annual evaporation isopleths for Kauaʻi, Oʻahu, Maui, and Hawaiʻi.

In 2014 the University of Hawaiʻi produced the first comprehensive estimation of the amount, spatial patterns, and temporal variability of ET. The data will allow resource managers to analyze the hydrological and ecological changes that occur due to changes in the landscape.

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[22] Giambelluca, T.W., et al., Evapotranspiration and energy balance of native wet montane cloud forest in Hawaiʻi. Agric. Forest Meteorol. (2008), doi:10.1016/j.agrformet.2008.08.004

G.6.5 Gaps

ET data is critical when computing water budgets and sustainable yields in Hawai‘i. The anticipated work by the University of Hawai‘i will allow researchers to determine where further study is needed to refine the data and to understand the impacts of climate change. There is a lack of direct evapotranspiration measurements in the forested watershed areas. Currently only two stations exist in the entire state. There is also a lack of meteorological data for computing evapotranspiration. Raw pan evaporation data is not readily available, and there is uncertainty in estimating evapotranspiration data using pan evaporation data.

A critical element in estimating ET is solar radiation. There are few solar radiation stations across the state of Hawai‘i, with the majority on Maui as part of the University of Hawai‘i’s HaleNet. The lack of solar radiation makes it difficult to readily ground truth solar radiation estimates, which are crucial to estimating ET. Efforts should be taken to continue the HaleNet climate station network and to establish long-term comprehensive (including solar radiation sensors) climate monitoring stations in critical areas across the state.

G.6.6 Recommendations for Evaporation Monitoring

Although fairly long periods of evaporation data exist for a number of pan evaporation stations, much of this data is for low elevation and low rainfall areas, and the data is not readily available to the general public. There is little measured and computed evapotranspiration data in the State, although the work by the University of Hawai’i will greatly improve the state of existing datasets. The following recommendations address these main concerns with evaporation and evapotranspiration data:

- Identify sources of evaporation and evapotranspiration data and improve access to this data;
- Investigate establishing island-wide or regional evapotranspiration reference networks comprised of measurement stations in areas needing real-time data to schedule irrigation, such as agricultural districts and urban areas with extensive landscaping;
- Establish evapotranspiration measurement stations in areas where aquifer sustainable yields need to be reassessed or improved;
- Increase and improve evapotranspiration estimates in areas where aquifer sustainable yields need to be reassessed or improved; and
- Conduct additional research on evapotranspiration in areas where aquifer sustainable yields need to be reassessed or improved.

APPENDIX H

Existing and Future Demands

Water Resource Protection Plan 2019 Update

H Existing and Future Demands

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H Existing and Future Demands

This section of the WRPP focuses on existing and future water demands statewide, as well as the issues that are associated with quantifying water use and projecting water demand. Available data on existing ground water use and surface water use are presented, followed by a summary of water demand projections through 2035 as prepared by each county. The section concludes with a discussion of county-level water planning, the status of each county's planning efforts, and the potential impacts on water resources based on coordinated land and water use planning at the county level.

H.1 CWRM Goals for Assessing Water Demands

The following Commission on Water Resource Management (CWRM) goals and objectives are intended to guide the assessment of existing and future water demands:

- Identify "hot spots" where actual and/or future water demands approach or will exceed available supply.
- Facilitate integrated water and land use planning to inform future decision-making on land use policies and plans.
- Provide State guidance, advice, and oversight in the preparation of the County Water Use and Development Plans (WUDP).
- Ensure equitable water allocation for all users in accordance with the State Water Code and the public trust doctrine.
- Utilize the best available information on water resources to make wise decisions about reasonable and beneficial use and protection of the resource.
- Provide the regulatory and internal framework, including the best use of information technology, for efficient ground and surface water management.
- Support community-based management of water resources and develop short- and long-range plans to avoid judicial and quasi-judicial disputes.
- Develop, implement, and update comprehensive short- and long-range plans protecting, conserving, and managing water resources.
- Foster comprehensive resource planning for the development, use, protection, and conservation of water.

- Promote sustainable resource management.
- Encourage and assist with the development and execution of drought planning and mitigation projects.
- Promote coordination and collaboration among agencies and private entities.

H.2 CWRM Water Use Categories

Different entities categorize and classify water use in different ways. CWRM classifies water use information based on seven broad categories of water use (see **Table H-1**). Within each category, sub-categories identify more specific applications. CWRM water use categories reflect common water uses occurring in the State of Hawaiʻi and are based on the types of uses identified in the State Water Code and in the County Water System Standards.

Table H-1 Water Use Categories and Sub-Categories

<table>
<tr><td rowspan="5">Individual Well Operators</td><th>Use Category</th><th>Use Sub-Category</th></tr>
<tr><td>Agriculture</td><td>• Aquatic plants and animals
• Crop irrigation and processing
• Livestock water, pasture irrigation, and processing
• Ornamental and nursery plants
• Taro
• Other agricultural applications</td></tr>
<tr><td>Domestic
Residential Domestic, includes potable and non-potable water needs</td><td>• Single- and multi-family households, including non-commercial gardening</td></tr>
<tr><td>Non-residential Domestic, includes potable (and non-potable) water needs</td><td>• Commercial businesses
• Office buildings
• Hospitals
• Religious Institutions
• Hotels
• Schools
• Other</td></tr>
<tr><td>Industrial</td><td>• Fire protection
• Mining, dust control
• Geothermal, thermoelectric cooling, power development, hydroelectric power
• Other industrial applications</td></tr>
</table>

Table H-1 Water Use Categories and Sub-Categories (Continued)

	Use Category	Use Sub-Category
Individual Well Operators	**Irrigation**	• Golf course • Hotel • Landscape and water features • Parks • Schools • Habitat maintenance • Other
	Military*	• All military use
	Municipal*	• State • County • Private

*May also include agriculture, domestic, industrial, and irrigation uses

Figure H-1 to **Figure H-4** show the locations of production wells on each of the major Hawaiian Islands. Each well is coded according to CWRM water use categories. The primary use of each well was determined based upon available records. CWRM staff continues to verify well uses as resources allow.

Figure H-1 Island of Kauaʻi Production Wells (2018)

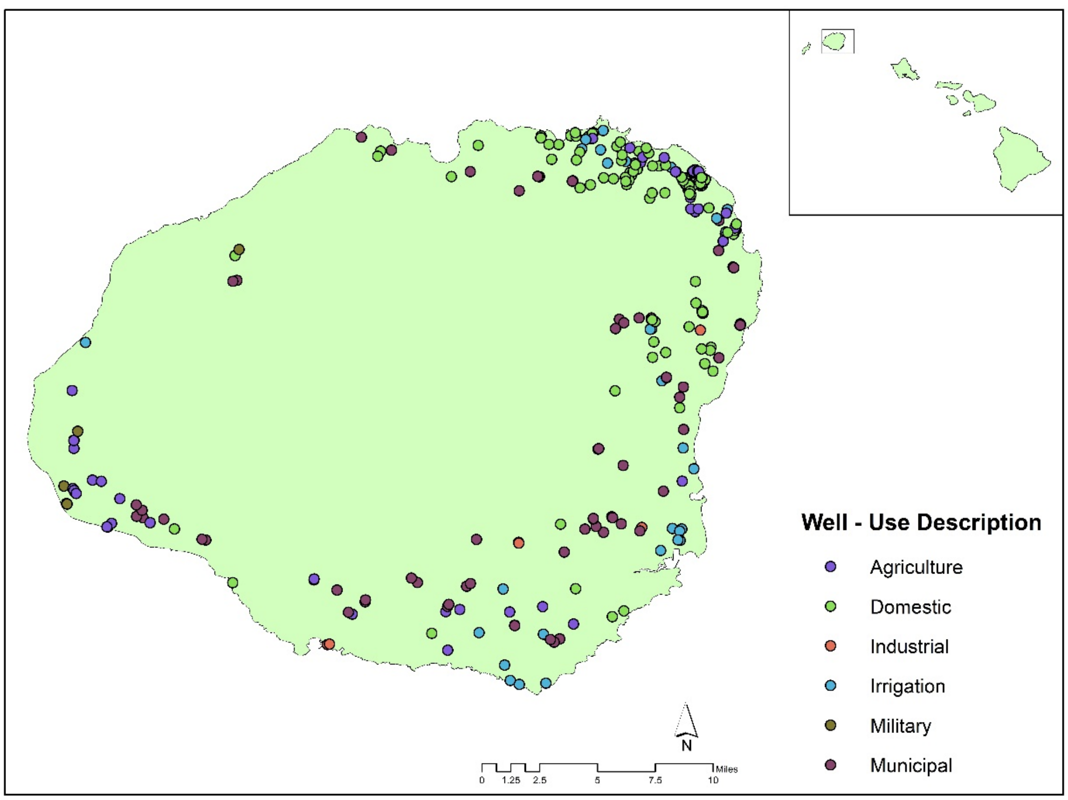


Figure H-2 Island of O‘ahu Production Wells (2018)

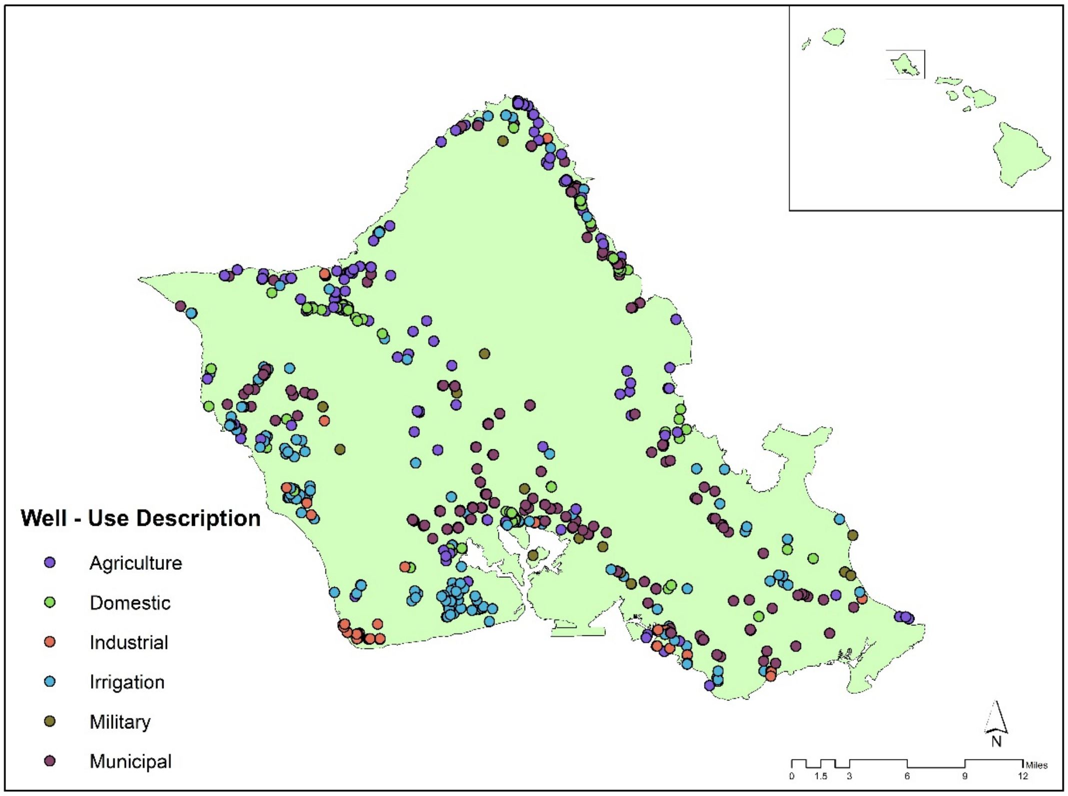


Figure H-3 County of Maui Production Wells (2018)

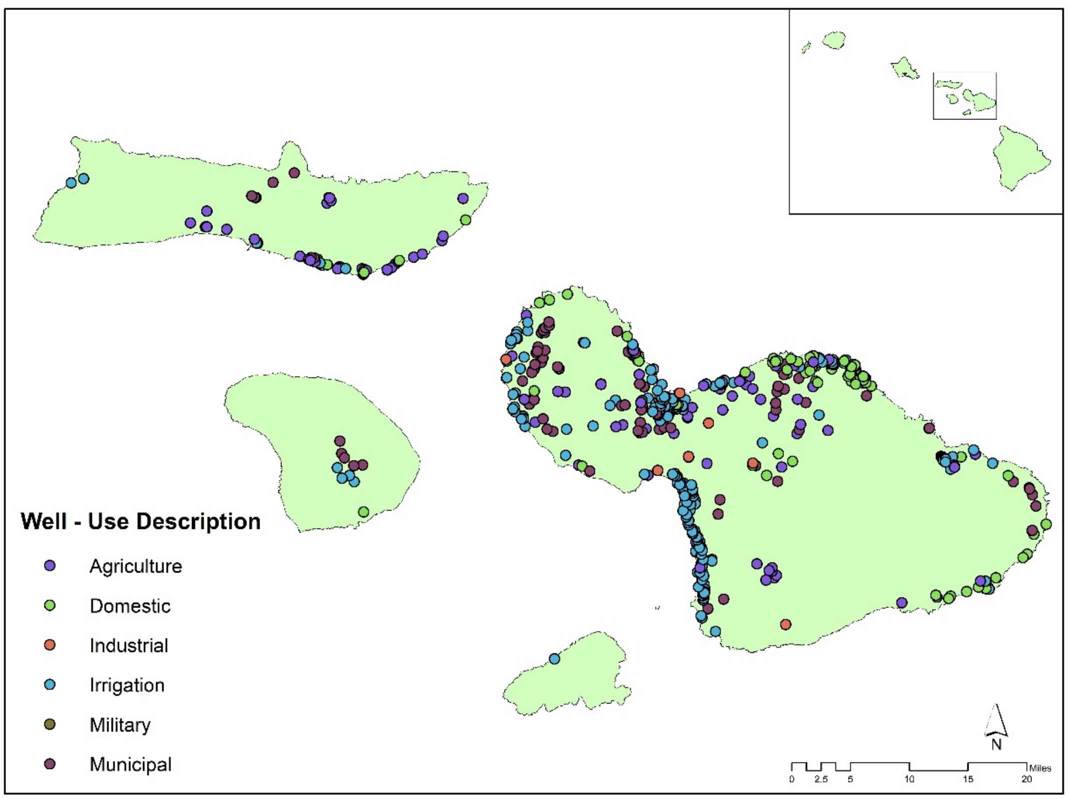
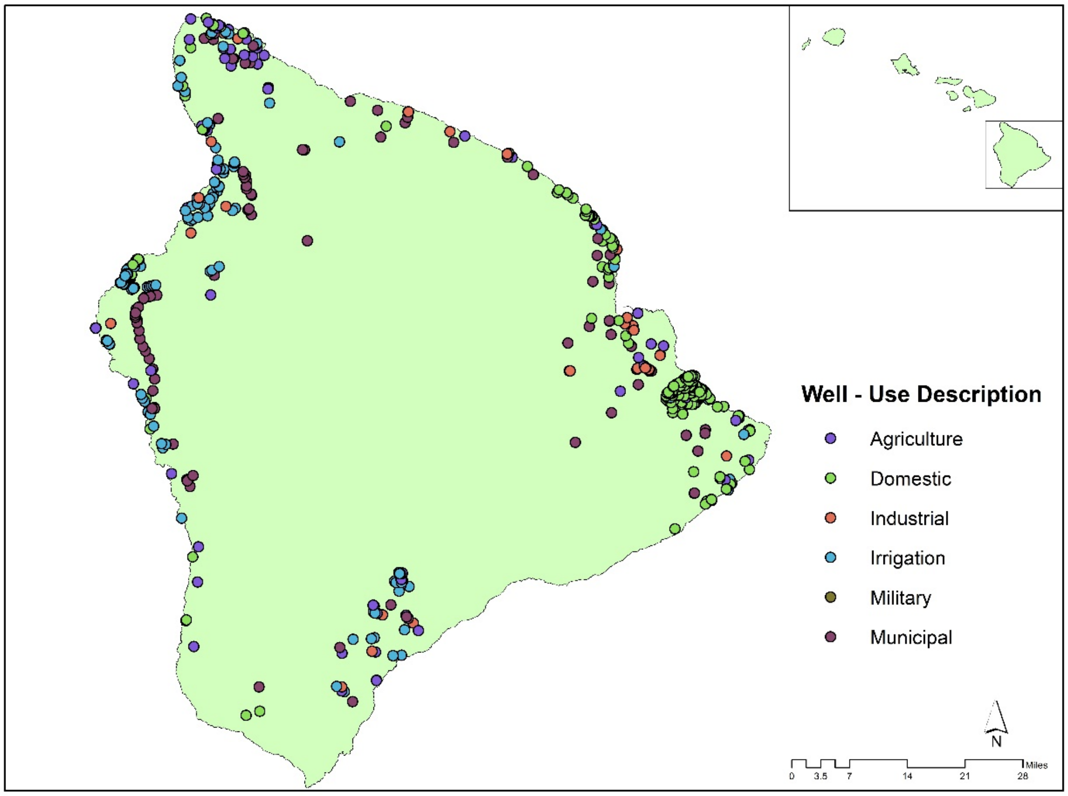


Figure H-4 Island of Hawai‘i Production Wells (2018)



H.3 CWRM Water Use Reporting Requirements

The collection and analysis of water use information is essential to understand the behavior and response of water resources to stresses from water withdrawals. Such information also ensures that demand is managed effectively within the sustainable limits of supply. Water use information can also be used to: evaluate the effectiveness of alternative water management policies, regulations, and conservation activities; assess the impacts of population growth and corresponding increases in water demands; develop trends in water use; and make projections of future demands.

In 1987, the State Water Code was enacted and HRS §174C-26 required water users to file a declaration of water use with CWRM, in compliance with the rules subsequently adopted for that chapter. The Hawai‘i Administrative Rules (HAR), §13-168-5(c), specify that declarations of water use shall at a minimum include information on the following:

> *"[T]he location of the water sources and all usage-related facts, or information within his knowledge or possession…the manner, purposes, and time in which the water source is being used and operated, the rate and volume of water being withdrawn or diverted therefrom, and the method or means of measuring and controlling the water taken or used."*

In 1989, CWRM began the process of registering existing water sources and declarations of water use in accordance with the State Water Code and administrative rules. By 1990, the declaration of water use program identified approximately 1,550 users statewide who were using water from wells, stream diversions, and water systems. Approximately 250 declarants were identified by CWRM as having "medium-to-large" uses. The remaining 1,300 water use declarations were for small uses, identified by CWRM to include individual domestic supplies, water systems involving small water capacities (pump motors less than five horsepower, or gravity-fed pipes less than two inches in diameter), and agricultural irrigation of fewer than three acres.

The Hawaiʻi Administrative Rules of the State Water Code require owners or operators of wells and stream diversion works to measure their water use and submit regular monthly reports of the use. In particular, HAR §13-168-7(a) and (c) provide that:

> *(a) The owner or operator of any well or stream diversion works from which water is being used shall provide and maintain an approved meter or other appropriate device or means for measuring and reporting total water usage on a monthly (calendar or work schedule) basis. If a well or stream diversion works is one of a battery of interconnected water sources, a centralized measuring device or facility may be approved by the commission.*
>
> *(c) At the discretion of the commission, requirements for measuring and reporting monthly water usage may be lessened, modified, or exempted for owners or operators of small individual wells or stream diversion works. The lessening, modification, or exemption of such requirements shall be approved, disapproved, or otherwise decided by the commission on a case-by-case basis.*

The monthly water use reporting requirement was difficult to implement and enforce. Enforcement of the water-use reporting requirements began in 1988, with the monthly collection of water use reports from major users, including county departments of water supply and large plantations. Water purveyors and large plantations already had monitoring equipment in place to measure and record water usage. However, the monthly reporting requirement specified in HAR §13-168-7(a) proved burdensome on other users, as evidenced by the requests for reporting exemptions received by CWRM.

By August 1992, approximately 140 medium and large users of water from well sources were submitting regular reports of their monthly water use to CWRM. CWRM continued to pursue approximately 20 other users who did not respond to the request for water use reports, and also followed up on requests from medium and large well users to be exempted from reporting, or to be approved for modified reporting requirements.

Meanwhile, CWRM had not attempted to enforce reporting requirements for the 1,300 water use declarants identified as "small users," or for approximately 100 medium-to-large users who indicated water use from stream sources and third-party distribution systems. At the time, CWRM anticipated that the majority of these 1,400 users would find the reporting requirements to be burdensome. CWRM further anticipated that these users would request exemption from, or modification of, the reporting requirements.

Therefore, in August and September 1992, CWRM staff submitted to CWRM a request for authority to exempt certain cases of water use from reporting requirements and to modify the reporting requirements in other cases.[1] CWRM voted to unanimously approve the staff's request, effectively creating priorities and exemptions regarding measurement and reporting of water use. These priorities and exemptions are listed below:

1. The following cases of water use are exempt from the requirements for measuring and reporting monthly water use, unless CWRM determines a specific need for these data for purposes such as resolving disputes, establishing instream flow standards, or quantifying the amount of water use for a water use permit in a water management area:
   - Individual end uses of water on multi-user distribution systems, where the end user does not control or operate the water supply source(s) to the system, providing that the operator of the system reports the total usage from the system and also maintains records which are available to CWRM upon request to describe the specific location, type, and quantity of individual end uses;
   - Water uses from individual water systems where the quantity of use averaged over a one-year period does not exceed 50,000 gallons per month (1,700 gallons per day);
   - Passive agricultural consumption, such as when crops are planted in or adjacent to springs and natural wetland areas; and
   - Livestock drinking from dug wells or stream channels.
2. The following cases of water use are allowed to report monthly water use on an appropriate quarterly, semi-annual, or annual basis, as determined by CWRM staff, unless a specific need is determined for monthly reporting:
   - Water uses from individual water systems where the quantity of use averaged over a one-year period does not exceed five million gallons per month;
   - Water uses from saltwater or brackish water sources; and
   - Water uses from surface water sources.
3. The requirement for monthly measurement and reporting of water use from gravity-flow, open-ditch stream diversion works which are not already being measured and which are not in designated surface water management areas is deferred until CWRM adopts guidelines regarding appropriate devices and means for measuring water use which are not unduly burdensome on water users.

[1] Commission on Water Resource Management, 1992, Staff Submittal, Approval to Allow Exemptions from Requirements or Measuring and Reporting Monthly Water Use.

CWRM's action had the effect of focusing water use monitoring and reporting where it was most needed at the time: large ground water sources and drinking-water wells. The exemptions and modifications allowed for more effective allocation of staff resources and prioritization of water use monitoring and tracking. Enforcement of the ground water use reporting requirement currently remains focused on large water users (e.g. municipal purveyors), and uses in designated water management areas,[2] where competition for water is greatest and aquifers may be pumping close to their sustainable yields (SY). Unfortunately, the focus on ground water sources has resulted in a lack of historical surface water use data. To date, very few users report surface water use to CWRM.

In 2014, CWRM unanimously approved rescinding the 1992 priorities and exemptions and replacing it with the following.[3]

1. The following exemptions from the requirement to measure and report monthly water use for the activities listed below are allowed, UNLESS the Commission determines a specific need for this data to resolve disputes, establish instream flow standards, or quantify the amount of water use for a water use permit in a water management, or for similar needs.
    - Passive agricultural consumption (e.g. when crops are planted in or adjacent to natural springs and natural wetland areas);
    - Livestock drinking from dug wells or stream channels;
    - In non-surface water management areas, individual end uses on multi-user ditch systems where IFS or water use permits are not an issue;
    - Salt-water wells may continue to report monthly estimates of pumpage and monthly actual measured water-levels and salinity on an annual basis.
2. Affirmatively require that unused and observation wells report monthly water-levels and salinity as determined by staff.

The repeal of the exemption for small individual domestic users was prompted in part by the Commission's adoption of the first edition of the Hawaiʻi Well Construction and Pump Installation Standards (HWCPIS, 1997) in accordance with HRS §174C-86 and its Administrative Rule (HAR §13-168-14). This version required all post-1997 permitted production wells, including small capacity wells, to install flow meters and to record and report monthly pumping, non-pumping static water-levels, and salinity. This has been a standard condition for all well construction and pump installation permits approved by the Commission statewide since 1997. The 2004 second edition of the HWCPIS clarified that salt water wells (greater than 17,000 parts per million [PPM] chlorides) need not install flow meters. Thus, consistent with the

[2] CWRM Internal Enforcement Guideline

[3] Commission on Water Resource Management, 2014, Staff Submittal, Rescinding Water Use Reporting Exemptions and Deferments Established under September 16, 1992 Commission Action, Statewide, Hawaiʻi.

HWCPIS, salt water wells continue to be exempt from the monthly reporting requirement and may instead report annually, and small capacity wells are no longer exempt from reporting, as all post-1997 wells are now equipped with flowmeters to measure water use.

CWRM also hired a consultant to produce a handbook with guidelines for appropriate devices and means of measuring surface water use that would not be unduly burdensome on water users,[4] the reason for deferment of surface water use reporting in 1992. Therefore, under the current policy, monthly measurement and reporting of all surface water uses, including from gravity-flow, open-ditch stream diversion works, is required statewide.

Finally, reporting exemptions were repealed because CWRM's Water Resource Management Information System (WRIMS) went live in 2012. The WRIMS system allows water use reporters to file their reports on-line, monitor their historical use from their source(s), and have access to all information about their source(s) on file via the internet. This new tool was developed to facilitate reporting by water users, provide owners access to all CWRM information about their source(s), and to enable CWRM staff to more efficiently enforce compliance with the reporting requirement. See **Appendix G Monitoring of Water Resources** for a more detailed discussion of WRIMS and the online reporting features.

H.3.1 Water Use Reporting for Ground Water Sources

In 2016, CWRM collected ground water pumpage data from 1,251 well owners/water users statewide. summarizes the status of ground water use reporting by island. See **Appendix G Monitoring of Water Resources** for the policy on water use reporting requirements.

Table H-2 shows that for all islands except Lānaʻi and Molokaʻi, the major portion of most ground water use reports is submitted by the county water departments. Better reporting is needed for non-municipal wells.

The coverage for ground water pumpage data varies by island, and pumpage reporting is only complete for the island of Lānaʻi. Water use data is reported for only 1,251 of the 2,699 existing production wells in the state, a compliance rate of 46%.

[4] Commission on Water Resource Management. (2009). *Stream Diversion Measurement Methods*. Honolulu, HI. Prepared by Element Environmental LLC.

Table H-2 Status of Ground Water Use Reporting by Island for 2016

Island	Total # of Production Wells[1]	# Production Wells Reported	Largest Reporter/ # Production Wells Reported
Kauaʻi	288	139	DOW[2]/67
Oʻahu	818	491	BWS[3]/220
Molokaʻi	89	40	KPHA[4]/7
Lānaʻi	10	10	LWC [5]/10
Maui	567	240	DWS[4]/46
Hawaiʻi	927	331	DWS[6]/71
TOTAL	2,699	1,251	

1. Production Wells are defined as all wells that are not abandoned, observation, or unused wells.
2. Kauaʻi Department of Water
3. Honolulu Board of Water Supply
4. Kawela Plantation Homeowners Association
5. Lānaʻi Water Company
6. Hawaiʻi Department of Water Supply

H.3.2 Reported Ground Water Use by Island and Category

Table H-3 summarizes reported total ground water use during the calendar year 2016 for the six major Hawaiian Islands by ground water use category. Based on the values shown in the table, Oʻahu uses the most ground water, withdrawing over 177 MGD primarily for municipal purposes (which includes many categories and subcategories of use). By contrast, ground water use is lowest on both Molokaʻi and Lānaʻi, with approximately 4.25 MGD of ground water being withdrawn. Municipal uses account for about 56% of total reported water use statewide. This is partly a reflection of the high reporting compliance rate of the municipalities, relative to other ground water users. Statewide, total reported ground water use exceeds 395 MGD. It should be noted that the figures in the table above exclude wells that are categorized as “other” in their use category, which results in a slight discrepancy with later tables that depict water use from all fresh water well sources.

Table H-3 Summary of 2016 Reported Ground Water Use[1]

Island	Use Category (MGD)						Island Total
	Agriculture	Domestic	Industrial	Irrigation	Military	Municipal	
Kauaʻi	9.17	0.02	0.18	0.30	0.25	13.13	23.06
Oʻahu	9.3	3.00	1.72	4.81	21.22	137.78	177.85
Molokaʻi	0.43	0.00	0.0	0.04	0.00	2.00	2.47
Lānaʻi	0.00	0.00	0.00	0.70	0.00	1.08	1.78
Maui	14.57	0.03	35.96	5.01	0.00	27.83	83.39
Hawaiʻi	0.68	0.06	49.18	16.08	0.00	41.42	107.41
Use Total	**34.16**	**3.11**	**87.03**	**26.94**	**21.4**	**223.23**	**395.96**

1. Values shown as a 12-month average from 1/1/2016 to 12/31/2016 for all fresh ground water sources, which excludes wells categorized as “other”, saltwater and caprock sources.

Based on the values shown above, Oʻahu uses the most ground water, withdrawing over 177 MGD primarily for municipal purposes (which includes many categories and subcategories of use). By contrast, ground water use is lowest on both Molokaʻi and Lānaʻi, with approximately 4.25 MGD of ground water being withdrawn. Municipal uses account for about 56% of total reported water use statewide. This is partly a reflection of the high reporting compliance rate of the municipalities, relative to other ground water users. Statewide, total reported ground water use exceeds 395 MGD. It should be noted that the figures in the table above exclude wells that are categorized as “other” in their use category, which results in a slight discrepancy with later tables that depict water use from all fresh water well sources.

H.3.2.1 Gaps in Ground Water Use Reporting

Better reporting is needed for all islands, except Lānaʻi. Ground water pumpage reporting on all other islands is not adequate to supply a reasonable representation of total water usage.

H.3.2.2 Recommendations for Ground Water Use Reporting

The following actions are recommended for improving ground water use reporting:

- CWRM should continue development of the ground water use database to implement an automatic notification system that will flag delinquent reports and send notices to well owners/water users that have neglected to send in pumpage reports by aquifer system area. This will help to prioritize ground water management areas and other aquifer system areas where outreach has been completed.

- CWRM should consider resurrecting the monthly newsletter (see **Section I.2** of **Appendix I "CWRM Regulatory Programs"**) to provide up-to-date information on deep monitor well, chloride, water-level, and/or water use information currently collected by CWRM.

- Continue staff efforts and also hire consultants to conduct online water use reporting outreach, field verification, and to encourage compliance throughout the State.

- Enforce reporting compliance using the Department's Civil Resource Violation System.

H.3.3 Water Use Reporting for Surface Water Sources

To date, relatively few users report surface water use to CWRM. However, these users represent many of the large irrigation systems which use the majority of surface water statewide. CWRM staff is continuing to work with water users in the field and promote the use of the WRIMS to improve reporting and data record accessibility.

H.3.3.1 Reported Surface Water Use by Island

Table H-4summarizes reported surface water use as of December 31, 2016, for six of the major Hawaiian Islands, by water use category:

Table H-4 Summary of Reported Surface Water Use (2016)

Island	Total (MGD)[1]
Kaua‘i	186.907
O‘ahu	13.811
Moloka‘i	0.000
Lāna‘i	0.000
Maui\	117.508
Hawai‘i	56.340

[1] Sum of 12-month moving averages for available water use reported from January to December 2016.

H.3.3.2 Gaps in Surface Water Use Reporting

Surface water use data: There remains a deficit of surface water use data statewide; however, CWRM has made great strides in water use data collection. The focus remains on water use reporting for large irrigation systems.

CWRM is continuing to develop and refine its database system to store and manage surface water data similar to that of the Ground Water Regulation Branch's database for ground water use data. CWRM is also working closely with landowners and system operators statewide to get more surface water gaging and water use reporting data into its information management system.

Guidelines for measuring water use: Although some stream diversions without monitoring devices were previously allowed to defer reporting, those 1992 exemptions, which have since been repealed, still identified reporting of use as important. This is evident in that CWRM directed its staff to create and adopt guidelines for appropriate measuring devices and methods for measuring diverted flow. In response to this directive, CWRM compiled various methods for measuring diverted streamflow. This handbook[5] serves as a starting point to inform users of the various types of methods that are available as CWRM continues to develop its surface water use reporting program.

Field Verification of Declared Stream Diversions: When CWRM conducted the Registration/Declaration process in 1990, many of the Registration of Stream Diversion Works and Declaration of Water Use applications were not field verified. In 2009, CWRM hired a contractor to verify stream diversions statewide based on a prioritized listing. The project resulted in only Maui and Kauaʻi being studied in large part due to high travel and staffing costs. CWRM was also in the process of transitioning to a new information management system, meaning that much of the data has yet to be reviewed and the records updated. CWRM will continue to work towards development of a regular field-investigation schedule to inspect surface water diversions and monitor water use.

Plantation-Ditch Systems: Formerly, surface water use was tied primarily to sugar cane and other plantation crops. Many plantation-ditch operators monitored streams and ditch systems for flow volumes and kept detailed records of rainfall conditions and diverted flows. The remaining plantation-ditch systems are typically underutilized, as former sugar cane lands are no longer in crop production or have been converted to other uses. Different portions of a ditch system may be under the ownership of several different entities, and maintenance and monitoring efforts may vary considerably between owners. Also, flow monitoring gages for these systems may no longer be in existence or may no longer be useful for monitoring the total diverted flow. As part of its efforts to implement priority actions identified in the 2013 Hawaiʻi Water Conservation Plan, CWRM staff contracted with the USGS in 2013 to conduct on-site training workshops

[5] Commission on Water Resource Management. (2009). Stream Diversion Measurement Methods. Honolulu, HI. Prepared by Element Environmental LLC.

statewide for measuring water flow and reporting water use for large-scale stream diversion ditch systems. This education and outreach effort, which was completed in 2014, will aid current ditch operators and owners in meeting the mandate for surface water use reporting. Outreach and education on surface water use reporting is being conducted by CWRM staff for small surface water diversions systems.

H.3.3.3 Recommendations for Surface Water Use Reporting

The following actions are recommended for improving surface water use reporting:

- CWRM must continue expanding its education and outreach to landowners and surface water system operators to further develop its collection of surface water use data statewide.
- CWRM needs to vigorously work on updating its information system with previously completed efforts to verify surface water diversions (Kauaʻi and Maui) in order to identify key surface water users to focus implementation of surface water use reporting requirements.
- Complete efforts to verify surface water diversions on all islands.
- Enforce reporting requirements using the DLNR's Civil Resource Violation System.

H.4 Assessing Existing Water Demands

Existing water demands are recorded and archived to varying degrees by several entities statewide. However, water demand data provided by different sources may not represent the same water users or water demand categories, as each agency or entity produces demand information in the form most useful for their respective purpose.

CWRM examines water demands in terms of hydrologic units. CWRM demand data is regional in scale and dependent upon the accuracy and completeness of water use reports provided to the agency by users.

In contrast, municipal water agencies can monitor water demand by looking at customer service areas and billing categories. This data provides an excellent picture of water use by customer distribution, but typically does not provide information on water use outside of the system service area.

The USGS also compiles water demand from public and private water systems, including military bases. Water demand data as assessed by CWRM, county water agencies, and the USGS are provided in the following sections.

H.4.1 CWRM Assessment of Existing Water Demands

CWRM relies on reported water use data to quantify ground water and surface water demands. While CWRM receives considerable information on statewide ground water demand, surface water demand data is lacking.

H.4.1.1 Summary of Existing Ground Water Demands

CWRM is able to track and quantify ground water demand through its water use reporting program. To protect ground water resources, CWRM must continually monitor water use, to ensure that the total withdrawal from an aquifer does not exceed its sustainable yield. Pumping an aquifer above its sustainable yield can result in seawater intrusion and negative impacts to the resource. CWRM uses a twelve-month moving average to assess water use (see **Section I.2.5** of **Appendix I CWRM Regulatory Programs**).

As discussed in **Appendix I**, when actual ground water withdrawals or authorized planned uses may cause the maximum rate of withdrawal to exceed 90% of the aquifer's sustainable yield, CWRM may designate the area as a water management area and regulate water use through the issuance of water use permits. Once an area has been designated, CWRM continues to monitor water use for compliance with allocation limits.

Table H-5 to Table H-10 summarize existing demands as of December 2016, in relation to aquifer system area sustainable yields for each of the six major Hawaiian Islands. Water use is based on reported pumpage as of December 31, 2016, unless otherwise noted. Differences in values from **Table H-3** are a result of reported pumpage from all production wells being listed, and not limited to the categories in **Table H-3**. Aquifer sustainable yields are those are being proposed in this update of the WRPP. Because caprock and saltwater withdrawals do not count against aquifer sustainable yields, water withdrawn from caprock and saltwater sources are excluded from the tables. The only exception is the inclusion of the ʻEwa Caprock Aquifer Sector Area on Oʻahu, consisting of the Malakole, Kapolei, and Puʻuloa Aquifer System Areas, which overlies portions of the Pearl Harbor Sector Area. The ʻEwa Caprock Aquifer Sector Area has been designated as a separate ground water management area.[6] For the islands of Oʻahu and Molokaʻi, where most or all of the aquifer system areas have been designated as ground water management areas, a comparison of total allocations to sustainable yields established is also presented. Existing water reservations in designated water management areas are considered a water allocation and are also counted against sustainable yields.

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[6] The ʻEwa Caprock Aquifer Sector has been declared a non-potable aquifer by CWRM. This brackish resource support mainly irrigation and industrial uses. CWRM has adopted a chloride limit of 1,000 mg/l for individual irrigation wells in lieu of an aggregate sustainable yield figure. No chloride limit has been set for industrial wells.

Table H-5 Existing Demands by Aquifer System Area, Island of Kaua‘i 2016

(Aquifer Code Number) Aquifer Sector	Sustainable Yield (SY) (MGD)	Existing Water Use (MGD) 12 MAV	SY minus pumpage (MGD)	Existing Water Use as a Percent of SY
(20101) Koloa	**29**	4.89	24.11	16.9%
(20102) Hanamā‘ulu	**27**	1.98	25.02	7.3%
(20103) Wailua	**51**	0.36	50.64	0.7%
(20104) Anahola	**21**	2.34	18.66	11.2%
(20105) Kilauea	**10**	0.74	9.26	7.4%
(20201) Kalihiwai	**16**	1.23	14.77	7.7%
(20202) Hanalei	**35**	0.18	34.82	0.5%
(20203) Wainiha	**24**	0.18	23.82	0.8%
(20204) Nāpali	**20**	NRU	NRU	NRU
(20301) Kekaha	**10**	1.76	8.24	17.6%
(20302) Waimea	**37**	0.06	36.95	0.1%
(20303) Makaweli	**26**	1.52	24.49	5.8%
(20304) Hanapepe	**22**	7.85	14.15	35.7%
KAUA‘I TOTAL	**328**	**23.09**	**304.91**	**7.0%**

NRU: No reported water use. There are no reports of ground water use to CWRM

NOTE: Kaua‘i aquifers are not designated ground water management areas; therefore withdrawals do not require water use permits.

Table H-6 Existing Demands by Aquifer System Area, Island of Oʻahu 2016

(Aquifer Code Number) Aquifer System	Sustainable Yield (SY) (MGD)	Existing Permit Allocation (MGD)	Unallocated SY (MGD)	Existing Water Use (MGD) 12 MAV	SY minus pumpage (MGD)	Existing Water Use as a % of SY
(30101) Pālolo[1]	**5**	5.646	-0.646	5.68	-0.68	113.6%
(30102) Nuʻuanu[1]	**14**	15.165	-1.165	13.97	0.03	99.8%
(30103) Kalihi	**9**	8.776	0.224	5.50	3.50	61.1%
(30104) Moanalua[1]	**16**	19.960	-3.960	11.50	4.50	71.9%
(30105) Waiʻalae-West[7]	**2.5**	2.797	-0.297	1.75	0.75	70%
(30106) Waiʻalae-East	**2**	0.79	1.210	0.16	1.84	7.8%
(30201) Waimalu	**45**	46.951	-1.951	37.60	7.41	83.6%
(30203) Waipahu-Waiawa	**105**	85.465[5]	18.535	54.52	50.48	51.9%
(30204) ʻEwa-Kunia	**16**	15.045	0.955	9.60	6.40	60.0%
(30205) Makaīwa	**<1**					
(30207) Malakole[3]	1,000 mg/l					
(30208) Kapolei[3]	1,000 mg/l					
(30209) Puʻuloa[3]	1,000 mg/l					
(30301) Nānākuli[2]	**1**	N/A	N/A	NRU	NRU	NRU
(30302) Lualualei[2]	**3**	N/A	N/A	0.13	2.87	4.3%
(30303) Waiʻanae[2]	**3**	N/A	N/A	2.77	0.23	92.3%
(30304) Mākaha[2]	**3**	N/A	N/A	2.68	0.32	89.3%
(30305) Keaʻau[2]	**3**	N/A	N/A	0.00	3.00	0.0%
(30401) Mokulēʻia	**17**	7.620	9.380	0.33	16.67	1.9%
(30402) Waialua	**17**	13.250	3.750	3.83	13.17	22.5%
(30403) Kawailoa	**22**	1.641	20.359	0.12	21.88	0.5%
(30501) Wahiawā	**23**	22.978	0.022	8.70	14.30	37.8%
(30601) Koʻolau Loa	**35**	19.970	15.030	6.78	28.22	19.4%
(30602) Kahana	**15**	1.101	13.899	0.96	14.05	6.4%
(30603) Koʻolau Poko	**28**	10.312	17.688	10.38	17.62	37.1%
(30604) Waimānalo	**9**	1.843[6]	7.157	0.90	8.10	10.0%
OʻAHU TOTAL[4]	**393.5**	**292.351**	**101.149**	**177.84**	**215.66**	**45.2%**

1. For the Pālolo, Nuʻuanu, Moanalua, and Waimalu ASYAs, total water use permit allocations exceed the aquifers' sustainable yields because declared existing uses at the time of designation exceeded the subsequent establishment of SYs for these aquifers. CWRM is monitoring the conditions in these over-allocated aquifers to determine whether the SYs can be adjusted based on operational experience or water use permit allocations may be reduced due to nonuse as land use changes or new sources come online.
2. No ASYAs in the Waiʻanae Sector Area have been designated as ground water management areas.
3. The ASYAs within the ʻEwa Caprock Sector Area are managed by a chloride limit of 1,000 mg/l for individual irrigation wells rather than an aggregate SY number. CWRM has not yet established a chloride limit for individual industrial wells.
4. Excludes ʻEwa Caprock Aquifer Sector Area.

5. Includes DHHL reservation for 1.358 MGD, which should not be considered available for allocation. The 1.358 mgd reservation amount is the remaining balance for the 1.724 mgd reservation established under HAR 13-171-61, of which 0.366 mgd has been converted to water use permits.
6. Includes DHHL reservation for 0.124 MGD, which should not be considered available for allocation.
7. Updated recharge data suggest a sustainable yield of 3 mgd; however, upon its July 16, 2019 adoption of the updated WRPP, the Commission amended the proposed sustainable yield for Waiʻalae-West from 3 to 2.5 mgd, conditioned on the Honolulu Board of Water Supply providing: 1) 100% compliance with their water use reporting requirement (i.e., monthly reporting of water levels, chlorides, and pumpages); and 2) Installation of a new deep monitor well in the Waiʻalae-West Aquifer System Area.

NRU: No reported water use. There are no reports of ground water use to CWRM for this aquifer system

Table H-7 Existing Demands by Aquifer System, Island of Maui, December 2016

(Aquifer Code Number) Aquifer System	Sustainable Yield (SY) (MGD)	Existing Water Use (MGD) 12 MAV	SY minus pumpage (MGD)	Existing Water Use as a Percent of SY
(60101) Waikapū	**3**	0.19	2.81	6.3%
(60102) ʻĪao	**20**	14.19	2.84	71.0%
(60103) Waiheʻe	**8**	4.67	3.33	58.4%
(60104) Kahakuloa	**5**	NRU	NRU	NRU
(60201) Honokōhau	**9**	NRU	NRU	NRU
(60202) Honolua	**8**	2.56	5.44	32.0%
(60203) Honokōwai	**6**	3.25	2.75	54.2%
(60204) Launiupoko	**7**	0.40	6.61	5.7%
(60205) Olowalu	**2**	0.12	1.88	6.0%
(60206) Ukumehame	**2**	0.04	1.96	2.0%
(60301) Kahului	**1**	52.58	-51.49	5257.5%
(60302) Pāʻia	**7**	0.51	6.49	7.3%
(60303) Makawao	**7**	0.37	6.64	5.2%
(60304) Kamaʻole	**11**	2.93	8.07	26.6%
(60401) Haʻikū	**24**	0.78	23.22	3.3%
(60402) Honopou	**16**	0.01	15.99	0.1%
(60403) Waikamoi	**37**	NRU	NRU	NRU
(6404) Keʻanae	**75**	0.04	74.96	0.1%
(60501) Kūhiwa	**14**	0.02	13.98	0.2%
(60502) Kawaipapa	**31**	0.72	30.28	2.3%
(60503) Waihoʻi	**18**	NRU	NRU	NRU
(60504) Kīpahulu	**15**	0.01	14.99	0.1%
(60601) Kaupō	**13**	0.00	13.00	0.0%
(6062) Nakula	**7**	NRU	NRU	NRU
(60603) Lualaʻilua	**11**	0.00	11.00	0.0%
MAUI TOTAL	**357**	**83.39**	**273.61**	**23.4%**

NRU: No reported water use. There are no reports of ground water use to CWRM for this aquifer system

NOTE: Only the ʻĪao ASYA is a designated ground water management area; therefore, withdrawals from the remaining ASYAs do not require water use permits. 2018 permitted allocations (excluding high level sources) in the ʻĪao ASYA total 19.089 MGD, or about 95% of sustainable yield.

Table H-8 Existing Demands by Aquifer System, Island of Moloka‘i, December 2016

(Aquifer Code Number) Aquifer System	Sustainable Yield (SY) (MGD)	Existing Permit Allocations (MGD)	Unallocated SY (MGD)	Existing Water Use (MGD) 12 MAV	SY minus pumpage (MGD)	Existing Water Use as a Percent of SY
(40101) Kaluako‘i	**2**	0.016	1.984	NRU	NRU	NRU
(40102) Punakou	**2**	0	2.000	NRU	NRU	NRU
(40201) Ho‘olehua	**2**	0	2.000	NRU	NRU	NRU
(40202) Pala‘au	**2**	0.663	1.337	0.34	1.66	17.1%
(40203) Kualapu‘u	**5**	3.824[1]	1.176	1.42	3.58	28.4%
(40301) Kamiloloa	**3**	0.211	2.789	0.04	2.96	1.3%
(40302) Kawela	**5**	0.786	4.214	0.35	4.65	6.9%
(40303) ‘Ualapu‘e	**8**	0.246	7.754	0.29	7.71	3.6%
(40304) Waialua	**6**	0.437	7.563	0.00	6.00	0.0%
(40401) Kalaupapa	**2**	.094	1.9	NRU	NRU	NRU
(40402) Kahanui	**3**	0.094	2.906	NRU	NRU	NRU
(40403) Waikolu	**5**	0.853	4.147	0.03	4.97	0.6%
(40404) Hā‘upu	**2**	0	2.000	0.00	2.00	0.0%
(40405) Pelekunu	**9**	0	9.000	NRU	NRU	NRU
(40406) Wailau	**15**	0	15.000	NRU	NRU	NRU
(40407) Hālawa	**8**	0	8.000	NRU	NRU	NRU
MOLOKA‘I TOTAL	**79**	**7.130**	**71.87**	**2.46**	**76.54**	**3.1%**

1 Includes DHHL reservation for 2.905 MGD, which should not be considered available for allocation

NRU: No reported water use. There are no reports of ground water use to CWRM for this aquifer system.

Table H-9 Existing Demands by Aquifer System Area, Island of Lānaʻi, December 2016

(Aquifer Code Number) Aquifer System	Sustainable Yield (SY) (MGD)	Existing Water Use (MGD) 12 MAV	SY minus pumpage (MGD)	Existing Water Use as a Percent of SY
(50101) Windward	3	0.27	2.73	8.9%
(50102) Leeward	3	1.51	1.49	50.4%
(50201) Hauola	0	NRU	NRU	NRU
(50202) Maunalei	0	NRU	NRU	NRU
(50203) Paomaʻi	0	NRU	NRU	NRU
(50301) Honopū	0	NRU	NRU	NRU
(50302) Kaumalapau	0	NRU	NRU	NRU
(50401) Lealia	0	NRU	NRU	NRU
(50402) Mānele	0	NRU	NRU	NRU
LĀNAʻI TOTAL	**6**	**1.78**	**4.22**	**30%**

NRU: No reported water use. There are no reports of ground water use to CWRM for this aquifer system.

NOTE: Lānaʻi aquifers are not designated ground water management areas; therefore, withdrawals do not require water use permits.

Table H-10 Existing Demands by Aquifer System Area, Island of Hawaiʻi, December 2016

(Aquifer Code Number) Aquifer System	Sustainable Yield (SY) (MGD)	Existing Water Use (MGD) 12 MAV	SY minus pumpage (MGD)	Existing Water Use as a Percent of SY
(80101) Hāwī	11	0.60	10.40	5.4%
(80102) Waimanu	110	NRU	NRU	NRU
(80103) Māhukona	10	1.61	8.39	16.1%
(80201) Honokaa	29	0.615	27.385	2.2%
(80202) Paʻauilo	56	0.090	52.910	0.2%
(80203) Hakalau	150	0.159	149.841	0.1%
(80204) Onomea	147	0.312	146.688	0.2%
(80301) Waimea	16	13.83	2.17	86.4%
(80401) Hilo	349	44.26	304.74	12.7%
(80402) Keaʻau	395	11.06	383.94	2.8%
(80501) ʻŌlaʻa	125	NRU	NRU	NRU
(80502) Kapāpala	19	NRU	NRU	NRU
(80503) Naalehu	118	1.05	116.95	0.9%
(80504) Ka Lae	31	NRU	NRU	NRU
(80601) Manukā	25	0.06	24.94	0.2%
(80602) Kaʻapuna	51	0.00	51.00	0.0%
(80603) Kealakekua	38	1.96	36.04	5.2%
(80701) ʻAnaehoʻomalu	30	5.45	24.55	18.2%
(80801) Pahoa	432	0.86	431.14	0.2%
(80802) Kalapana	158	0.06	157.94	0.0%
(80803) Hilina	20	NRU	NRU	NRU
(80804) Keaīwa	17	NRU	NRU	NRU
(80901) Keauhou	38	18.13[1]	19.87	48%
(80902) Kīholo	18	8.01	9.99	44.5%
HAWAIʻI TOTAL	**2393**	**108.12**	**2284.88**	**4.5%**
HAWAIʻI STATE WIDE	**3556.5**	**409.75**	**3146.75**	**11.5%**

1 Includes DHHL reservation for 3.398 MGD, which should not be considered available for allocation.

NRU: No reported water use. There are no reports of ground water use to CWRM for this aquifer system.

NOTE: Hawaiʻi island aquifers are not designated ground water management areas; therefore, withdrawals do not require water use permits.

Table H-5 shows that total reported pumpage on Kauaʻi is well within the sustainable yield for all aquifer system areas. Islandwide, reported water use is only 7% of the island's total sustainable yield. Unlike Oʻahu, Kauaʻi does not have an extensive municipal distribution system. Residents in many areas rely on individual, domestic wells. For the most part, water used by individual, domestic users is not reflected in **Table H-5**, due to past exemptions from water use reporting, and lack of compliance and enforcement of reporting requirements for small-capacity, domestic wells.

Table H-6 shows that total reported pumpage on Oʻahu is within the sustainable yield for most aquifer system areas. However, pumpage from the Pālolo aquifer exceeds the sustainable yield limit by 0.68 MGD because existing uses at the time of designation exceeded the subsequent establishment of sustainable yields for these aquifers. CWRM should establish a deep well monitoring network in aquifers that are either overpumped or close to sustainable yield to determine if the pumpage is sustainable, and if so, amend the theoretical sustainable yields based on operational experience. If the data show unacceptable impacts to the aquifers, CWRM should require pumpage and permitted uses to be reduced. Historically these aquifers, along with several others in the Honolulu and Pearl Harbor sector areas, have been over-allocated.

Table H-6 also shows that the total existing ground water withdrawals for Oʻahu are about 114 MGD less than total water use permit allocations (including DHHL reservations). A portion of the unused allocation is earmarked to provide for future demands. There is also a significant volume of water allocated to agricultural water use permits that remains unused due to the closure of plantation agriculture, particularly in the Central and North Sector Areas. CWRM may revoke permitted allocations due to four years or more of continuous non-use.

Existing ground water demand on Maui is summarized in **Table H-7**. The table indicates that the Kahului Aquifer System Area within the Central Aquifer Sector Area is being overpumped by over 5,000%. Pumpage is currently sustainable at these levels because there is a substantial quantity of return irrigation recharge in the Central Aquifer Sector Area that has not been factored into the established sustainable yields of these two aquifers. Much of the irrigation water applied on the central isthmus comes from surface water delivered via ditch systems from East Maui. Should these diversions be reduced, the artificial recharge will also be reduced. Further discussion on sustainable yields is contained in **Appendix F "Inventory and Assessment of Resources"** of the WRPP.

Another noteworthy statistic on Maui is the pumpage of the ʻĪao Aquifer System Area at about 71% of its sustainable yield. CWRM designated the ʻĪao Aquifer System Area as a ground water management area, effective July 21, 2003. Water use permits are now required for all non-individual domestic ground water uses. ʻĪao Aquifer has a sustainable yield of 20 MGD, with the existing permit allocations of 19.089 MGD counted against the sustainable yield. It should also be noted that high level ground water sources are not counted against the total water use permit allocation for ʻĪao Aquifer.

Also noteworthy on Maui is the concentration of Waiheʻe pumpage along the ʻĪao-Waiheʻe Aquifer System Area boundary. Roughly half the sustainable yield of Waiheʻe is pumped along this boundary which is a concern as water can flow across system boundaries, exacerbating the pressure on the ʻĪao ground water management area.

Water use permit allocations on Molokaʻi are only about 9% of the island's total sustainable yield. Existing withdrawals are even less, at approximately than 3% of total sustainable yield (see **Table H-8**). The Kualapuʻu Aquifer System Area is the most heavily utilized, with reported water use at about 28% of the aquifer's sustainable yield. Additionally, the remanded contested case hearing for Molokaʻi Ranch's actual needs in the Kualapuʻu Aquifer System Area have yet to be determined.

Lānaʻi is mostly privately owned and is the least populated of the major islands, with the exception of Niʻihau. Ground water pumpage is reported for two of its nine aquifer system areas. Existing withdrawals, shown in **Table H-9**, total about 30% of total sustainable yield for the island.

The island of Hawaiʻi has the greatest amount of ground water resources, with over 2,300 MGD estimated to be available for development. Islandwide, only 4.5% of ground water is reportedly being used, as shown in **Table H-10**. Like Kauaʻi, the municipal water distribution system does not cover large parts of the island. There are many private domestic wells that serve residential needs. For the most part, these uses are not reflected in the table.

H.4.1.2 Summary of Existing Surface Water Demands

Surface water demands are difficult to quantify for numerous reasons. Presently, there is a deficiency in surface water use data. In addition to past exemptions, which deferred the requirement for surface water use reporting (see **Section H.3**), quantification of surface water demand is hindered by the lack of information on stream diversions (field verification information), changes in water use by large-scale agricultural systems, and the difficulties associated with measuring diverted flow. The types of diversion structures range widely from PVC pipes or large concrete structures set within the stream bed, to hand-built rock walls for taro loʻi. As a result, diversion amounts may also vary widely with rainfall freshets, as well as the relative ease with which some diversions can be installed, removed, or altered.

Another difficulty in measuring surface water use is the utilization, cost and location of accurate and appropriate water measurement devices. For many large irrigation systems, it is not practical to measure every stream diversion, therefore only a handful of gaging stations may exist at key locations along the length of the system to provide cumulative flow amounts. For smaller water users, the cost, operation and maintenance of installing a gaging device is a prohibitive factor. However, as noted earlier, CWRM staff has worked with the USGS to conduct on-site training workshops statewide for measuring water flow and reporting water use for large-scale stream diversion ditch systems. This education and outreach effort will aid current ditch operators and owners in meeting the mandate for surface water use reporting. Outreach and education for small surface water diversion systems is being conducted by CWRM staff. CWRM data on surface water demand is limited to information on reported water use, as shown in **Table H-4**.

CWRM has limited information to contribute to the quantification of historical surface water use and demand. **Section H.3** discusses CWRM's 1989 efforts to register declarations of water use and stream diversion works in accordance with the State Water Code and administrative rules. Through the registration process, CWRM collected information on stream diversions and surface water use at that time. The registration provides a "snapshot in time" of the existing water sources and uses at that time.

Appendix P is a summary of the 1989 declared surface water use for each Surface Water Hydrologic Unit. Field verifications of declared stream diversions and surface water use were conducted for diversions on Molokaʻi, in parts of Oʻahu, Kauai, and Maui. However, while the existence of declared diversions were verified, there was difficulty in quantifying the diverted amounts. Therefore, most of the quantities listed in **Appendix P** are unverified and may represent the declarant's desire to reserve or claim water for intended future use. Many water use declarations indicate volumes of water that do not correlate with the declared use, while other declarations claim use of all available stream flow. Furthermore, some declared water use volumes are omitted from **Appendix P** because the declarant provided cumulative use amounts across several Surface Water Hydrologic Units; these volumes could not be assigned to specific hydrologic units. Thus, much of the information in **Appendix P** is based on unverified and dated user declarations and the information is included in this document for reference purposes only. However, this represents the best available information on diverted surface water amounts for most areas in the State.

H.4.2 County Assessments of Existing Water Demands

For the purposes of this report, county water departments provided municipal water use data to characterize existing water demands in terms of the agency's customer billing categories. This data represents existing water use only from county water systems and is intended to provide information on the relative distribution of demands across various use categories. County assessments of existing water demand data are presented in the tables below.

Table H-11 County of Kaua'i 2012 Municipal Water Use (MGD)

Water Use Category / Department of Water Premise Type	2012
Agriculture	
Agriculture	0.291
Domestic – Residential	0.007
Single-Family Dwelling	6.032
Multi Family Dwelling	1.285
Housing – State	0.002
Domestic – Non-Residential	
Commercial	0.960
Hotel	1.713
Resort	0.030
Religious	0.084
Schools – State	0.031
Industrial	
Industrial	0.040
Irrigation	
Golf Course – Private[1]	0.000
Irrigation – Private	0.061
Parks – County	0.006
Irrigation - City	0.004
Military	
United States Military Facility	0.020
Municipal	
County of Kaua'i	0.394
State Facility	0.512
United States Non-Military Facility	0.011
Total	**11.483**

[1] Private golf course water use was 59,000 gallons.

Note: Consumption data for Fiscal Year 2011-2012.

Source: Kaua'i Department of Water, November 22, 2013 Letter and January 9, 2104 Email.

Table H-12 City and County of Honolulu 2012 Municipal Water Use (MGD)

Water Use Category Honolulu BWS Metered User Type	2012
Agriculture	**3.40**
Agriculture	3.40
Residential	**73.41**
Mixed Residential	0.54
Multi-Family High Rise	4.56
Multi-Family Low Rise	7.30
Single-Family Dwelling	47.39
Multi-Family Dwelling	13.36
Housing - State	0.26
Non-Residential	**34.33**
Commercial	20.87
Hotel	5.07
Mixed Use	3.63
Private Schools	0.38
Religious	0.43
Resort	0.01
State Schools	3.95
Industrial	**2.51**
Industrial	2.51
Irrigation	**7.59**
Irrigation - City	0.13
Irrigation – Private	2.08
Irrigation - State	0.64
City Golf Courses	0.32
Private Golf Courses	0.97
City Parks	3.43
State Parks	0.03
Military	**2.87**
United States Military	2.87
Municipal	**4.85**
City	1.32
State	3.38
United States Non-Military	0.15
Other	**0.03**
Unknown	0.03
Total	**128.99**

Source: Honolulu Board of Water Supply, May 21, 2014 Email.

Table H-13 County of Maui 2012 Municipal Water Use (MGD)

Billing Class	2012
Agriculture[1]	1.649
Single-Family Dwelling	16.588
Multi-Family Dwelling[2]	4.467
Commercial	3.273
Hotel	2.376
Industrial	0.884
Government[3]	2.344
Religious Users	0.147
Total	**31.728**

1 Includes Irrigation-Private

2 Includes Multi-Family High Rise, Multi-Family Low Rise, Mixed Use

3 Includes Housing-County, Schools-Private, Schools-State, Irrigation-City, Irrigation-State, U.S. Military, City Facility, Parks-City, Parks-State, State Facility, U.S. Non-Military

Note: Unknown is 0.070 MGD

Source: Maui Department of Water Supply, November 26, 2013 Email.

Table H-14 County of Hawai'i 2012 Municipal Water Use (MGD)

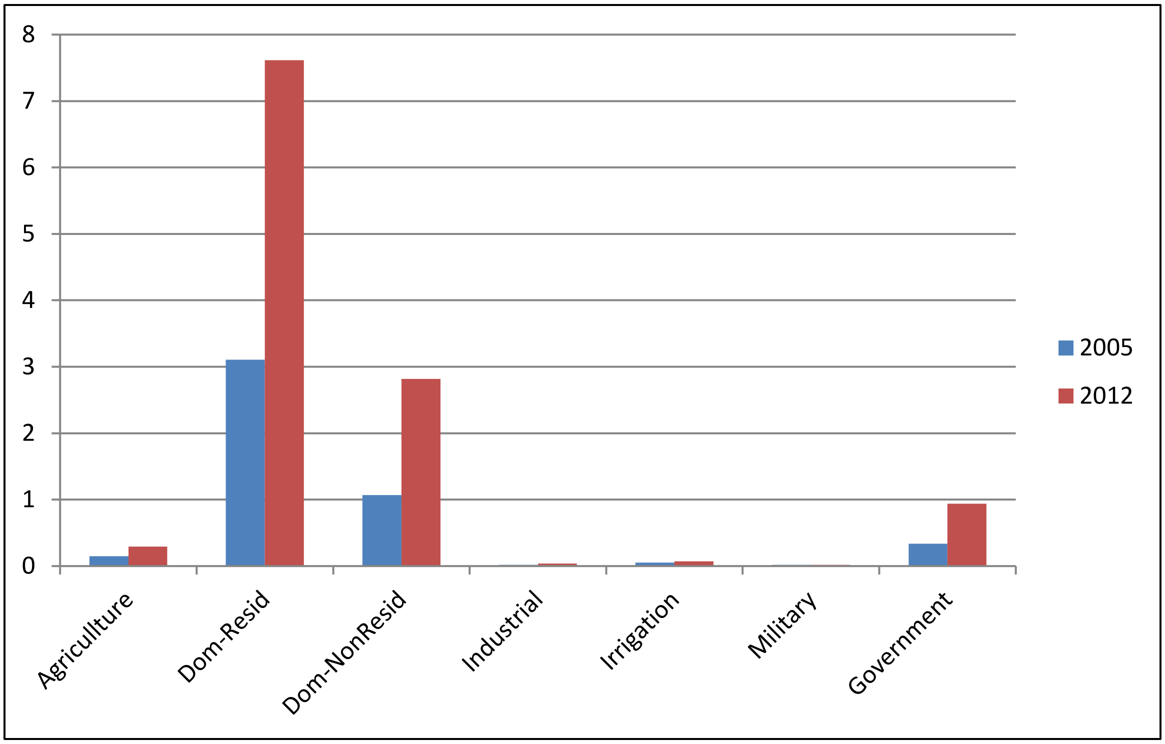
Water Use Category DWS Category	2012
Agriculture	
AG Agriculture Rate	2.238
AO Agriculture-Other	0.186
Domestic – Residential	
RM Residential – Multi	3.385
RO Residential – Other	0.010
RS Residential – Single	11.811
Domestic – Non-Residential	
SK Schools – K/12	0.078
SO Schools – Other	0.027
SU Schools – Univ	0.020
CH Comm – Hotel	1.878
CO Comm – Other	4.121
CR Comm – Restaurants	0.018
CS Comm – Stores	0.046
CV Comm – Service Station	0.001
CY Comm – Laundry	0.000
F TD Flat Rate	0.000
MH Medical – Hospital	0.005
MO Medical – Other	0.062
NC Nonprofit – Church	0.317
NO Nonprofit – Other	0.025
Industrial	
DC DC Meters	0.007
IG Industrial – General	0.000
IL Industrial – Limited	0.000
IO Industrial – Other	0.000
SP Standpipe	0.017
Irrigation	
IC Irrigation – Comm	0.090
IR Irrigation – Res	0.260
Military	0.00
Municipal	
GC Gov't – County	2.699
GF Gov't – Federal	0.062
GS Gov't – State	1.166
Total	**28.527**

Source: Hawai'i Department of Water Supply, December 13, 2013 Email.

H.4.2.1 Municipal Water Use Trends

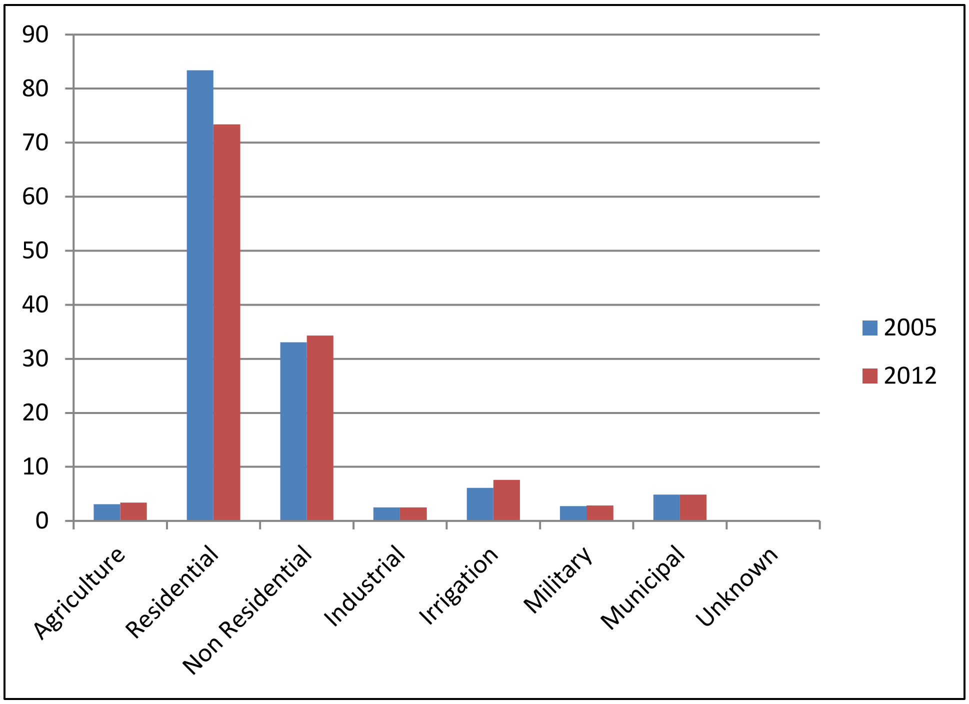
Municipal water use data from 2005-2006, documented in the 2008 WRRP, is compared to 2012 municipal water use data provided by the water departments in the figures below. **Figure H-5 to Figure H-8** show the relative changes in various water use sectors over the selected time period.

Figure H-5 County of Kauaʻi 2005-2012 Municipal Water Use (MGD)



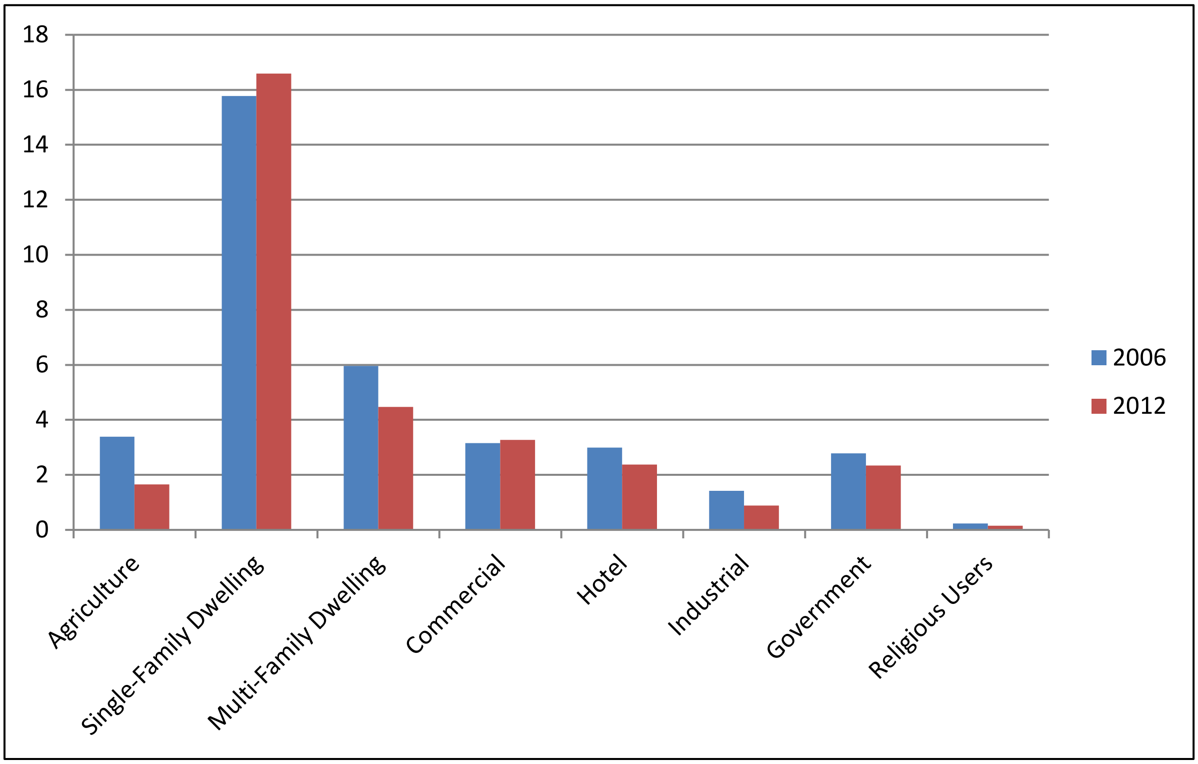
Large increases in domestic use, both residential and non-residential, have occurred since 2005. Government use has also more than doubled. The Kauaʻi Department of Water is researching the reasons for these observed trends.

Figure H-6 City and County of Honolulu 2005-2012 Municipal Water Use (MGD)



Water use for all sectors on O‘ahu remained flat or increased slightly, as is to be expected with an increasing population. The only sector experiencing a decrease between 2005 and 2012 is the residential component. This is probably due to ongoing public outreach and education on water conservation and initiatives.

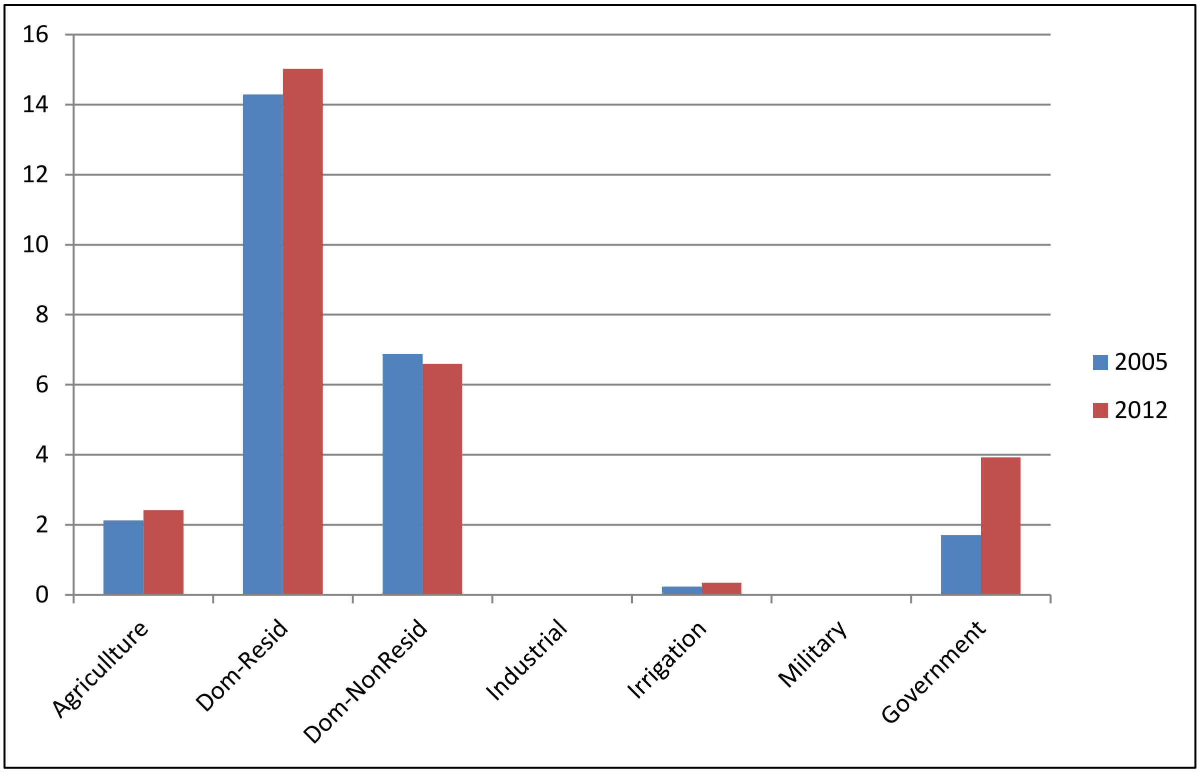
Figure H-7 County of Maui 2006-2012 Municipal Water Use (MGD)



On the island of Maui, most sectors have experienced a decline in water use. Conservation measures are likely a contributing factor, but the economic recession beginning in 2008 has also contributed to the observed trend. Single family use is directly correlated to population growth, so this sector has seen an overall increase, even with targeted conservation measures. It might also be assumed that there are more persons per single family household due to the current housing shortage.[7]

[7] Maui Department of Water Supply, June 19, 2017 email communication.

Figure H-8 County of Hawai'i 2005-2012 Municipal Water Use (MGD)



Except for non-residential domestic use which shows a slight decrease from 2005 to 2012, water use for all categories in the County of Hawai'i showed slight increases, which is most likely attributable to population increases. Government water use increased significantly due to the expansion or construction of new facilities, such as the airport and harbors expansions; elementary, high school and university (Hilo) expansions; new West Hawai'i Civic Center; new judiciary building in Hilo, and new police and fire departments in Pahoa.[8]

[8] Hawai'i Department of Water Supply, August 29, 2014 email communication.

H.4.3 2015 USGS Assessment of Existing Water Demands

Freshwater use data is compiled by the USGS and is updated approximately every five years. Most recently completed in 2015, the data includes water use from public and private water systems serving cities and military bases. Water used for domestic, commercial, recreational, industrial, and thermoelectric purposes is included, as well as water used in water and wastewater treatment, pools, parks, and other facilities.

Table H-15 2015 Freshwater Use by Type and by County

Use	State total	Hawai‘i	Honolulu	Kalawao[2]	Kaua‘i	Maui
	(Million gallons per day)					
Ground water	502.53					
Public supply[1]	252.31	37.38	168.78	0.01	13.67	32.47
Domestic	144.48	0	143.81	0.01	0.54	0.12
Industrial	0.24	0.21	0	0	0.03	0
Irrigation	73.8	14.47	15.09	0	1.88	42.36
Livestock	0.51	0	0.11	0	0.20	0.20
Aquaculture	8.58	6.21	1.92	0	0.34	0.11
Mining	0.89	0.34	0.48	0	0.05	0.02
Thermoelectric[3]	21.72	1.48	3.74	0	0	16.50
Surface water	701.72					
Public supply[1]	14.61	2.32	0	0	2.67	9.62
Domestic	7.44	7.44	0	0	0	0
Industrial	0	0	0	0	0	0
Irrigation	311.26	12.19	68.65	0	23.97	206.45
Livestock	1.1	1.10	0	0	0	0
Aquaculture	10.04	6.75	3.08	0	0	0.21
Mining	0.03	0	0	0	0	0.03
Thermoelectric[3]	357.24	0	356.80	0	0.44	0
Total	**1204.25**	**89.89**	**762.46**	**0.02**	**43.79**	**308.09**

1 Includes water withdrawn by public and private water systems for use by cities and military bases. Water withdrawn by these facilities may be delivered to users for domestic, commercial, industrial, and thermoelectric purposes, or may be used for water and wastewater treatment, pools, parks and city buildings.

2 Kalawao County consists of the Kalaupapa peninsula on Moloka‘i and is a judicial district of Maui County. Source: U.S. Geological Survey, Water Resources, *Water Use in the United States, Estimated Use of Water in the United States County-Level Data for 2015* (https://waterdata.usgs.gov/hi/nwis/wu)

3 Does not include water withdrawn for recirculation and once-through.

H.5 Estimating Future Water Demands

The accuracy of future water use projections over the long term is subject to many influences, including economic conditions, population growth, land use policies, and conservation practices. Several methods are used to derive water demand projections and increase the accuracy of estimates.

Land use-based water demand projections are intended to evaluate the water demands of an area, relative to a certain density level based on zoning and/or land use type. Land use-based demand projections indicate the water needs anticipated with current land use policies and entitlements. This method, however, can produce unrealistically high water demand projections in the full build-out scenario at maximum allowable density. Projections based on more moderate development densities may be more useful.

Future water demand can also be estimated based on population growth projections, which assume a per-capita water demand to provide estimates over planning horizon increments of 5, 10, 15, or 20 years. Multiple growth scenarios are evaluated for each time increment to provide a range of projected demand, with the most conservative projection derived from the “high population growth” scenario. Regional population growth rates for various land use categories can also be applied to predict future residential water demand. Additionally, recent consumption rates by region and land use type can help to improve predictions of future water demand.

The primary vehicles for refining water demand projections for each of the four Counties in Hawaii are the WUDPs, Whether the demands are derived from land use, population projections, or a combination, the WUDPs provide the means to refine those demands by incorporating the information from the other components of the Hawaii Water Plan such as the State Water Projects Plan (SWPP) and the Agricultural Water Use and Development Plan (AWUDP). Additionally, the WUDP should also incorporate information on federal and private water systems, and historical water use data. The SWPP identifies future water demands for State of Hawaiʻi projects. The AWUDP identifies both State and private agricultural water system demands.

H.5.1 Projected Future DHHL Water Demands

As a State agency, the water needs of the Department of Hawaiian Home Lands (DHHL) are identified in the SWPP. DHHL water needs are an identified purpose of the water resources public trust and given high priority under the Hawaiʻi State Constitution and Water Code. Please refer to **Appendix C Legal Authorities and Guidance** for a discussion of DHHL’s rights under the State Constitution, Water Code, and Section 221 of the Hawaiian Homes Commission Act. In order to ensure that DHHL’s foreseeable future needs are provided for, CWRM has established water reservations by rule pursuant to HRS §174C-49(d) in designated water management areas on Oʻahu and Molokaʻi, and by regular Commission action in non-designated areas, as summarized in **Table H-16.**

Table H-16 Current DHHL Water Reservations

Hydrologic Unit	Quantity of Water Reserved (MGD)	Effective Date
Waipahu-Waiawa	1.358[9]	February 18, 1994
Waimanalo	0.124[10]	February 18, 1994
Kualapu‘u	2.905[11]	June 10, 1995
Keauhou	3.398	August 17, 2015
Waimea River	6.903	June 20, 2017

These reservations are counted against available sustainable yields or are incorporated in established instream flow standards and may not be used by other parties. The existing water needs and future demands of DHHL protected through water reservations, as well as those identified in the SWPP, must be incorporated and recognized in the Hawai‘i Water Plan.

On May 16, 2017, CWRM adopted an updated SWPP prepared by DLNR's Engineering Division, the agency responsible for developing and updating the SWPP.[12] Due to limited funding, the SWPP update was only done for DHHL projects. The decision to focus on DHHL was made for several reasons: DHHL's high priority rights to water, an actively evolving project list, ownership of significant land areas, and exemption from County zoning. The 2017 SWPP update projects both potable and non-potable water needs to 2031 based on DHHL's Island Plans.

Table H-17 below summarizes mid-range cumulative potable and non-potable water demand projections to 2031 by island, based on DHHL's Island Plans. Two non-potable scenarios are presented: 1) total non-potable demands and 2) non-potable demands requiring infrastructure development. The latter scenario does not include demands from General Agricultural land use designations (unless a specific use was identified for the particular area). Most General Agriculture lands were designated as such in the Island Plans as a temporary land use designation until better uses become feasible; therefore, the plan is not recommending infrastructure development for land uses that are not permanent.

A breakdown by hydrologic unit is provided in the 2017 SWPP for both potable and non-potable needs. While DHHL does own and operate water systems, the plan envisions most of DHHL's potable development needs will be served by municipal water systems. Therefore, information contained in the 2017 SWPP update is a critical input to county water use and development planning.

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[9] HAR 13-171-61 reserves 1.724 mgd, of which 0.366 mgd has been converted to water use permits.

[10] HAR 13-171-62

[11] HAR 13-171-63

[12] http://files.hawaii.gov/dlnr/cwrm/planning/swpp2017.pdf

Table H-17 Cumulative Potable and Non-Potable Water Demand Projections to 2031 by Island

Island	Primary Use	Cumulative Average Day Demand (MGD)							
		2012	2013	2014	2015	2016	2021	2026	2031
Kaua'i	Potable	0.000	0.000	0.000	0.026	0.353	0.919	2.208	2.918
	Non-Potable for Water Development	0.819	0.819	0.819	0.819	29.966	31.298	33.548	34.765
	Non-Potable	0.819	0.819	0.819	0.819	30.831	32.163	34.413	35.807
	Total for Water Development	**0.819**	**0.819**	**0.819**	**0.845**	**30.319**	**32.217**	**35.756**	**37.684**
	Total	**0.819**	**0.819**	**0.819**	**0.845**	**31.184**	**33.082**	**36.621**	**38.726**
O'ahu	Potable	0.009	0.009	0.031	0.609	0.739	0.965	5.290	5.426
	Non-Potable for Water Development	0.000	0.000	0.000	0.000	1.800	1.814	19.503	19.503
	Non-Potable	0.000	0.000	0.000	0.000	1.800	1.814	19.503	22.539
	Total for Water Development	**0.009**	**0.009**	**0.031**	**0.609**	**2.539**	**2.779**	**24.793**	**24.929**
	Total	**0.009**	**0.009**	**0.031**	**0.609**	**2.539**	**2.779**	**24.793**	**27.965**
Moloka'i	Potable	0.000	0.000	0.000	0.000	0.259	0.662	1.061	1.061
	Non-Potable for Water Development	0.000	0.000	0.000	0.000	4.721	5.360	6.091	6.091
	Non-Potable	0.000	0.000	0.000	0.000	4.721	5.360	6.091	34.985
	Total for Water Development	**0.000**	**0.000**	**0.000**	**0.000**	**4.980**	**6.022**	**7.153**	**7.153**
	Total	**0.000**	**0.000**	**0.000**	**0.000**	**4.980**	**6.022**	**7.153**	**36.046**
Lāna'i	Potable	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067
	Non-Potable for Water Development	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Non-Potable	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Total for Water Development	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.067**
	Total	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.067**
Maui	Potable	0.000	0.000	0.000	0.000	2.213	2.715	3.457	3.521
	Non-Potable for Water Development	0.000	0.000	0.000	0.000	1.870	11.397	11.397	11.652
	Non-Potable	0.000	0.000	0.000	0.000	1.870	11.397	11.397	27.557
	Total for Water Development	**0.000**	**0.000**	**0.000**	**0.000**	**4.083**	**14.112**	**14.853**	**15.173**
	Total	**0.000**	**0.000**	**0.000**	**0.000**	**4.083**	**14.112**	**14.853**	**31.078**
Hawai'i	Potable	0.076	0.113	0.149	0.269	1.766	3.184	4.227	9.002
	Non-Potable for Water Development	0.000	0.000	0.000	0.102	0.932	4.114	5.266	31.721
	Non-Potable	0.000	0.000	0.000	0.102	0.932	4.114	5.606	62.582
	Total for Water Development	**0.076**	**0.113**	**0.149**	**0.371**	**2.698**	**7.298**	**9.493**	**40.722**
	Total	**0.076**	**0.113**	**0.149**	**0.371**	**2.698**	**7.298**	**9.833**	**71.584**
State	Potable	0.085	0.121	0.180	0.904	5.331	8.445	16.243	21.996
	Non-Potable for Water Development	0.819	0.819	0.819	0.921	39.288	53.982	75.805	103.732
	Non-Potable	0.819	0.819	0.819	0.921	40.153	54.847	77.011	183.470
	Total for Water Development	**0.904**	**0.941**	**0.999**	**1.825**	**44.619**	**62.427**	**92.048**	**125.728**
	Total	**0.904**	**0.941**	**0.999**	**1.825**	**45.484**	**63.292**	**93.253**	**205.466**

Note: Non-Potable for Water Development represents the non-potable demands used to determine water development strategies within the 20-year planning window; Non-Potable represents the total non-potable demands, including General Agriculture demands not anticipated to be developed within the 20-year planning window.

H.5.2 Projected Future County Water Demands

According to county water agency projections, by the year 2035, water demands will approach 268 MGD statewide.

Table H-18 summarizes the water demands projected by the county water agencies through 2035. **Table H-19** through **Table H-22** provides a breakdown by county and by water demand categories or billing classes (as designated by the water departments). The tables are useful in comparing demands associated with potable and non-potable water uses. Notwithstanding the discussion of land use and population-based projections in **Section H.4**, it is noted that the demand forecasts in the tables below were prepared independently by each county; therefore, assumptions and forecast methods vary between counties.

Figure H-9 through **Figure H-16** are provided to illustrate the data in the tables and show the actual municipal use for each county from 1990 to 2010 relative to its 5-year projected future demands from 2015 to 2035. Please refer to each County's Water Use and Development Plan for more information on existing and projected future water demands.

Table H-18 Projected Water Demand for All Counties, 2020 to 2035 (MGD)

County	2020	2025	2030	2035
Kauaʻi[1]	17.795	18.744	19.696	20.526[6]
Honolulu[2]	144.8	144.3	147.2	150
Maui[3] **(DWS system - includes Maui & Molokaʻi)** **Lānaʻi (private system)**[4]	39.945	42.913	45.856	48.808[6]
Hawaiʻi[5]	36.941	40.786	45.031	49.718
TOTAL	**239.481**	**246.743**	**257.783**	**268.852**

1 Source: Kauaʻi Department of Water, November 22, 2013 Letter.

2 Source: Honolulu BWS, June 20, 2018 Email.

3 Source: Maui Department of Water Supply, January 7, 2014 Email.

4 Lānaʻi water demand information was not available from Pūlama Lānaʻi at the time of this writing.

5 Source: Hawaiʻi Department of Water Supply, December 13, 2013 Email.

6 Data interpolated from county demand projections from 2015 to 2030.

NOTE: Water use reporting and metered data is incomplete, particularly in earlier years.

Table H-19 Kauaʻi County Projected Water Demand by Use Category, 2015 to 2035 (MGD)

Use Category	2015	2020	2025	2030	2035*
Single Family	8.998	9.431	9.934	10.438	10.878
Multi Family/Resort	4.244	4.449	4.686	4.924	5.132
Commercial	1.358	1.424	1.500	1.576	1.643
Industrial	0.170	0.178	0.187	0.197	0.205
Government	1.528	1.601	1.687	1.773	1.848
Agriculture	0.679	0.712	0.750	0.788	0.822
Total	**16.977**	**17.795**	**18.744**	**19.696**	**20.526**

* Data Interpolated from county demand projections from 2015 to 2030.

Source: Kauaʻi Department of Water, November 22, 2103 Letter.

Figure H-9 Kauaʻi County Projected Water Demand by Use Category, 2015 to 2035

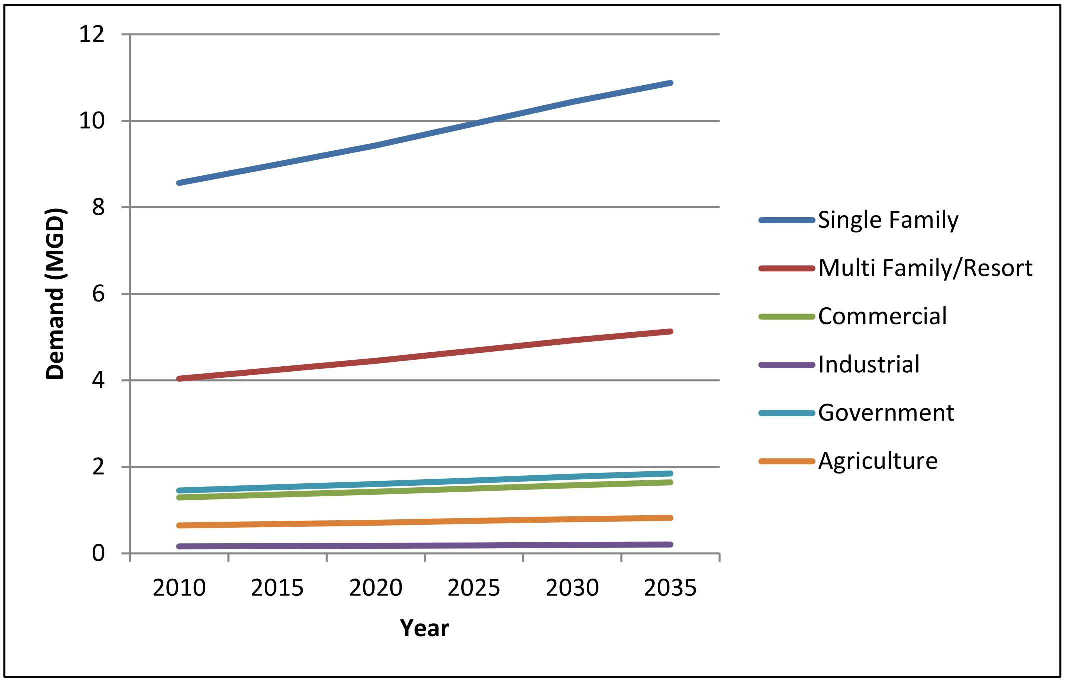
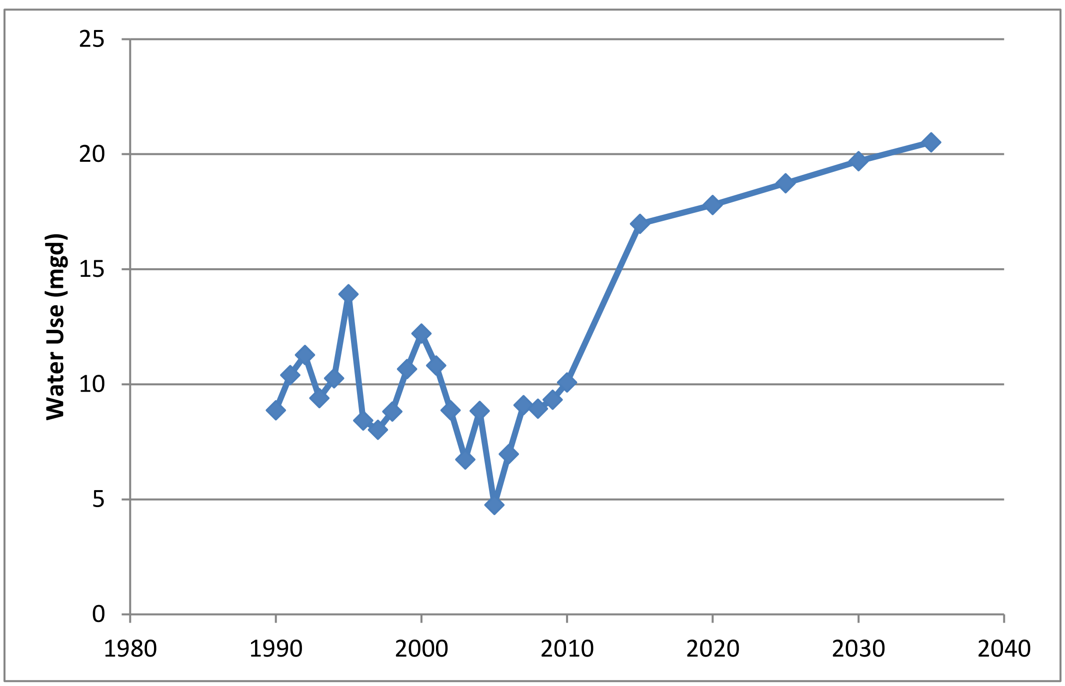


Figure H-10 Kauaʻi County Water Use and Projected Water Demand to 2035



Note: Water use reports for 2005 not available; 2005 estimated water use provided by Kauaʻi DWS

Table H-20 City and County of Honolulu Projected Water Demand, 2015 to 2035 (MGD)

Use Category	2015	2020	2025	2030	2035
Agriculture	3.8	3.9	3.9	4.0	4.1
Domestic Residential[1]	80.2	83.5	83.3	84.9	86.5
Domestic Non-Residential[1]	52.5	54.4	54.3	55.3	56.3
Industrial	1.2	1.3	1.3	1.3	1.3
Irrigation	1.6	1.7	1.7	1.7	1.8
Total	**139.3**	**144.8**	**144.5**	**147.2**	**150**

1 Includes potable and non-potable water needs.

Source: Honolulu BWS, June 20, 2018 Email.

Figure H-11 City and County of Honolulu Projected Water Demand 2010 to 2035

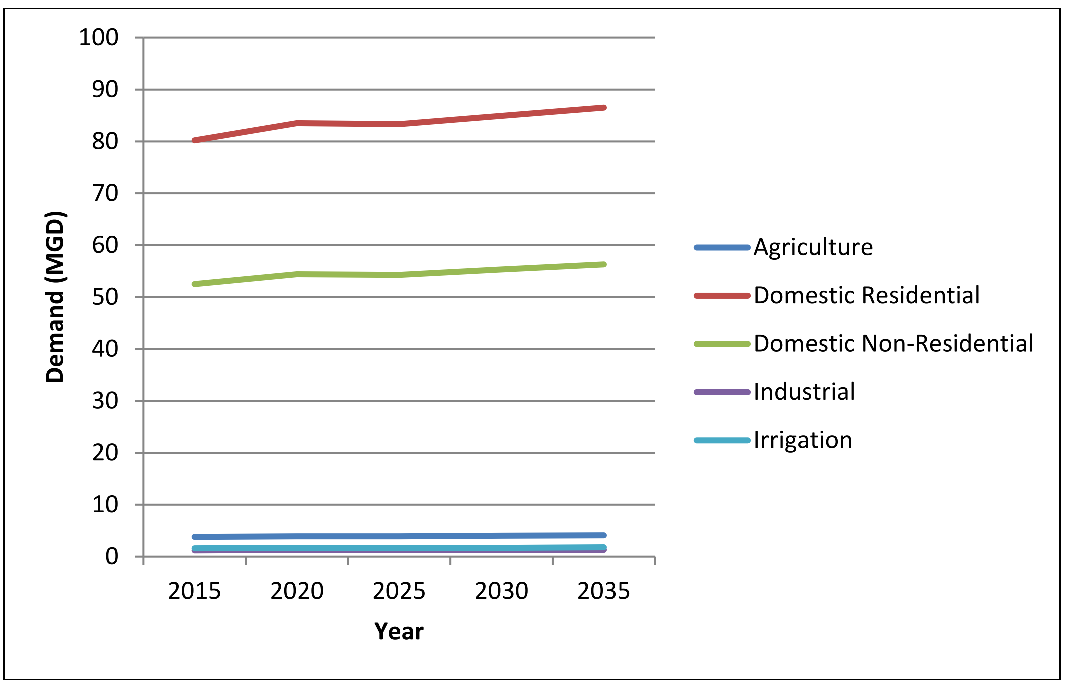


Figure H-12 City and County of Honolulu Water Use and Projected Water Demand to 2035

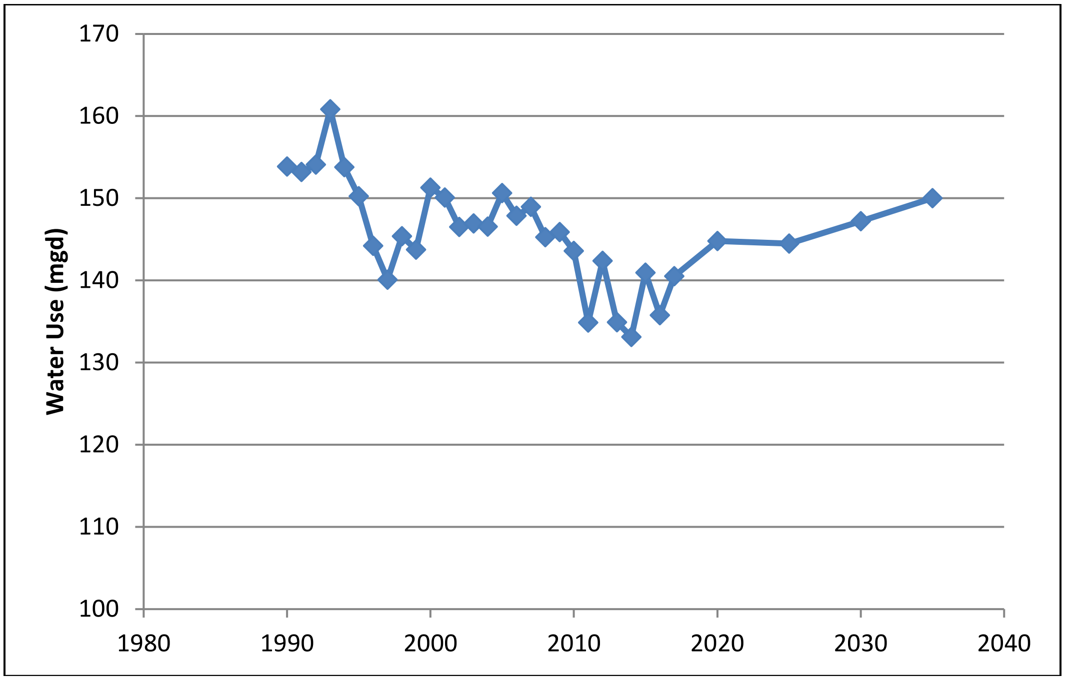


Table H-21 Maui County Projected Water Demand by Use Category, 2015 to 2035 (MGD)

Use Category	2015	2020	2025	2030	2035*
Single Family	19.680	21.241	22.819	24.384	25.954
Multi-Family/Resort	8.465	9.136	9.815	10.488	11.163
Commercial	3.686	3.978	4.274	4.567	4.861
Industrial	1.081	1.167	1.253	1.339	1.425
Government	2.628	2.836	3.047	3.256	3.466
Agriculture	1.399	1.510	1.622	1.733	1.845
Unknown	0.071	0.077	0.082	0.088	0.094
Total	**37.010**	**39.945**	**42.913**	**45.856**	**48.808**

* Data Interpolated from county demand projections from 2015 to 2030.

Notes: "Use Category" corresponds to the Maui Department of Water Supply billing class.

Source: Maui Department of Water Supply, January 7, 2014 Email.

Figure H-13 Maui County Projected Water Demand by Use Category, 2015 to 2035

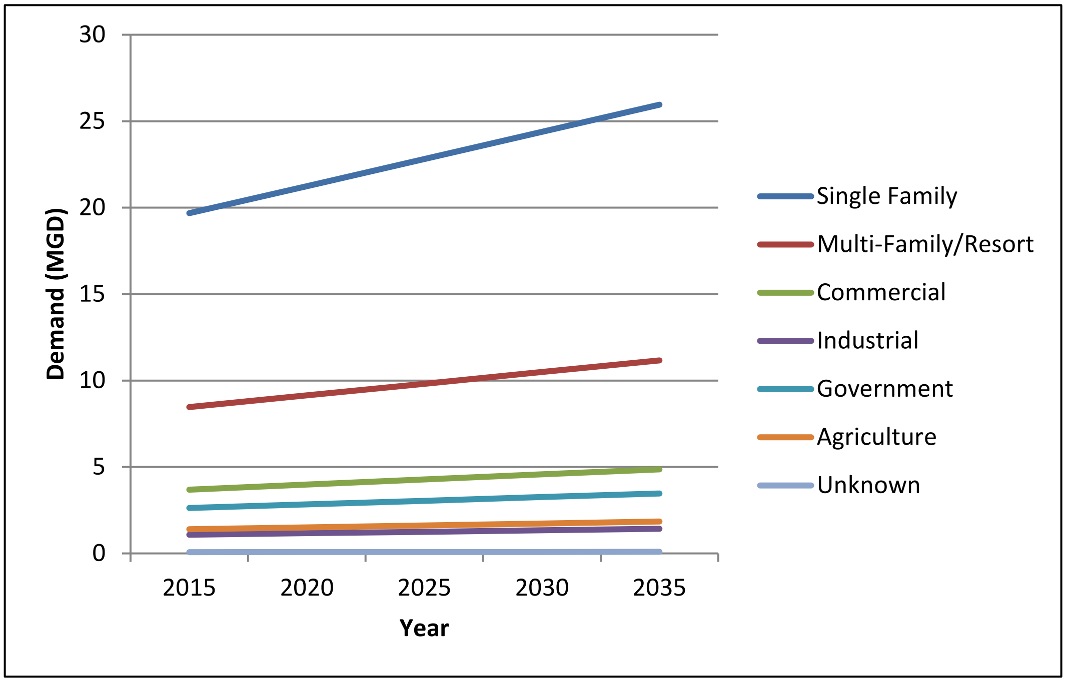


Figure H-14 Maui County Water Use and Projected Water Demand to 2035

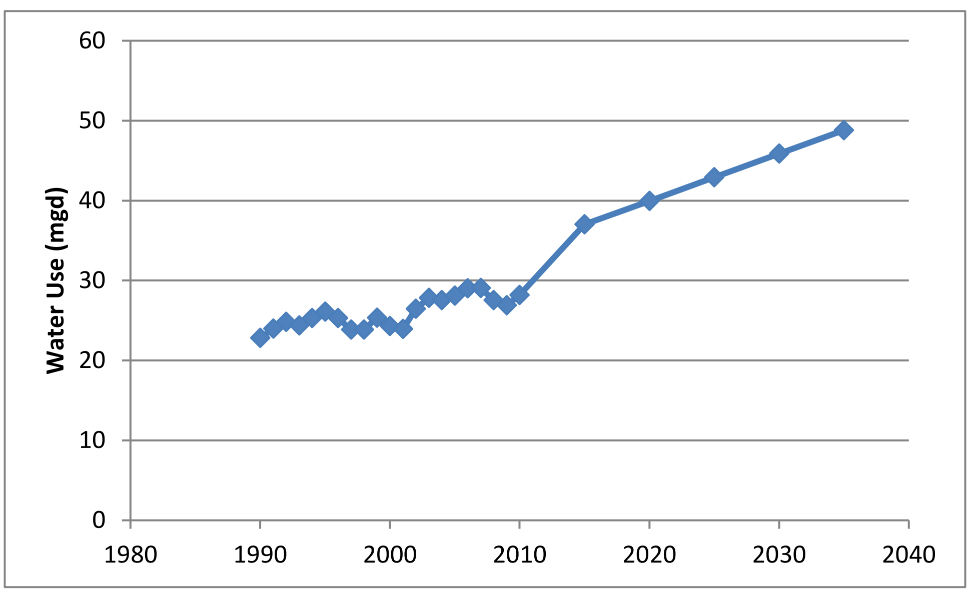


Table H-22 Hawai‘i County Projected Water Demand by Use Category, 2015 to 2035 (MGD)

Use Category	2015	2020	2025	2030	2035
Agriculture	2.572	2.840	3.136	3.462	3.822
Domestic-Residential	16.137	17.816	19.671	21.718	23.978
Domestic-Non-Residential	7.002	7.731	8.535	9.424	10.404
Industrial	0.025	0.028	0.031	0.034	0.038
Irrigation	0.371	0.410	0.453	0.500	0.552
Military	0.000	0.000	0.000	0.000	0.000
Municipal	4.167	4.601	5.080	5.609	6.192
Un-Accounted Water	3.184	3.515	3.881	4.285	4.731
Total	**33.459**	**36.941**	**40.786**	**45.031**	**49.718**

Note: Projections for 2015, 2020, 2025, 2030, & 2035 were made after recalibrating 2012 for actual production levels. Percent Average Annual Growth was assumed to be 2% in all categories. The 2010 Water Use and Development Plan Update considered 2% growth to be moderate. (Note: Average Annual Total Growth Island wide from 2005 to 2012 was 1.755 % but the economy was relatively slow for much of this period.)

Source: Hawai‘i Department of Water Supply, December 13, 2013 Email.

Figure H-15 Hawai‘i County Projected Water Demand by Use Category, 2015 to 2035

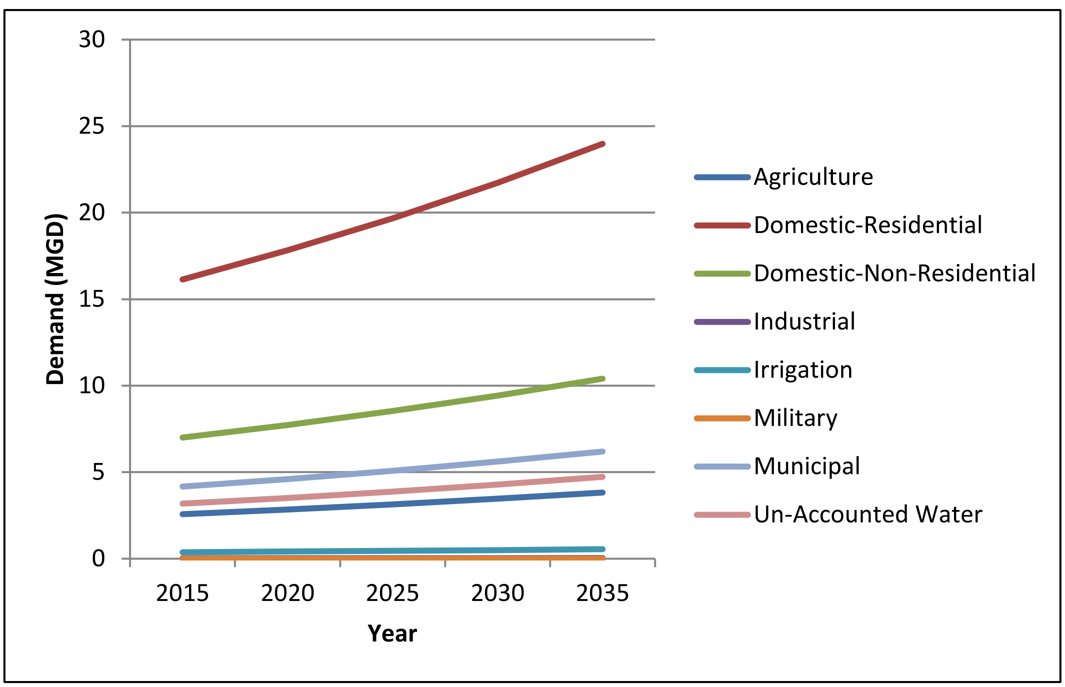
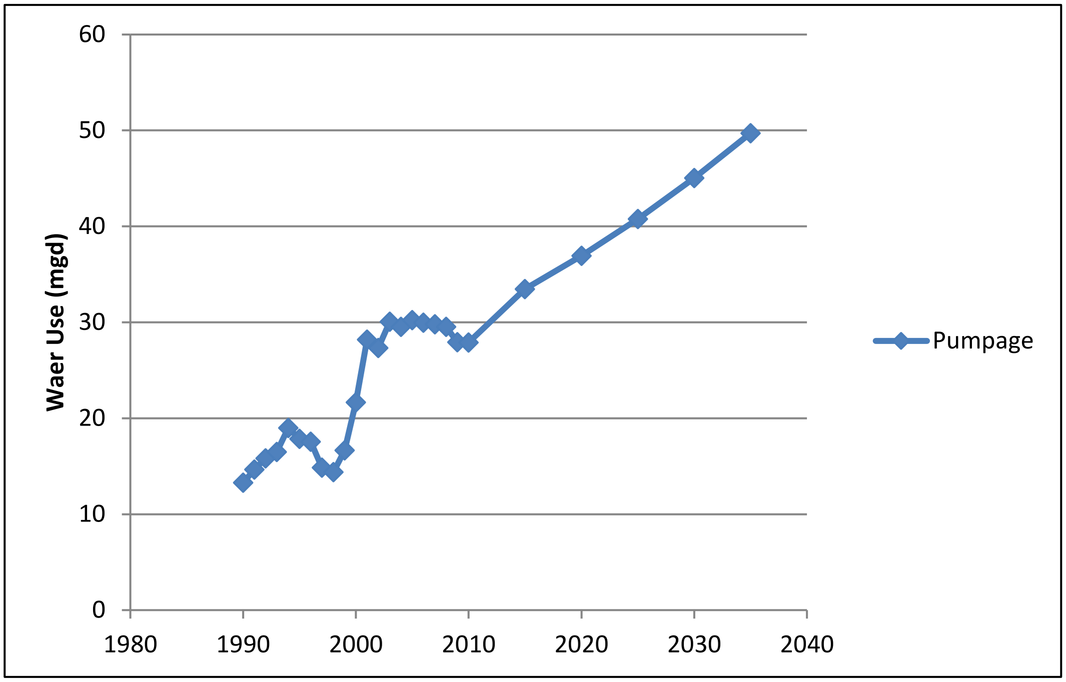


Figure H-16 Hawai‘i County Water Use and Projected Water Demand to 2035



H.6 Water Planning at the County Level

One of the primary objectives of the State Water Code is the development of a program of comprehensive water resource planning to address the supply and conservation of water. A major component of this program is the Water Use and Development Plan that must be prepared by each county. The Water Code also provides for planning consistency across government levels by requiring the County WUDPs to be adopted by CWRM, and integrated into the Hawai‘i Water Plan.

The initial County WUDPs were prepared in 1990 to meet the deadline set by the State Water Code legislation, but the County WUDPs were adopted by CWRM with the condition that the plans be updated with more information on certain plan elements. In 1992, CWRM was briefed on draft updates to the County WUDPs, but deferred adoption of the updates, pending the refinement of the plans. The following describes the purpose and content of the County WUDPs, the process for updating the plans, and the status of each county’s planning efforts.

H.6.1 The County WUDP Update Process

The State Water Code requires each county to prepare and regularly update its County WUDP to address future water demands and to set forth the "allocation of water to land use in that county." It is important to note that the WUDPs are the instruments by which all other Hawai‘i Water Plan components are integrated, and are used to implement comprehensive water resource planning at the county level. This is emphasized through the adoption of the WUDP as a County ordinance.

The County WUDP objectives include the following planning activities:

- Assess existing and future land uses and associated municipal water demands;
- Incorporate agriculture, military, private, State, and other non-municipal water demand projections; and
- Evaluate the cost and adequacy of proposed development plans and identify preferred and alternative water development plans to meet projected demands.

Requirements, recommendations, and guidance for preparing the County WUDPs are found in the State Water Code and the Statewide Framework for Updating the Hawai‘i Water Plan. The pertinent sections of the State Water Code and the Framework are summarized below.

H.6.1.1 State Water Code and Administrative Rule Requirements

The purpose of the County Water Use and Development Plans is to inventory all projected water demands and ensure that the future water needs of the county are met. The plans allocate water to land use, and provide additional guidance to CWRM for decision-making regarding water management area designation, water use, and water reservation requests.

The State Water Code mandates that each county update and modify its WUDP as necessary, to maintain consistency with zoning and land use policies. It also specifies that County WUDPs must be adopted by county ordinance.

HRS §174C-31(f) states that the County WUDPs must include, but are not limited to the following information:

(1) Status of water and related land development including an inventory of existing water uses for domestic, municipal, and industrial users, agriculture, aquaculture, hydropower development, drainage, reuse, reclamation, recharge, and resulting problems and constraints;
(2) Future land uses and related water needs; and
(3) Regional plans for water developments including recommended and alternative plans, costs, adequacy of plans, and relationship to the water resource protection and water quality plans.

Hawaiʻi Administrative Rules §13-170-32 provides additional guidelines for preparation of the County WUDPs:

> *(b) All water use and development plans shall be prepared in a manner consistent with the following conditions:*
>
> *(1) Each water use and development plan shall be consistent with the water resource protection plan and the water quality plan.*
>
> *(2) Each water use and development plan and the state water projects plan shall be consistent with the respective county land use plans and policies, including general plan and zoning as determined by each respective county.*
>
> *(3) Each water use and development plan shall consider a twenty-year projection period for analysis purposes.*
>
> *(4) The water use and development plan for each county shall also be consistent with the state land use classification and policies.*
>
> *(5) The cost of maintaining the water use and development plan shall be borne by the counties; state water capital improvement funds appropriated to the counties shall be deemed to satisfy Article VIII, section 5 of the State Constitution.*

H.6.1.2 Framework Requirements

The Statewide Framework for Updating the Hawaiʻi Water Plan[13] is intended to help integrate and update the components of the Hawaiʻi Water Plan. With respect to the County WUDPs, several key Framework objectives are listed below:

- To achieve integration of land use and water planning efforts that are undertaken by federal, State, county, and private entities so that a consistent and coordinated plan for the protection, conservation and management of water resources is achieved;
- To recommend guidelines for the HWP update so that the plan and its component parts are useful to CWRM, other State agencies, the counties, and the general public;
- To develop a dynamic planning process that results in a "living document" for each component of the HWP which will provide county and State decision-makers with well formulated options and strategies for addressing future water resource management and development issues;
- To better define roles and responsibilities of all State and county agencies with respect to the development and updating of the HWP components; and
- To describe and outline the techniques and methodologies of integrated resource planning as the basic approach that should be utilized in developing and updating the County WUDPs.

[13] Commission on Water Resource Management, Department of Land and Natural Resources, State of Hawaii, 2000, *Statewide Framework for Updating the Hawaii Water Plan*

The County WUDPs respond to the need for integration of resource development strategies at the county level. It is emphasized that the County WUDPs are required to encompass all water usage and water development plans projected throughout the county. Since the various State agencies ultimately build their projects within one of the four counties, State agency water use demands and proposals for development of various resources to meet those demands must be factored into the overall water demands and development strategies of each of the counties. The responsibility for preparation of the County WUDP rests with the specific entities charged with water planning within that county, as may be enumerated by county ordinance.

The Framework advocates the use of an integrated resource planning (IRP) approach. IRP is a comprehensive form of planning that encompasses least-cost analyses of resource management options, as well as a participatory decision-making process. It involves the development of water resource alternatives that take into consideration communities and environments that may be affected, the numerous institutions concerned with water resource development and protection, and the potential for competing policy goals.

In adopting the Framework, the Commission recognized that each county faces a unique set of conditions that have an impact on the county's planning process, including:

- The nature and occurrence of water resources and existing infrastructure in the county;
- The planning issues and water use priorities the county must address;
- The financial resources available to the county; and
- The financial and organizational structure that has been established by its County Council and administration.

Thus, the Framework recognizes the need for appropriate flexibility and versatility to encourage innovation as well as to accommodate unique and county-specific concerns that may be addressed within the WUDP. In light of the above conditions, the Framework requires that each county develop a scope of work for updating its WUDP which best meets its overall objectives. The process by which these objectives are to be achieved should be set forth in a detailed project description and schedule for updating the County WUDP.

Now that the agencies involved in the Hawaiʻi Water Plan process have gained experience implementing the Framework, the Framework should be reassessed to determine what changes can be made to improve the updating process.

H.6.2 Status of County WUDP Updates

The status of the County updates, as well as the other components of the Hawaiʻi Water Plan are shown in **Table H-23** below. Since the deferral of adoption of the 1992 draft updates, the Framework was adopted in 2000 to provide guidance to agencies responsible for preparing HWP components. That same year, the Hawaiʻi Supreme Court's decision in the Waiāhole Ditch Combined Contested Case imparted and reaffirmed the application of the Public Trust Doctrine and the precautionary principle in Hawaiʻi's water resource planning efforts.

Both the City and County of Honolulu and the County of Maui had begun the WUDP update process as the HWP Framework and the Waiāhole case were developing. Therefore, these counties have adapted and adjusted their programs to incorporate policy developments and to formulate planning mechanisms best suited to them. The sections below provide information on the current WUDP update activities in each county, and summarize the status of planning efforts. Some of the following discussion is taken directly from published WUDPs.

Table H-23 Status of County Water Use and Development Plans

County Island or District	Current WUDP Adoption Date	Status of WUDP Update	Strategies to Meet Future Water Needs
Kauaʻi	February 1990	In progress	
Oʻahu			
Central Oʻahu	March 1990	In progress	
East Honolulu	March 1990	Awaiting funding	
ʻEwa	March 1990	In progress	
Koʻolau Loa	March 2011	Current	• Ground water development • Water reuse expansion • Conservation
Koʻolau Poko	September 2012	Current	• Ground water development • Water reuse expansion • Surface water for kalo expansion • Conservation
North Shore	December 2016	Current	• Current supplies sufficient
Primary Urban Center	March 1990	In progress	
Waiʻanae	March 2011	Current	• Decrease ground water development • Increase import from Pearl Harbor ASYA • Conservation
Maui			
Maui	March 1990	In progress	
Molokaʻi	March 1990	Awaiting completion of Maui Island WUDP update	
Lānaʻi	August 2012	Current	• Ground water development • Water reuse expansion • Desalination • Conservation
Hawaiʻi	December 2011	Current	• Extend ground water system service areas • Water transfers • Alternative source development • Demand-side management

H.6.3 Summary of Water Resource Implications for Updated WUDPs

The following sections summarize the findings of the updated WUPDs in terms of existing and future water demands, resource options and strategies, and the implications for natural supplies.

H.6.3.1 Lānaʻi WUDP, County of Maui[14]

In August 2012, CWRM adopted the Lānaʻi WUDP. The WUDP emphasizes the many challenges Lānaʻi faces in meeting its water needs. The total sustainable yield of the island is only 6 MGD. Virtually all of the island's available ground water resources are confined to dike compartments in the Central Aquifer Sector Area, which is divided into two aquifer system areas having sustainable yields of 3 MGD each (see **Table H-24**). Recharge is highly dependent on the forested mauka watershed, with a significant amount deriving from fog drip. Although historical evidence suggests the existence of perennial streams, no surface water sources currently exist on the island. Lānaʻi has two drinking water systems, one brackish water system used for irrigation, and two recycled water systems, also used for irrigation.

Total pumpage in 2008 was about 2.24 MGD. However, metered consumption was found to be 1.66 MGD. Therefore, Lānaʻi's water loss was over 25% of production. This analysis revealed opportunities for supply-side savings, which are included in the proposed capital plan. However, water losses are already being addressed and are currently less than that identified in the plan.

Future water demands were assessed based on the estimated rate of increase in demand predicted by economic and demographic considerations through 2030 and based on build-out of known projects and projects with Phase II approval. The estimated demand for projects with Phase II approval is over 5 MGD. However, with water conservation measures, total pumpage would be limited to 3.7 MGD.

The resource development strategy includes new ground water source development, water reuse expansion, and desalination in addition to both supply-side and demand-side conservation. Pumpage from the Leeward Aquifer System Area, where most of the existing supply is currently derived, would be limited to 2.67 MGD under the plan. New Windward sources are identified and would be brought online as needed. Identified source contributions from the Windward Aquifer System Area total 2.58 MGD. **Table H-24** shows maximum planned ground water withdrawals in relation to aquifer system area sustainable yields.

Table H-24 shows maximum planned ground water withdrawals for both the Windward and Leeward Aquifer System Areas, which includes estimated demand for projects with Phase II approvals, are just below 90% of the respective aquifers estimated sustainable yields. This highlights the importance of implementing water conservation and resource augmentation measures that are included as part of the long-term resource development strategy.

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[14] County of Maui, Department of Water Supply, 2011, *Lānaʻi Island Water Use and Development Plan*

Table H-24 Maximum Planned Ground Water Withdrawals in Relation to Sustainable Yields, Island of Lānaʻi

Aquifer System Area	Sustainable Yield (MGD)	2035 Maximum Planned Withdrawals (MGD)	2035 Maximum Planned Withdrawals As a Percent of SY
Windward	3	2.67	89%
Leeward	3	2.58	86%

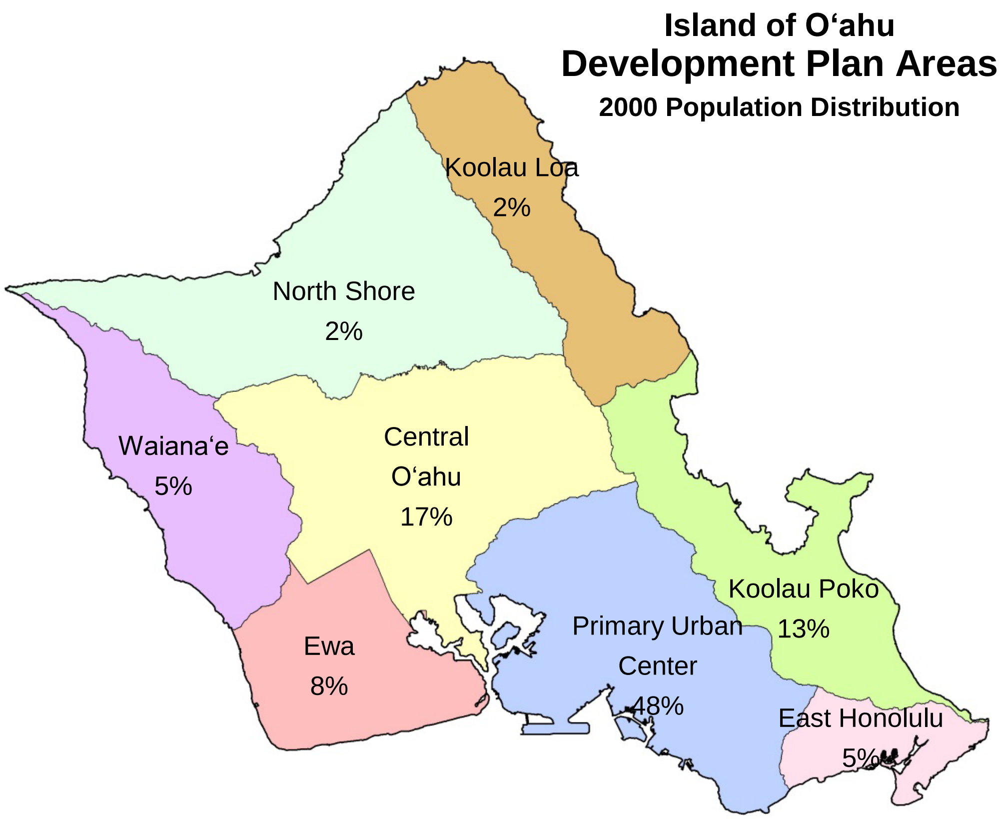
Water conservation measures, which would contribute 0.485 MGD toward meeting demands, include pipe repair/replacement, fixture replacement, leak detection and repair, reservoir loss reduction, and various demand-side management programs. Total reclaimed water use, currently at 0.307 MGD, would rise to 0.416 MGD under the planning horizon. Under the strategy, desalination of 0.300 MGD would only be needed to meet build out demands.

A significant portion of the Plan addresses the issues of source water protection and watershed protection. The importance of watershed management and drinking water source protection are recognized along with proposed actions to achieve both. These include but are not limited to inventorying wells at risk from overland contamination, refinement of a well-head protection strategy, fencing valuable watershed areas, ungulate control, weed removal, and education.

As illustrated in **Table H-24** above, Lānaʻi faces challenges with respect to its limited natural supplies, water needs for existing land use entitlements, watershed decline, and aging infrastructure. The following measures are identified as essential elements to be implemented in order to maintain the sustainability of ground water resources and meet demands:

- Watershed protection — development of a new watershed protection plan, fencing, ungulate removal, fire protection, invasive plant eradication, and erosion management.
- Water resource protection — well head protection, aquifer monitoring and reporting, watershed monitoring and recharge assessments, water use monitoring, and enforcement of existing water management allocation agreements.
- Water conservation — water recycling, demand-side management, education, replacement and/or repair of leaking pipes, leak detection and repair, and reservoir loss control.
- New supply resource development — develop Leeward Aquifer System Area sources, expand wastewater recycling, develop Windward Aquifer System Area sources.
- Land use entitlements — determine whether sufficient water resources are available for new land use entitlements without unreasonable risk or harm to existing users or water resources.

Figure H-17 O‘ahu Development Plan Areas



H.6.3.2 Ko‘olau Loa Watershed Management Plan, City and County of Honolulu[15]

In March 2011, CWRM adopted the Ko‘olau Loa WMP. The Ko‘olau Loa district encompasses the entire Ko‘olau Loa Aquifer System Area and most of the Kahana Aquifer System Area, with sustainable yields of 35 and 16 MGD, respectively. The northern part of the Ko‘olau Loa study area also includes a small sliver of the North Shore Aquifer Sector Area’s Kawailoa Aquifer System Area. The Ko‘olau Loa district contains five perennial streams (Ka‘a‘awa, Kahana, Punalu‘u, Kaluanui, and Mālaekahana).

[15] City and County of Honolulu, Honolulu Board of Water Supply. 2009. *Ko‘olau Loa Watershed Management Plan.*

In 2000, the total water demand in Koʻolau Loa was 26.14 MGD. Of the 26.14 MGD total demand in 2000, potable demand accounted for 11.01 MGD, while non-potable needs were 15.13 MGD. 2000 demands were met by three main water sources: Koʻolau Loa Aquifer Sector pumpage, surface water, and recycled water. Ground water supplies most of Koʻolau Loa's residential, commercial and agricultural needs. Of the 17.9 MGD of pumped ground water, 8.60 MGD was exported to the Koʻolau Poko and North Shore districts. Surface water provided 7 MGD of agricultural irrigation water for Punaluʻu and Kahana Valleys. A small amount of recycled water, 0.6 MGD, supplied irrigation water need in Lāʻie and at Turtle Bay.

The most likely growth scenario shows Koʻolau Loa projected 2030 demand is 32.93 MGD, 12.34 MGD of which are potable demands and 20.59 MGD are non-potable. The 6.79 MGD projected 2030 increase in water demand will be met primarily through increased ground water pumpage from the Koʻolau Loa Aquifer System Area, increased use of recycled water, and increased water conservation. No additional withdrawals from the Kahana and Kawailoa Aquifer System Areas are planned. Exports to Koʻolau Poko and North Shore will not change significantly. Future agricultural water demand is the largest unknown. If more agricultural water were needed, the plan identifies ground water as the largest, most readily-available source.

There is a need for additional diversification in water supply, and the development of additional non-potable sources can replace some potable water currently being used for non-potable purposes. Additional use of surface water will be deferred pending the establishment of measurable instream flow standards. The lack of surface water use information is a significant data gap that hinders water use and development planning.

The resource strategy for meeting 2030 demands is summarized in **Table H-25 and Figure H-18** below.

Table H-25 Ko‘olau Loa Projected Water Demand and Supply Options

DEMAND (mgd)	2000	2005	2010	2015	2020	2025	2030
BWS Potable	1.46	1.57	1.86	1.89	1.92	1.96	2.15
BWS Potable export to Ko‘olau Poko & North Shore	8.60	8.60	8.60	8.60	8.60	8.60	8.60
LWC Potable	0.95	1.15	1.32	1.39	1.46	1.52	1.59
Total Potable Demand	**11.01**	**11.32**	**11.78**	**11.87**	**11.97**	**12.08**	**12.34**
Non-Potable Agriculture	13.25	13.79	14.37	14.99	15.68	16.42	17.22
Non-Potable Other	1.88	2.28	2.39	2.40	2.67	3.02	3.37
Total Non-Potable Demand	**15.13**	**16.07**	**16.75**	**17.39**	**18.34**	**19.44**	**20.59**
TOTAL DEMAND	**26.14**	**27.39**	**28.53**	**29.26**	**30.32**	**31.52**	**32.93**

SUPPLY (mgd)	2000	2005	2010	2015	2020	2025	2030
Ko‘olau Loa GWMA[1]	17.24	18.47	19.49	20.01	21.06	22.05	23.36
Kahana GWMA[2]	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Kawailoa GWMA	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Surface Water[3]	6.98	6.98	6.98	6.98	6.98	6.98	6.98
Recycled Water	0.56	0.57	0.68	0.89	0.90	1.10	1.20
Agriculture Water Savings	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Water Conservation	0.00	0.01	0.02	0.02	0.02	0.03	0.03
TOTAL SUPPLY	**26.14**	**27.39**	**28.53**	**29.26**	**30.32**	**31.52**	**32.93**

[1] Sustainable yield for Ko‘olau Loa GWMA is 36 mgd.
[2] Sustainable yield for Kahana GWMA is 15 mgd.
[3] Surface Water is assumed to be the existing water use pending measurable instream flow standards.

Figure H-18 Ko‘olau Loa Projected Water Demand and Supply Options

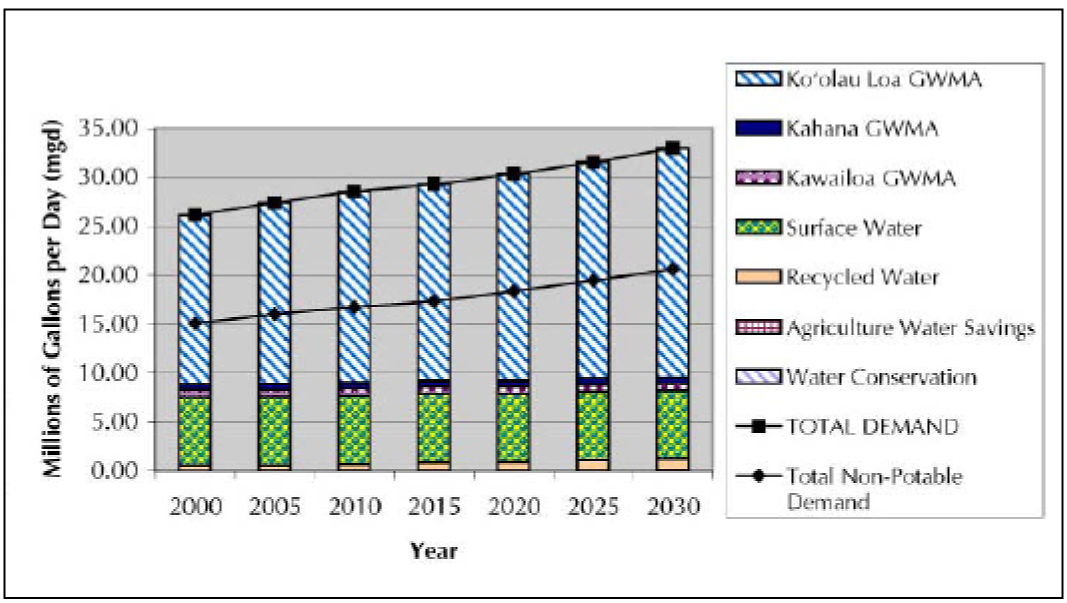


Table H-26 2030 Ground Water Withdrawals in Relation to Sustainable Yields, Koʻolau Loa District, Island of Oʻahu

Aquifer System Area	Sustainable Yield (SY) (MGD)	2030 Proposed Withdrawals (MGD)	2030 Proposed Withdrawals As a Percent of SY
Koʻolau Loa	36	23.36	65%
Kahana	15	0.06	<1%
Kawailoa	29	0.75	2.3%

Table H-26 shows that 2030 proposed ground water withdrawals for all aquifer system areas are well within the respective aquifer's sustainable yields.

H.6.3.3 Waiʻanae Watershed Management Plan, City and County of Honolulu[16]

In March 2011, CWRM adopted the Waiʻanae WMP. The Waiʻanae district boundaries generally coincide with the Waiʻanae Aquifer Sector Area. There are 5 individual aquifer system areas within the Waiʻanae Aquifer Sector Area. Individual aquifer system areas and their sustainable yields are show in **Table H-27** below. The Waiʻanae district contains six perennial streams (Nānākuli, Ulehawa, Māʻiliʻili, Kaupuni, Mākaha, and Mākua).

Table H-27 Waiʻanae Aquifer System Area Sustainable Yield (SY)

Hydrologic System Area	SY (MGD)
Nānākuli	2
Lualualei	4
Waiʻanae	3
Mākaha	3
Keaʻau	4
Waiʻanae Total	**16**

In 2000, the total water demand in Waiʻanae was 11.43 MGD. Of the 11.43 MGD, potable demand accounted for 6.81 MGD, while non-potable needs were about 4.27 MGD. 2000 demands were met by four main water sources: Waiʻanae Aquifer Sector pumpage (potable BWS sources), Glover Tunnel (non-potable BWS source), Waiʻanae Aquifer Sector pumpage (non-BWS sources), and water imports from Pearl Harbor. While previously used for irrigation of both native Hawaiian and western plantations, stream flow is currently intermittent and no longer commonly used. There are several anchialine ponds located in Waiʻanae that provide critical habitat to crustaceans that are candidates for listing as threatened or endangered species.

[16] City and County of Honolulu, Honolulu Board of Water Supply. 2009. *Waiʻanae Watershed Management Plan.*

Studies to identify impacts of ground water pumpage on anchialine pond salinity levels, impacts of land-based pollution, and sensitivity of biota to changes in water quality are ongoing in other parts of the State.

The most likely growth scenario shows Waiʻanae projected 2030 demand is 13.75 MGD, 8.82 MGD of which are potable demands and 4.54 MGD are non-potable. The 2.32 MGD projected 2030 increase in water demand will be met through increased imports from Pearl Harbor (including potential desalination from Kalaeloa), and water conservation. No additional withdrawals from Waiʻanae Aquifer Sector sources are planned. In fact, Honolulu BWS will continue to reduce the pumpage of Mākaha and Waiʻanae Valley sources as a drought mitigation strategy to increase ground water storage and to allow for an increase in the natural flows in the Mākaha and Kaupuni streams. Future agricultural water demand is the largest unknown. If more agricultural water were needed, the plan identifies ground water as the largest, most readily-available source.

As was found to be the case in Koʻolau Loa, there is a need for additional diversification in water supply, and the development of additional non-potable sources can replace some potable water currently being used for non-potable purposes. Ground water is limited and fully developed in Mākaha and Waiʻanae and not readily accessible in Lualualei and Keaʻau so additional large-scale in-district ground water source development is not feasible. Surface water is unreliable and not available in sufficient volumes for large-scale development. Water conservation will become increasingly important as water demands continue to grow. The resource strategy for meeting 2030 demands is summarized in **Table H-28 and Figure H-19** below.

Table H-28 Waiʻanae Projected Water Demand and Supply Options

All units in mgd	2000	2005	2010	2015	2020	2025	2030
BWS Potable Demand	6.62	6.97	7.29	7.69	8.03	8.33	8.63
Non-BWS Potable Demand	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Potable Demand	**6.81**	**7.16**	**7.49**	**7.88**	**8.22**	**8.52**	**8.82**
BWS Non-Potable Demand	3.00	2.85	2.95	3.01	3.08	3.18	3.25
Non-BWS Non-Potable Demand	1.27	1.28	1.30	1.30	1.30	1.30	1.30
Non-Potable Demand	**4.27**	**4.13**	**4.25**	**4.31**	**4.38**	**4.47**	**4.54**
Buffer	**0.35**	**0.38**	**0.38**	**0.38**	**0.38**	**0.38**	**0.38**
TOTAL DEMAND	**11.43**	**11.67**	**12.11**	**12.57**	**12.98**	**13.38**	**13.75**
Waianae Aquifer Sector Area - BWS (Potable)	4.96	4.50	4.34	4.34	4.34	4.34	4.34
Glover Tunnel - BWS (Non-Potable)	0.51	0.51	0.51	0.51	0.51	0.51	0.51
Waianae Aquifer Sector Area - Non-BWS	1.46	1.46	1.46	1.46	1.46	1.46	1.46
Pearl Harbor Import, including potential Desal from Kalaeloa	4.50	5.16	5.73	6.15	6.52	6.88	7.21
Conservation	0.00	0.04	0.08	0.11	0.15	0.19	0.23
TOTAL SUPPLY	**11.43**	**11.67**	**12.11**	**12.57**	**12.98**	**13.38**	**13.75**

Figure H-19 Wai‘anae Projected Water Demand and Supply Options

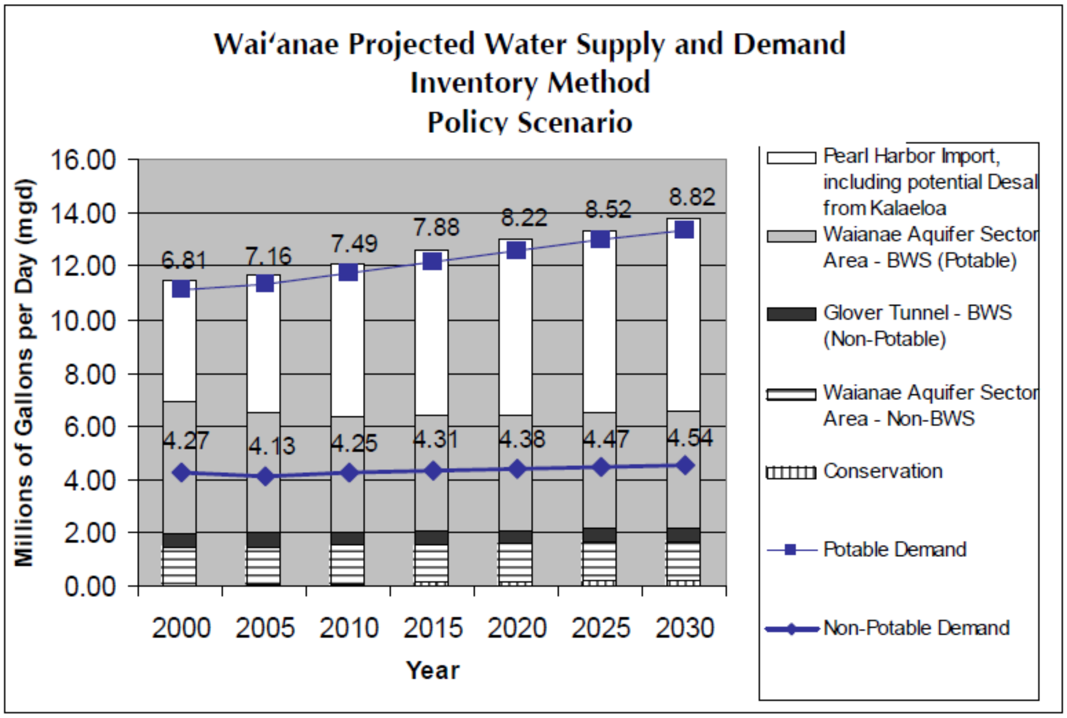


Table H-29 shows proposed 2030 ground water withdrawals in relation to aquifer system area sustainable yields.

Table H-29 2030 Ground Water Withdrawals in Relation to Sustainable Yields, Wai‘anae District, Island of O‘ahu

Aquifer System Area	Sustainable Yield (MGD)	2030 Proposed[17] Withdrawals (MGD)	2030 Proposed Withdrawals As a Percent of SY
Nānākuli	2	N/A	N/A
Lualualei	4	N/A	N/A
Wai‘anae	3	2.67	89%
Mākaha	3	1.67	56%
Kea‘au	4	N/A	N/A

[17] Staff communication, Honolulu BWS, June 16, 2018

The following recommendations are made for Waiʻanae and Mākaha Aquifer System Areas:

- Obtain all available water level and salinity data.
- Expand ground water monitoring network.
- Obtain all available streamflow monitoring data.
- Carefully manage pumpage to prevent salt water upconing at Mākaha Shaft.
- Conduct an informational hearing and invite the participation of water users in the Waiʻanae Aquifer System Area to assess the ground water situation and devise other appropriate mitigative measures.
- Consider initiation of water management area designation proceedings for the Waiʻanae Aquifer System Area.

H.6.3.4 Koʻolau Poko Watershed Management Plan, City and County of Honolulu[18]

Honolulu BWS submitted the project description for the Koʻolau Poko WMP in July 2008, and it was adopted by CWRM in September 2012. The Koʻolau Poko district encompasses the entire Koʻolau Poko and Waimānalo Aquifer System Areas, having sustainable yields of 30 MGD and 10 MGD, respectively. The district also contains a sliver of the Kahana Aquifer System Area. There are 13 perennial streams in Koʻolau Poko. The major portion of baseflow derives from dike-impounded ground water that originates in the upland areas in the back of the valleys. There is interaction between ground and surface waters, and in general, withdrawal of ground water will impact streamflow. Therefore, all of the estimated sustainable yield may not be readily available as impacts to established instream flow standards must first be considered. Many of the streams are diverted. A survey by Honolulu BWS documented 109 stream diversions in Koʻolau Poko, as well as 24 diversions in Kahana and Kaʻaʻawa.

In 2005, the total water demand in Koʻolau Poko was 31.204 MGD. Most of the district's water demand, 23.004 MGD (excluding Waiāhole Ditch water), was met by ground water from Honolulu BWS sources, which provided for both potable and non-potable needs. About 5.6 MGD of ground water was imported from Koʻolau Loa, while about 0.500 MGD is exported to East Honolulu. Surface water sources contributed 7.650 MGD for non-potable needs. A small amount of recycled water, 0.550 MGD, serves the Klipper Golf Course at the Marine Corps Air Station at Kāneʻohe Bay. DHHL has a water reservation of 0.124 MGD from the Waimānalo Aquifer System Area to support three residential development projects.

[18] City and County of Honolulu, Honolulu Board of Water Supply. 2012. *Koʻolau Poko Watershed Management Plan.*

The most likely growth scenario shows Koʻolau Poko projected 2030 demand will increase to 32.346 MGD. Potable water demand is expected to decrease, due to projected declines in the district's population in 2030. Most of the increase in demand is for non-potable agricultural irrigation needs. 2030 non-potable demands are projected to be 14.271 MGD, with much of the increase over current levels mainly attributable to possible future kalo production. The increases in non-potable needs will be met through water conservation, increased use of recycled water, and increased diversion of surface water. It was estimated that half of base stream flow (defined as Q70, the volume of daily mean stream flow present in the stream 70 percent of the time) would potentially be available for off-stream uses. Where streams were ungaged, the Q70 was estimated based on watershed size and adjacent streamflow. The estimated amount of stream water available for additional use, 1.88 MGD, was calculated by subtracting the estimated amount of stream water in use in 2005 from half of base flow. Proposed increases in the diversion of surface water may require an instream flow standard amendment.

The resource strategy for meeting 2030 demands is summarized in **Table H-30 and Figure H-20** below.

Table H-30 Koʻolau Poko Projected Water Demand and Supply Options

	2000	2010	2015	2020	2025	2030
SUPPLY	34.569	36.404	37.702	38.335	39.672	40.551
Koʻolau Loa Import – Ground Water	8.838	7.000	6.900	6.800	6.700	6.600
BWS Permitted Use – Ground Water	16.595	16.595	16.595	16.595	16.595	16.595
State and Private Permitted Use – Ground Water	0.936	3.942	4.077	4.147	4.222	4.537
Surface Water	7.650	7.894	8.734	8.975	9.215	9.456
Recycled Water	0.550	0.550	0.550	0.550	1.250	1.250
Agricultural Conservation	0.000	0.227	0.455	0.682	0.909	1.137
Conservation	0.000	0.195	0.391	0.586	0.781	.977
DEMAND	29.494	29.324	29.950	30.257	31.574	32.346
Potable Demand*	18.060	17.695	17.977	17.972	17.789	18.075
Non-Potable Demand:	11.434	11.629	11.973	12.286	13.785	14.271

Figure H-20 Ko‘olau Poko Projected Water Demand and Supply Options

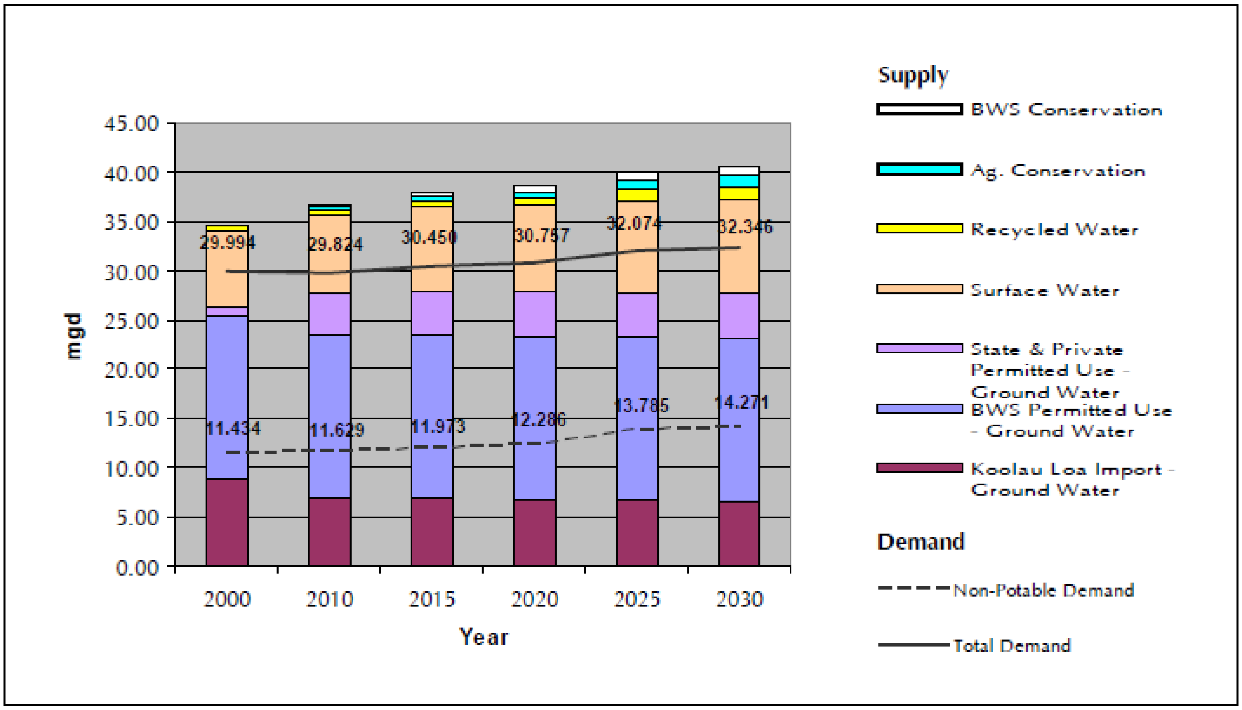


Table H-31 shows proposed 2030 ground water withdrawals in relation to aquifer system area sustainable yields. 2030 proposed ground water withdrawals for the Ko‘olau Poko and Waimānalo Aquifer System Areas are well within the aquifers’ sustainable yields. However, full utilization of the sustainable yields may be constrained due to surface water impacts.

Table H-31 2030 Ground Water Withdrawals in Relation to Sustainable Yields, Ko‘olau Poko District, Island of O‘ahu

Aquifer System Area	Sustainable Yield (SY) (MGD)	2030 Proposed Withdrawals[19] (MGD)	2030 Proposed Withdrawals As a Percent of SY
Ko‘olau Poko	30	16.52	55%
Waimanalo	10	4.61	46%

[19] Staff communication, Honolulu BWS, June 8, 2018

H.6.3.5 North Shore Watershed Management Plan, City and County of Honolulu[20]

In December 2016, CWRM adopted the North Shore Watershed Management Plan. The North Shore district stretches from Kaʻena Point in the west to Waialeʻe Gulch near Kawela Bay in the east and overlays four ASYAs for ground water: Mokulēʻia, Waialua, and Kawailoa ASYAs of the North Aquifer Sector Area, and a portion of the Wahiawa ASYA in the Central Aquifer Sector Area, with sustainable yields of 8 MGD, 25 MGD, 29 MGD, and 23 MGD, respectively. There are ample surface water resources, and the Wahiawa Irrigation System is supplied by diversions both within and outside of the district and served about 5,500 acres of pineapple and diversified agricultural farms in 2007. The surface water system is supplemented with recycled water from the Wahiawa and Schofield Wastewater Treatment Plants.

In 2010, existing water use totaled about 27 MGD, with about 25 MGD of the use for agriculture. The plan projects that potable water needs in 2035 will increase by about 0.2 MGD, and agricultural demands will increase by about 5 MGD based on the most probable demand scenario. Existing potable and non-potable water sources and systems are adequate to meet current and future potable water needs, and so no additional development of ground or surface waters are anticipated. Water for planned kalo expansion, which is projected to be 10 MGD in 2035, will need to be met with additional surface water from springs and Anahulu stream diversions, which may require amendments to existing interim instream flow standards.

[20] City and County of Honolulu, Honolulu Board of Water Supply. 2016. *North Shore Watershed Management Plan.*

The resource strategy for meeting 2035 demands is summarized in **Table H-32 and Figure H-21** below.

Table H-32 North Shore Projected Water Demand and Supply Options

	2010	2015	2020	2025	2030	2035
DOMESTIC WATER SYSTEMS						
BWS Potable Water System Demand	2.81	2.80	2.89	2.94	3.00	3.01
BWS System - Permitted Ground Water Supply[1]						
Waialua GWMA	3.00	3.00	3.00	3.00	3.00	3.00
Kawailoa GWMA	0.75	0.75	0.75	0.75	0.75	0.75
Dole Potable Water System Demand	0.00	0.13	0.13	0.13	0.13	0.13
Dole - Permitted Ground Water Supply[1] Waialua GWMA	0.26	0.26	0.26	0.26	0.26	0.26
North Shore Water Company Potable Water System Demand	0.12	0.12	0.13	0.15	0.16	0.18
North Shore Water Company - Ground Water Supply[1] Mokuleʻia GWMA	0.15	0.15	0.15	0.15	0.18	0.18
US Army/State DOT Dillingham Airfield System Demand	0.06	0.06	0.06	0.06	0.06	0.06
Federal Systems - Ground Water Supply[1] Mokuleʻia GWMA	0.07	0.07	0.07	0.07	0.07	0.07
Domestic Water Demand	2.99	3.10	3.21	3.27	3.34	3.37
Domestic Water Supply	4.24	4.24	4.24	4.24	4.27	4.27
AGRICULTURE						
Agriculture Water Demand	24.15	25.17	26.19	27.21	28.23	29.25
Ag Surface Water Supply						
KS Surface Water Supply	3.50	3.50	3.50	3.50	3.50	3.50
Dole Surface Water Supply (Wahiawa Irrigation System)[2]	8.90	8.90	8.90	8.90	8.90	8.90
Ag Recycled Water Supply						
Wahiawa Wastewater Treatment Plant[3]	1.60	1.60	1.60	1.60	1.60	1.60
Ag Ground Water Supply[4]						
Mokuleʻia GWMA Permitted Use[5]	7.80	7.80	7.80	7.80	7.77	7.77
Waialua GWMA Permitted Use[6]	6.49	6.49	6.49	6.49	6.49	6.49
Kawailoa GWMA Permitted Use[5]	1.16	1.16	1.16	1.16	1.16	1.16
Wahiawa GWMA Permitted Use[7]	5.16	5.16	5.16	5.16	5.16	5.16
Agriculture Water Demand	24.15	25.17	26.19	27.21	28.23	29.25
Agriculture Water Supply	34.62	34.62	34.62	34.62	34.59	34.59
TOTAL WATER DEMAND	27.14	28.27	29.40	30.48	31.57	32.62
TOTAL WATER SUPPLY	38.85	38.85	38.85	38.85	38.85	38.85
Kalo Water Demand	1.00	2.80	4.60	6.40	8.20	10.00

1 CWRM Water Use Permit (WUP) Index (2012) and revised 2013 Waialua GWMA WUP
2 Existing use with current losses; add'l water demands to be met with water conservation savings (eg. piping)
3 Effluent from Wahiawā WWTP used for North Shore irrigation and will eventually be used for Galbraith lands irrigation
4 WIS system improvements should be implemented before future water use permits are granted
5 Private wells used to meet agricultural needs; excludes wells used to meet potable water demands
6 Private wells; KS (3.212 mgd), Dole (1.785 mgd - domestic use), and 1.725 mgd of various wells
7 The permitted uses in North Shore Development Plan/NB area (3103-01 Galbraith Estate Del Monte #5, 3203-01 Helemano Pump 25, and 3203-02 Waialua Sugar Pump 26) with a total WMP of 5.162 mgd

Figure H-21 North Shore Projected Water Demand and Supply Options

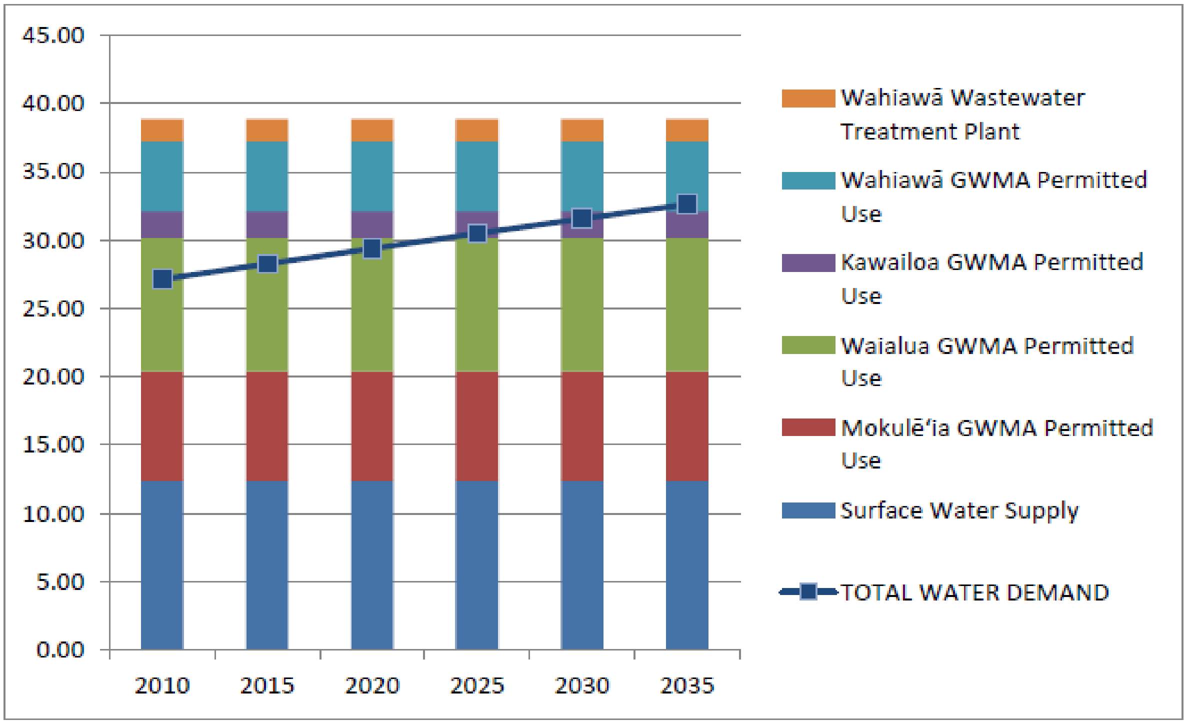


Table H-33 2035 Ground Water Withdrawals in Relation to Sustainable Yields, North Shore District, Island of Oʻahu

Aquifer System Area	Sustainable Yield (SY) (MGD)	2035 Proposed Withdrawals (MGD)	2035 Proposed Withdrawals As a Percent of SY
Mokulēʻia	8	7.77	97%
Waialua	25	9.49	38%
Kawailoa	29	1.91	1%
Wahiawā	23	5.162*	22%

* Includes only those wells located in the North Shore District.

Table H-33 shows proposed 2035 ground water withdrawals in relation to aquifer system area sustainable yields. An Ultimate Demand Scenario was done for the North Shore District and assumes the full build-out of residential units within the community growth boundary and irrigation of all the prime and unique agricultural lands outside of it. Under this scenario, total estimated demand for domestic uses is 6 MGD, 72 MGD for agriculture, and 40 MGD for kalo, for a grand total of 118 MGD. Proposed supply sources include the entire North Shore aquifer SY (62 MGD), currently permitted well amounts from the Wahiawā ASYA (5 MGD), allowable surface diversions (estimated to be 33 MGD), and recycled water from the Wahiawā Wastewater Treatment Plant (2 MGD). Total available supply is 102 MGD, which is insufficient to meet ultimate demands of 118 MGD. Additional diversions from springs and streams would be needed to make up the deficit.

H.6.3.6 County of Hawai‘i WUDP[21]

In December 2011, CWRM adopted the updated WUDP for the County of Hawai‘i. Existing water use is calculated based on available data, including reported ground water pumpage, water purveyor records, DOH records, and available GIS data. The current and future needs of agriculture are identified as a significant planning gap. Existing agricultural water use was extremely difficult to determine due to lack of data. While the AWUDP recommends using 3,400 gallons per acre per day (GPAD) as a planning guide for diversified agriculture, public input during plan formulation suggested that the need for irrigation water was not predicated on the classification of agricultural lands. Rather, agricultural users would grow crops that are feasible based on climatic conditions, and irrigation from ground water sources would be minimal. In response, the plan recommended that detailed agricultural demand projections be relegated to the next update of the AWUDP, and used a range of agricultural water use, from no irrigated agriculture to the AWUDP-recommended average daily demand of 3,400 GPAD. Based on this analysis, the following table shows the estimated existing uses for the various aquifer sector areas:

Table H-34 2005 Existing Water Use by Aquifer Sector Area

Sector	SY (MGD)	W/Out Agriculture	With Agriculture
Kohala	140	2.32	6.49
E Mauna Kea	388	2.84	12.4
W Mauna Kea	24	7.71	11.05
NE Mauna Loa	744	6.41	8.27
SE Mauna Loa	293	1.18	4.77
SW Mauna Loa	114	2.57	5.57
NW Mauna Loa	30	7.97	8.15
Kīlauea	621	4.37	6.58
Hualālai	56	15.62	16.33
Total	**2,410**	**50.99**	**79.61**

Table H-34 shows of Hawai‘i Island’s total sustainable yield of 2,410 MGD (revised in the 2008 WRPP to be 2,345 MGD), about 51 MGD was used in 2005. If estimated agricultural demands are included, there is almost 80 MGD of existing water use. Besides agriculture, existing uses include domestic, irrigation, municipal, industrial demands. While ground water supplies most of the Island’s water existing water needs, surface water sources support agriculture and other irrigation uses, rainwater catchment is the only available source for many individual domestic users, and reclaimed wastewater is used for golf course, pasture and landscape irrigation.

[21] County of Hawaii, Department of Water Supply. 2010. *Hawaii County Water Use and Development Plan Update.*

The approach for assessing future water needs and resource strategies involved projecting water demand for the full build-out land use policies (i.e., County General Plan Land Use Pattern Allocation Guide [LUPAG], and zoning), and 5-year incremental water demand projections based on the rate of population growth to the year 2025 for each of the island's nine aquifer sector areas. The 20-year demand projections based on the medium rate of population growth were assumed to be the most realistic water demand scenarios. The projections were then evaluated to determine master plan level resource and facility needs and options. This process involved: 1) evaluation of water source adequacy and determination of source development requirements, 2) evaluation of conventional water infrastructure capabilities and identification of conceptual water system upgrades, 3) exploration of alternative water resource enhancement measures, and 4) evaluation of conventional and alternative measures and selection of recommended alternative.

While the Hawai'i DWS serves the majority of the population, accounting for 25.3 MGD of the 2005 demand, there are numerous smaller private water systems that serve rural communities of various sizes. Due to the large size of Hawai'i County and the fact that there are many dispersed communities, it is not feasible to fully integrate the county water system into an island-wide system.

Table H-35 shows projected 2025 demands based on both land use water demand projections (LUPAG and zoning) and population and rate-of-growth projections. Land use-based evaluations provide the full build-out projections, or the ultimate water needs, if the maximum density allowed is developed. This assesses the sustainability of land use policies set by the State and County. It provides a means to integrate land use and water resource planning and inform future land use decisions and policy-setting. In addition, the island-wide approach taken by Hawai'i County has the advantage of identifying and highlighting potential "problem" areas early on, where more detailed regional planning should ensue.

Projected 2025 demands that are at or above 90% of the aquifer's sustainable yields are highlighted in red in the table below. If all agricultural lands in the General Plan are irrigated at 3,400 GPAD, the underlying ground water would be insufficient to support 11, or almost one-half, of the aquifer system areas. If it is assumed that no irrigation of agricultural lands will occur, then only five of the 24 aquifer system areas are deficient. Irrigation of all agricultural-zoned lands will result in insufficient ground water supplies in 8 of the 24 aquifer system areas, while no irrigation on agricultural-zoned lands will result in only one of the aquifers, Keauhou Aquifer System Area, being insufficient. However, if only population and growth rate projections are analyzed, no aquifers would be pumped above 90% of its sustainable yield, although the Waimea Aquifer System Area comes close, at 83%.

Table H-35 Projected 2025 Demands With and Without Agricultural Irrigation by Aquifer System Area

Aquifer System Area	SY (MGD)	LUPAG W/Out Ag (MGD)	LUPAG % SY	LUPAG With Ag (MGD)	LUPAG % SY	Zoning W/Out Ag (MGD)	Zoning % SY	Zoning With Ag (MGD)	Zoning % SY	20-Yr Projected Demands W/Out Ag (MGD)	20-Yr % SY	20-Yr With Ag (MGD)	20-Yr % SY
Hāwī	13	6.75	52	74.24	571	1.09	8	67.72	521	1.08	8	4.49	35
Waimanu	110	0.82	1	10.21	9	0.07	0	9.33	8	0.16	0	0.56	1
Māhukona	17	32.59	192	123.16	724	7.74	46	97.43	573	3.11	18	7.23	43
Honokaʻa	31	9.48	31	105.21	339	2.10	7	92.56	299	2.38	8	5.89	19
Paʻauilo	60	2.46	4	135.62	226	0.55	1	131.77	220	0.43	1	4.60	8
Hakalau	150	5.19	3	98.02	65	2.54	2	93.07	62	0.32	0	3.03	2
Onomea	147	8.27	6	66.61	45	2.97	2	60.72	41	0.65	0	2.26	2
Waimea	24	52.14	217	186.75	778	13.80	58	150.63	628	13.95	58	19.98	83
Hilo	349	69.20	20	70.67	20	21.86	6	28.04	8	5.17	1	5.19	1
Keaʻau	395	49.41	13	131.96	33	4.41	1	79.37	20	2.50	1	5.18	1
ʻŌlaʻa	125	1.52	1	22.07	18	0.40	0	20.26	16	0.53	0	1.49	1
Kapāpala	19	0.00	0	0.98	5	0.00	0	0.98	5	0.00	0	0.04	0
Nāʻālehu	118	10.75	9	113.33	96	2.88	2	105.07	89	1.00	1	4.63	4
Ka Lae	31	1.41	5	22.91	74	0.40	1	21.33	69	0.28	1	0.99	3
Manukā	25	7.72	31	33.21	133	0.00	0	25.15	101	0.78	3	1.71	7
Kaʻapuna	51	0.02	0	40.77	80	0.02	0	40.41	79	0.42	1	1.96	4
Kealakekua	38	10.26	27	68.53	180	1.43	4	57.52	151	2.67	7	4.73	12
ʻAnaehoʻomalu	30	81.67	272	88.74	296	10.99	37	18.06	60	14.41	48	14.74	49
Pāhoa	437	33.34	8	67.57	15	3.77	1	37.59	9	7.10	2	8.61	2
Kalapana	158	3.05	2	53.14	34	0.83	1	50.41	32	1.08	1	3.41	2
Hilina	9	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
Keaīwa	17	0.06	0	6.59	39	0.00	0	6.52	38	0.00	0	0.17	1
Keauhou	38	171.06	450	245.70	647	39.42	104	111.91	295	17.50	46	18.60	49
Kīholo	18	36.13	201	36.22	201	3.23	18	3.23	18	6.66	37	6.66	37
Total	**2,410**	**593.30**		**1,802.21**		**120.50**		**1,309.08**		**82.18**		**126.14**	

As indicated in the table above, the Keauhou ASYA, in particular, requires attention and more detailed planning. In July 2014, the County of Hawaiʻi informed CWRM that it was initiating a regional WUDP update focusing on the Keauhou ASYA. The update is well underway.

For all aquifers studied, the WUDP contains specific resource and facility recommendations for each aquifer studied. These include extension of ground water system service areas, water transfers, alternative source development, demand-side management (development density control and water conservation). The WUDP also offers the following general recommendations:

- The highest quality water should be reserved for the most valuable end use.
- Water conservation should be promoted.
- Additional monitoring and studies are recommended to determine the "safe" sustainable yields and to improve the accuracy of the island's ground water hydrologic units.
- Regional studies should be initiated to examine the impacts of water transfers amongst sectors to satisfy increasing competition for water resources.
- Future updates of the WUDP should promote a policy of well-planned source development.
- Water development coordination and cooperation between public and private sectors are emphasized to assist the success of future planning.
- The involvement of collaborative and advisory groups has had a positive impact on water resources planning, and thee groups are encouraged to continue to provide input and insight.

H.7 Recommendations for County Water Planning

The State Water Code mandates that the County WUDPs "be prepared by each separate county…setting forth the allocation of water to land use in the county." To achieve this objective, water planning efforts related to municipal and non-municipal water demands should be coordinated and integrated at the county level. The responsible county agency will need to bring the many other water planning agencies at the State and federal levels, stakeholders, and representatives from the private sector into a collaborative process.

Water allocation planning must be accomplished in accordance with State and county policies and be in line with county-specific strategies for sustainable development. In addition to addressing the availability of water resources, planning activities must also relate to the community's desires for development, economic growth, environmental protection, and competing uses in managing the relationship between water demand and water supply.

Demand projections for the planning horizon must account for and reflect the cumulative effects of consumptive use. Consumptive uses reduce the source water level or flow; water is not returned to its source (for example, water used for irrigation or urban supply). Typically, all water use in Hawaiʻi is consumptive, with the exception of stream diversions for ornamental ponds or taro loʻi that return water to the stream over the course of a short period of time and at a point relatively near the initial diversion. Water loss due to evaporation, seepage, and evapotranspiration in such diversion scenarios can be considered as negligible, due to the relatively small displacement in location and limited time frame.

While the Framework provides overall guidance and recommended elements for the County WUDPs, the following list of recommendations is provided to help guide the counties in their allocation of water to land use and to encourage the assessment of cumulative impacts to the resource. Recommendations for measuring existing consumptive uses and assessing future demand are presented, along with recommendations for associated land use planning issues.

Recommendations for county water planning are as follows:

- Promote coordination and collaboration among agencies, private entities, and users to account for the cumulative effects of water use and to mitigate negative impacts to the resource.
- Establish strategies for increasing system efficiency and for managing higher water demand associated with land use and planned development.[22]
- Compare the total water demand projection associated with land use plans and zoning, to assess the need to evaluate/revise of land use policies (e.g., full build-out scenario).
- County Planning Departments should consider findings from the WUDPs in their future updates of general plans, community development plans, and zoning decisions.
- Seek the optimization of infrastructure to minimize local stress on aquifers and increase confidence in ground water modeling of sustainable yields.
- Increase drought preparedness and awareness, and implement Hawai‘i Drought Plan recommendations for county actions.
- Implement economic incentives for resource stewardship, conservation, and reuse.
- Monitor agricultural demand for potable water and use alternative non-potable water for agricultural demands wherever possible.
- Gather information on community values and expectations for water use.[23]
- Encourage local stakeholder partnerships to implement County WUDP recommendations.

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[22] Denotes recommendations adapted from the *Guidance Notes for Planning for Water Allocation* prepared in August 2003 by Ton Snelder, NIWA and Richard Keys, Marlborough District Council for the Quality Planning Project, a partnership between the New Zealand Planning Institute, the Resource Management Law Association, Local Government New Zealand, the NZ Institute of Surveyors and the Ministry for the Environment.

[23] Denotes recommendations adapted from the *Guidance Notes for Planning for Water Allocation* prepared in August 2003 by Ton Snelder, NIWA and Richard Keys, Marlborough District Council for the Quality Planning Project, a partnership between the New Zealand Planning Institute, the Resource Management Law Association, Local Government New Zealand, the NZ Institute of Surveyors and the Ministry for the Environment.

- Consider the impacts of climate change in long-range planning.
- Promote aggressive water conservation.
- Prioritize the needs of public trust purposes and consider and protect water rights, including traditional and customary Hawaiian rights.
- Extend the planning horizon and assess the implication of current land use plans, policies, and entitlements on water resources.

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APPENDIX I

CWRM Regulatory Programs

Water Resource Protection Plan 2019 Update

I CWRM Regulatory Programs

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Figures

I CWRM Regulatory Programs

This section of the Water Resources Protection Plan (WRPP) summarizes Commission on Water Resource Management's (CWRM) regulatory programs and recommendations for program implementation. CWRM's authority to designate ground and surface water management areas, regulate the use and development of water sources, resolve complaints and disputes, and declare water shortage and water emergency conditions are discussed.

Goals and Objectives:

- Provide the regulatory and internal framework, including best use of information technology, for efficient ground and surface water management.
- Ensure the permitting process provides for adequate protection of public trust purposes and water rights in all areas of the State.
- Ensure that the limits of available supply established by CWRM are not exceeded.
- Ensure consistency with other State and County plans and policies.

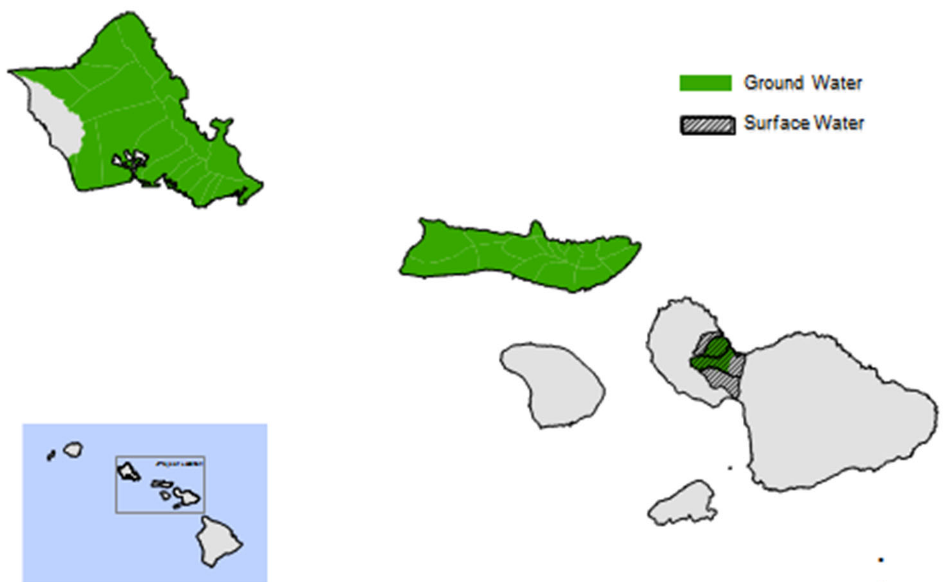
CWRM uses regulatory controls to implement its policies and Hawaiʻi Water Plan guidelines for source development and water use. Regulations are also used to protect water quantity and quality, optimize water availability, protect public rights, and obtain maximum reasonable-beneficial uses. CWRM relies on permit systems to apply and implement regulations concerning source development and water use.

In making decisions on permit applications, CWRM looks to the Hawaiʻi Water Plan for guidance. Therefore, the regulations also help to implement the counties' long-range plans and policies regarding land and water use. The regulations are also aimed at promoting hydrologic data gathering by requiring specific data to be collected and submitted to CWRM. In turn, this helps to assure wise decision-making in the future based on new and better information.

I.1 Designation of Water Management Area

When the water resources of an area are determined to be threatened by existing or proposed withdrawals of water, CWRM shall designate the area as a water management area for the purpose of establishing administrative control over the withdrawals and diversions of ground and surface waters to ensure reasonable-beneficial use of the water resources in the public interest. The State Water Code provides eight (8) criteria for CWRM to consider in designating an area for regulation of ground water use[1] and three (3) criteria for surface water[2]. **Figure I-1** shows the location of designated ground and surface water management areas.

Figure I-1 Designated Water Management Areas



[1] HRS §174C-44.

[2] HRS §174C-45.

I.2 Water Use Permit

CWRM applies a water use permitting process to regulate use in designated water management areas. A water use permit must be obtained to continue actual existing uses at the time of designation and prior to commencing any new water use.[3] The water use permitting system provides for the protection of public trust purposes and allows for maximum reasonable-beneficial use of water resources, while ensuring that the integrity of the resource and public trust uses are not threatened. Water use permit applications are evaluated according to seven criteria identified in the State Water Code.[4] A diagram illustrating the permitting process is included in **Appendix D, Permit Process Diagrams**.

Through its review of various contested case hearing decisions and orders, the Hawaiʻi Supreme Court has identified four water resources public trust purposes: 1) maintenance of waters in their natural state, 2) domestic water use, 3) the exercise of Native Hawaiian and traditional and customary rights,[5] and 4) Department of Hawaiian Home Lands (DHHL) reservations.[6]

There is no hierarchy of priorities between these public trust purposes, but there is a presumption in their favor over other interests that seek water use permits. CWRM is obligated to consider, protect, and advance public rights to the resource at every stage of the planning and decision-making process.

Although not a public trust use, CWRM gives greater priority to agricultural uses over golf course uses, which was affirmed by the Hawaiʻi Supreme Court in its first decision in the Waiāhole Ditch Contested Case Hearing (CCH-OA95-1).

I.2.1 Requirement for Alternatives Analysis

The Water Code is silent regarding any requirements for alternative source analysis in the water use permitting process. The only instance where an analysis of alternatives is mentioned in the Water Code is in the instream flow standard setting process. However, the Hawaiʻi Supreme Court has issued an opinion that water use permit applicants are required to demonstrate the absence of practicable mitigating measures, including the use of alternative water sources. As part of the evaluation of reasonable-beneficial use, an efficiency test and assessment of alternative water sources are required. Such an assessment is intrinsic to the protection of public trust purposes and essential to balancing competing interests.[7] CWRM has therefore established that an analysis of alternatives is required to establish that proposed water uses are reasonable-beneficial for any water use permit.

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[3] HRS §174C-48.

[4] HRS §174C-49(a).

[5] Supreme Court Decision in Waiāhole Ditch Contested Case Hearing CCH-OA95-1.

[6] Supreme Court Decision in Waiola O Molokaʻi Contested Case Hearing CCH-MO96-1.

[7] Waiāhole I, 94 Hawaiʻi at 161, 9 P.3d at 473.

I.2.2 Determining Reasonable Water Use Quantities

The State Water Code requires that permitted use quantities be reasonable and reflect efficient water use. To determine reasonable water quantities, CWRM utilizes actual metered use data, when possible, in conjunction with established guidelines and standards.

Actual metered water use data is the best method that can be used to project future water needs for a particular use. Metered use data can also be extended to estimate the future water use requirements of similar, nearby uses. Meters have been required for all production wells constructed since 1997 under the Hawaii Well Construction and Pump Installation Standards. Surface water metering has been more difficult due to the nature of open channel flow and varied diversion structures. CWRM staff does not have the resources to monitor meters and must rely on owners to self-report.

Beginning in 2013, CWRM initiated online water use reporting to facilitate comprehensive water use data reporting. However, metered water use data may not be available in many cases (see **Section H.3** in **Appendix H** for a discussion of CWRM's water use reporting program).

Where use data is not available, CWRM must utilize other means to determine reasonable quantities for future demands. To estimate various types of domestic consumption, CWRM refers to the *Water System Standards,*[8] prepared by the county water departments. The water departments use these standards for the design and construction of municipal water system facilities. The standards also include water consumption guidelines for commercial, resort, light industrial, school/park, and agricultural water use for each county. Guidelines are system-wide averages that do not reflect variations between drier and wetter service areas.

It is difficult to determine reasonable water use quantities for irrigation & agricultural purposes due to the variations in regional climatic variables, such as rainfall and evapotranspiration, and variations in soil, irrigation and crop-rotation methods, and crop demands. The Agricultural Water Use and Development Plan, published by the Department of Agriculture (DOA) in 2004, provides a guideline of 3,400 gallons per acre per day (GPAD) to estimate the irrigation rate for diversified crop farming in Hawai‘i. This estimate is based on the eight-year average irrigation rate for diversified crop farming within the Lalamilo Section of the Waimea Irrigation System on the island of Hawai‘i. Estimates of irrigation water requirements for other agricultural irrigation systems were not provided in the Agricultural Water Use and Development Plan (AWUDP) report. Diversified crop farming involves active cultivation of land to produce commercial crops throughout the crop's growing cycle. Depending on the crop, the growing cycle may include several harvesting cycles in a calendar year. Portions of the land may be rotated out of cultivation and left unirrigated for a short period of time as part of routine farming activities.

[8] State of Hawai‘i, 2002, *Water System Standards, as amended*.

Water requirements for aquaculture activities are determined using draft guidelines prepared by the DOA's Aquaculture Development Program. Two ranges of use (Intensive and Semi-Intensive) were developed by the DOA for selected aquaculture species. Economics and various management factors dictate the aquaculture management system and actual water consumption rates.

CWRM's reliance on the methods, standards, and guidelines described above are subject to change with new information and technological advances. For example, in the interest of improving irrigation water demand projections and evaluation of reasonable irrigation water use quantities, CWRM contracted the University of Hawai'i's College of Tropical Agriculture and Human Resources (CTAHR) to develop a model for estimating irrigation water demands in different physical areas. The model is called the Irrigation Water Requirement Estimation Decision Support System (IWREDSS), which provides CWRM with a standardized methodology to estimate the regional water requirements of various crop types. The model is a computer software application that has been used since 2008. In 2013, the model was updated and IWREDSS Version 2.0 is now in use. The model is based on a water budget irrigation consumption mass balance that utilizes a Geographical Information System (GIS) platform to determine local climate and soil characteristics. GIS inputs include the latest digitized maps from the *Rainfall Atlas of Hawai'i*[9]*, Pan Evaporation: State of Hawai'i, 1894-1983,*[10] *NRCS Soil Data Hawai'i;*[11] *Kaua'i, O'ahu, Maui, Moloka'i.*[12] The irrigation model also considers differences in crop type and crop practices. It is important to note that IWREDSS is a tool to estimate crop water demands and the actual permitted allocation could be determined based on other factors as well.

I.2.3 Using a 12-Month Moving Average to Manage Ground Water Use

The State Water Code specifies monthly averages to assess water use but does not specify a standard time-period over which to calculate this average. The only instance where guidance is given in the State Water Code is the use of the prior three-month average water use to determine whether or not an existing water use in a newly designated water management area will require a public hearing.[13] However, it should be noted that three-month average water use varies throughout the year, depending on the season and antecedent rainfall conditions (e.g.,

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[9] Giambelluca, T.W., Q. Chen, A.G. Frazier, J.P. Price. Y.-L. Chen, P.-S. Chu,J.K. Esicheid, and D.M. Delparte, 2011Hawai'iHawai'i72 p.

[10] Ekern, P.C., and Chang, J.-H., 1985, Pan evaporation: State of Hawai'i, 1894-1983: State of Hawai'i, Department of Land and Natural Resources, Division of Water and Land Development, Report R74, 172p.

[11] *Hawai'iHawai'i*U.S. Department of Agriculture, Natural Resource Conservation Service, SSURGO Data, http://soildatamart.nrcs.usda.gov, September 2012

[12] U.S. Department of Agriculture, Natural Resource Conservation Service, STATSGO Data, http://soildatamart.nrcs.usda.gov, September 2012.

[13] HRS §174C-50(b).

summer versus winter weather), and most likely will not be reflective of actual annual water demand.

Existing ground water uses certified under Chapter 177 HRS, which was repealed and replaced by the State Water Code, were determined based on the prior five-year daily average of water use. Some parties have advocated the continued use of a five-year moving average for water use assessment; others have advocated the use of a 10-year moving average, which would better accommodate the cyclical nature of drought conditions. However, these longer-term statistics may conflict with the State Water Code's provision for revocation of water use permits due to four continuous years of nonuse.[14] In addition, allocating water based on assumed drought conditions would conflict with CWRM's mandate to ensure maximum reasonable-beneficial use because, in most years, the full amount of the allocation would not be used and new uses could not be accommodated if aquifers are fully allocated, even if aquifers are not actually being pumped up to their sustainable yields. The water shortage provisions under the Water Code is the method to address temporary drought conditions.[15]

CWRM currently uses a twelve-month moving average (12-MAV) to assess ground water use.[16] The first official reference to the use of a 12-MAV for assessing hydrologic data appeared in the October 21, 1992 issue of *Rainfall Trend,* a monthly newsletter issued by CWRM.[17] The newsletter provided up-to-date information on rainfall and water level information collected by CWRM, discussed the relationship between rainfall trends and water levels, and presented an outlook for rainfall. It was distributed to about 100 governmental agencies and private businesses interested in rainfall information.

The use of a 12-MAV has been used with reference to ground water use permits since 1993.[18] The 12-MAV considers the average daily use over an entire annual climatic cycle, accounting for seasonal variations in water use, where water use is typically higher in the summer when the weather is dry and lower in the winter due to increased precipitation. Further exploration of an appropriate statistic for water use assessment, allocation, and enforcement would be beneficial. If an alternative measure is identified, the State Water Code should be updated to include the assessment measure.

At this time, the statistic for allocation and enforcement of surface water use permits has not been determined. To date, no surface water use permits have been issued.

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[14] HRS §174C-58(4).

[15] HRS §174C-62.

[16] CWRM actions referencing the use of a twelve-month moving average to assess water use began on March 17, 1993.

[17] *Rainfall Trend* newsletter was published monthly by the Commission on Water Resource Management's Hawai‘i Climate Center. The Hawai‘i Climate Center ceased to exist in 2000, when the rainfall program was transferred to the University of Hawai‘i.

[18] March 17, 1993 meeting of the Commission on Water Resource Management.

I.2.4 Encouraging Best and Highest Use of Water

CWRM encourages the management of aquifer water quality, primarily with regard to chloride levels, by disallowing the application of lower quality water over a higher quality aquifer.[19] Proposed uses that will result in a degradation of aquifer water quality are not allowed, especially where the chloride concentration of ground water may increase. Either the same or higher-quality water must be used, or the lower-quality water must be treated until it is at least of the same quality as the affected underlying aquifer. Generally, the ground water source and end use occur at the same site or within the same aquifer system area. The application of water of a relatively lower quality (i.e., brackish) over an aquifer that yields high-quality water (i.e., potable) is not allowed. CWRM examines water quality in terms of chloride concentration, and the Department of Health (DOH) has authority over other water quality parameters should other quality issues be raised. See the DOH Water Quality Plan for more information.

As stated above, an analysis of alternatives is required for all water use permit applications. Recycled wastewater may be a viable alternative to the use of ground or surface waters. However, because there are certain chemicals and constituents (i.e. pharmaceuticals and personal care products) that are not removed in the wastewater treatment process, the DOH has indicated that there may be shallow drinking water aquifers over which recycled wastewater should not be applied. DOH updated its Reuse Guidelines in 2016 (http://health.hawaii.gov/wastewater/home/reuse/), identifying areas where recycled water application is either restricted, conditional, or unrestricted.

The DOH is afforded an opportunity to review all water use permit applications and is required to review well construction permits. The DOH may recommend special conditions to address contamination concerns resulting from the proposed land use, such as nearby individual wastewater systems (IWS) or pesticides and fertilizers that may be applied to golf courses. CWRM attaches any special conditions recommended by the DOH to water use, well, or pump permits, to ensure that the water quality of aquifers and wells is not threatened or degraded.

> *The quality of the water supply should be matched to the quality of water needed, and the highest quality water should be allocated for the highest uses. However, potable water can be used for non-potable purposes if the proposed use meets the regulatory requirements and there are no practical non-potable alternatives. In these cases, special conditions are attached to the water use permit to require conversion to an alternate non-potable source when it becomes available.*[20]

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[19] March 15, 1990 meeting of the Commission on Water Resource Management, Staff Submittal Item 3.

[20] October 25, 2005 meeting of the Commission on Water Resource Management, Staff Submittal Item C-1.

> *It is the policy of the Water Commission to promote the viable and appropriate reuse of reclaimed water insofar as it does not compromise beneficial uses of existing water resources. Recognizing that reclaimed water is a valuable resource in the Ewa Plain, direct or indirect reuse will be championed by the Water Commission. It is the policy of the Water Commission that the water resources of the Ewa Caprock Aquifer will be allocated only for nonpotable uses.*[21]

By declaring that the ‘Ewa Caprock Aquifer will only be allocated to non-potable uses, CWRM cleared the way for recycled water use for landscape, golf courses, and other non-potable uses over the ‘Ewa Caprock.

I.2.5 Modification of Ground Water Use Permit

The Water Code and its administrative rules provide for modification of water use permits.[22] In order to streamline the water use permitting process, CWRM clarified, through a declaratory ruling in §174C-57 HRS, [23] that ground water use permit modifications that meet the following criteria may be approved administratively:

1. The net change in permitted use within an aquifer is zero.
2. The modification would result in more efficient and optimal operation of multiple sources under a single operator.
3. No adverse impacts to water resources or other existing legal uses are anticipated.
4. End use location and type remain unchanged.

This order clarifies and streamlines the water use permit modification process for well owners with multiple wells within a single aquifer system area. CWRM encourages more efficient and optimal water source operations, which can also result in minimizing the potential for over-pumpage violations, for situations that meet the above criteria.

CWRM continues to refine and streamline the water use permitting process in response to Hawai‘i Supreme Court rulings, CWRM decisions and actions, statutory changes to the State Water Code, and requests from the public or government agencies. CWRM decisions on permit applications are recorded in the CWRM water use permit database, which serves as the agency's system for documenting and indexing formal decisions and actions. CWRM water use permitting policies described above have been identified through Hawai‘i Supreme Court rulings and CWRM actions.

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[21] March 13, 1996 meeting of the Commission on Water Resource Management, Staff Submittal Item 3.

[22] HRS174C-57, HAR13-171-23

[23] Declaratory Order No. DEC-ADM97-A1.

I.2.6 Recommendations

CWRM should further explore the use of different statistics, methods, and measures to assess ground water use over time. If an alternative measure is identified, the State Water Code should be updated to include the assessment measure. CWRM must determine the appropriate statistic to use in its regulation of surface water use.

I.3 Well Construction and Pump Installation Permits

A well construction permit from CWRM is required prior to the construction, modification, or sealing of any well that will explore for, develop, recharge[24], or permanently monitor ground water aquifers. A pump installation permit is required prior to the installation of new or replacement of existing well pumps with pumps of greater capacity.[25]

The standard conditions of all well construction and pump installation permits require that the work be done in accordance with the Hawai‘i Well Construction and Pump Installation Standards (HWCPIS). The HWCPIS contains all of CWRM’s goals and regulatory directives regarding proper well construction and pump installation to ensure protection and optimization of ground water resources. CWRM only issues permits to licensed contractors in good standing (i.e., no outstanding CWRM permit or Department of Commerce and Consumer Affairs licensing requirements).[26]

Under the HWCPIS, approval and issuance of well construction permits are generally ministerial actions.[27] A diagram illustrating the well construction and pump installation permitting process is included in **Appendix D Permit Process Diagrams**.

I.3.1 The Hawai‘i Well Construction and Pump Installation Standards

The State Water Code requires CWRM to develop minimum standards for the construction, modification, repair/maintenance, and sealing/abandonment of wells[28], in order to prevent polluting, contaminating, and wasting ground water, and to minimize saltwater intrusion into wells and ground water. The HWCPIS is a technical document that contains minimum standards governing virtually all aspects of well construction and pump installation, from a resource protection and optimization perspective. The HWCPIS was initially adopted by CWRM in 1997 and revised in 2004.

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[24] Injection wells are regulated by the State Department of Health’s Underground Injection Control Program.

[25] HRS §174C-84.

[26] Ground Water Regulation Branch Internal Enforcement Guideline, February 16, 2005 meeting of the Commission on Water Resource Management.

[27] January 23, 1997 meeting of the Commission on Water Resource Management, Staff Submittal Item 3.

[28] HRS §174C-86.

Additional protection of ground water quality is done through coordination with the DOH to determine appropriate permit conditions. All applications for well construction and pump installation permits are sent to the DOH for their review. The DOH review comments, including recommended permit conditions, are attached as special conditions to all permits issued by CWRM.

Since well construction and pump installation permits require adherence to the HWCPIS, CWRM is ensuring adequate protection, testing, and optimization of aquifers with respect to the development of new ground water sources. The DCCA requires well drillers to demonstrate adequate understanding of the HWCPIS through a testing and licensing process. However, licensed drillers are not required to pass any additional tests or complete any continuing education programs to retain their license. Currently, only licensed drillers are notified of changes to the HWCPIS. While the HWCPIS also provides adequate standards for the proper sealing of abandoned wells, the timely decommissioning of abandoned wells is an issue.

I.3.2 Abandoned Wells

The State Water Code defines an abandoned well as any well that has been permanently discontinued, or which is in such a state of disrepair that continued use for the purpose of obtaining ground water is impractical.[29] Section 3.1 of the HWCPIS further provides that all wells and test borings must be properly abandoned and sealed whenever:

- The well has served its purpose;
- The use of the well has been permanently discontinued;
- The well is not being properly maintained;
- The physical condition of the well is causing a waste of ground water, or is impairing or threatens to impair the quality of the ground water resources; or
- The well is in such a state of disrepair that its continued use is impractical or it is a hazard to public health or safety.

Because wells are generally considered assets to the property and can be expensive to properly seal, many well owners are reluctant to declare their well abandoned. The Hawai‘i Administrative Rules give additional authority to CWRM to determine when a well is abandoned[30]; however, making such a determination is still difficult. The submission of monthly water use reporting, including pumping, chloride concentrations, temperature, and (pump off) water level data is required[31] for any well not declared abandoned. If the well has no usage for the time frame represented for that report, then well owners must report that “0” gallons was

[29] HRS §174C-81.

[30] HAR §13-168-16.

[31] HAR §13-168-7.

pumped. In order to stop reporting on a well, the well needs to be properly sealed and abandoned. Therefore the regular reporting of monthly water usage is a one way that well owners can keep CWRM updated on the status of their well.

If a well is determined to be abandoned by CWRM or is declared by the well owner to be abandoned, the HWCPIS requires that it be completely sealed in accordance with the HWCPIS. Depending on the size and depth of these wells, the cost will average about several thousand dollars for most wells and up to tens, and even hundreds, of thousands of dollars for especially large or deep wells or shafts.

A recent CWRM analysis found that there are 1,101 wells classified as either abandoned and not sealed or unused in CWRM records. If a well has been determined to be abandoned, and the owner does not or is unable to seal their well, CWRM has the authority to seal the well and place a lien on the property.[32] However, CWRM currently lacks a funding mechanism to initiate and execute the sealing of abandoned wells.

Should funds become available, CWRM has identified priority wells that need to be sealed based on the potential threat to drinking water sources. This was done by utilizing the Department of Health's Source Water Assessment Program (SWAP) maps[33], which allowed staff to geographically analyze and identify abandoned and unused wells within the capture zones of public water system wells. Through this analysis CWRM found that 64 wells met the criteria with 47 of those wells located on Oʻahu. A rudimentary engineering cost analysis indicated that it would cost approximately $660,000 to properly seal the identified wells. However, as this analysis only utilized the records available in CWRM files, further investigation and site inspections are needed to make a final determination of abandonment and develop accurate cost figures.

To help assure Hawaiʻi's aquifers are suitable for future drinking water source usability, all abandoned wells must be properly sealed. Because of this potential harmful risk of contamination to aquifers, other states and counties have come up with additional support to properly seal abandoned wells. CWRM should consider and explore the programs and mechanisms employed by other jurisdictions to resolve the problem of unsealed abandoned wells.

For instance, Minnesota's Capital Region Watershed District has a Well Sealing Cost Share and Loan Availability program for funding half of the cost of sealing a well if you live within the district.[34] In 2012, Washington County, MN, received state support from the Clean Water Fund

[32] HRS §174C-86.

[33] Hawaii Department of Health Source Water Protection Program: http://health.hawaii.gov/sdwb/swap/

[34] SmallWaterSupply.org & PrivateWellClass.org 2014, The Private Well Class 2012, *Lesson 7 – Getting Help, Finding Local Answers (Abandoned Wells)*, accessed 29 August 2014 < http://mad.ly/277f63#>.

to expand cost share reimbursement to 100%, in some priority areas in the county.[35] The Water Bureau of the Michigan Department of Natural Resources and Environment has implemented a comprehensive Abandoned Well Management Program to coordinate statewide abandoned well location and sealing activities. The City of Durand, MI, was awarded an Abandoned Well Management (AWM) Grant in 2005. The AWM grant provides state funds in the amount of $45,000.00 dollars for locating and plugging abandoned water wells within the City of Durand's well fields. This grant requires the City of Durand to provide matching funds in the amount of 25% for a total project budget of $60,000.00.[36] Illinois' Water Well Abandonment Program provides technical and financial assistance to owners of improperly abandoned wells. An applicant may receive a cost-share of $500 or 80% of actual cost, whichever is less, for one well within each Soil and Water Conservation District.[37] In Nemaha County, Nebraska, 75% cost-share is available (up to $500 for drilled wells or $700 for hand dug wells) to properly close and seal abandoned wells. Abandonment must be completed by a licensed well driller within 90 days after approval.[38] In Iowa, the Department of Public Health, working with the Iowa Department of Natural Resources, use their Grants to Counties Program to provide cost share reimbursement to help pay some of the cost associated with plugging abandoned wells.[39]

The Rural Repair and Rehabilitation Loans and Grants program provides grants to very low-income homeowners to repair, improve, or modernize their dwellings or to remove health and safety hazards, which could include sealing of abandoned wells. The Rural Development office of the U.S. Department of Agriculture administers this program. The program is for families who live in a rural area or a community with a population of 25,000 or less. Individuals who are 62 years of age or older may qualify for a grant or a combination of a loan and grant; younger applicants are eligible only for loans.

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[35] Washington County Minnesota, Abandoned Wells, accessed 29 August 2014, <http://www.co.washington.mn.us/index.aspx?NID=640>.

[36] The City of Durand Water Department, *Abandoned Well Management Program*, accessed 29 August 2014, <http://www.durandmi.com/abandonedwellbroc.pdf>.

[37] Illinois Department of Agriculture 2002, Bureau of Land and Water Resources 2002, *Illinois Water Well Abandonment Program (IWWAP)*, accessed 29 August 2014, <http://www.agr.state.il.us/Environment/LandWater/IWWAP.pdf>.

[38] Nemaha Natural Resources District 2014, Well Abandonment, accessed 29 August 2014, <http://www.nemahanrd.org/water.php>.

[39] Iowa Department of Natural Resources, Well Plugging Program, accessed 4 January 2018, http://www.iowadnr.gov/Environmental-Protection/Water-Quality/Private-Well-Program/Well-Plugging

I.3.3 Recommendations

- CWRM should explore further education programs for drillers to ensure they are knowledgeable of current construction standards.
- Because improperly abandoned wells are largely a contamination and pollution issue, CWRM should coordinate with the DOH to identify funding sources and implement a program for sealing wells that pose existing or potential pollution concerns.
- CWRM should further explore the means and mechanisms employed by other states and counties to fund well sealing work.
- If sufficient funding cannot be obtained for CWRM to begin sealing those abandoned wells which the landowner/well owner will not or cannot do, then CWRM should consider revising the State Water Code to give CWRM clear authority to order landowners/well owners to seal abandoned wells, subject to daily fines for noncompliance.

I.4 Stream Channel Alteration Permit

CWRM protects stream channels from alteration, whenever practicable, to provide for fishery, wildlife, recreational, aesthetic, scenic, and other beneficial instream uses. Such protection of stream channels is made possible through the requirement that a Stream Channel Alteration Permit (SCAP) be obtained from CWRM prior to undertaking a stream channel alteration. "Channel alteration" means: (1) to obstruct, diminish, destroy, modify, or relocate a stream channel; (2) to change the direction of flow of water in a stream channel; (3) to place any material or structures in a stream channel; or (4) to remove any material or structures from a stream channel.[40] A diagram illustrating the SCAP process is included in **Appendix D Permit Process Diagrams**.

Generally, SCAPs are required for projects that are in the streambed itself, or on the banks of the stream. The exact delineation of the bank is sometimes problematic, but it is usually within the regular or common flow variations of a particular stream, as opposed to flood stages where the normal banks are overtopped. While most streams have a distinct break in the top of the slope which defines the extent of the stream channel, some streams lack a distinct break. In these cases, where a watercourse perennially or continuously contains flowing water, but may not have a definite break in slope facilitating a determination of the stream channel, the stream channel for that portion of the stream shall be defined as the area within 50 feet from the water's edge during a non-flooding event.[41]

[40] HRS §174C-3.

[41] Declaratory Ruling No. DEC-OA96-S5

SCAPs are issued for all projects that alter a stream channel, including those that divert water away from the stream. Such projects include, but are not limited to, armoring stream banks (such as the installation of retaining walls to protect banks from erosion), lining of stream channels (for flood control), placing structures in streams (bridge foundations, pipelines, etc.), removing of material and structures from streams (boulders, sand from stream mouths, existing walls and structures, etc.), realigning streams, and constructing stream diversion works.

CWRM supports routine maintenance of channels, streambeds, streambanks, and drainageways. The maintenance of stream channels, streambeds, streambanks, and drainageways is mandated by law, under HRS §46-11.5. The statute asserts that each county shall provide for the maintenance of channels, streambeds, streambanks, and drainageways, unless such features are privately owned or owned by the State, in which case, it becomes the responsibility of the respective owner. The statute also provides each county with the ability to enforce maintenance work on privately owned channels, streambeds, streambanks, and drainageways, and to assess civil penalties for non-compliance by private entities or individuals.

CWRM supports this statute by exempting routine streambed and drainageway maintenance activities and maintenance of existing facilities from the SCAP requirements.[42] The State Water Code is silent on defining "routine maintenance" and the specific activities allowed therein. As a result, CWRM has defined maintenance activities for which SCAPs are not required. Provided the watercourse is determined to be "natural," thereby meeting the definition of a stream, CWRM assesses the magnitude of channel alteration and the reasonable expectation of impacts to instream uses. The following stream clearing activities qualify as "routine maintenance" and do not constitute significant channel alteration or impact on instream uses, and therefore qualify to be exempt from the SCAP requirements.[43]

- Manual clearing of streams or work without the use of heavy equipment.
- Clearing of sand plugs at stream mouths, as long as the sand plugs are not submerged or do not contain silt or mud.
- Clearing of lined channels, as long as the work does not disturb submerged (accumulated) silt and mud.
- Clearing of vegetation, rock, silt, and debris of artificially lined (concrete or grouted rubble paving), non-submerged portions of streams. These activities also include removal of rocks from boulder basins.
- Reconstruction of channel linings to original configuration. These include activities such as repairing of spalls, patching concrete channel linings, and re-grouting of rubble pavement.

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[42] HRS §174C-71(3)(A)

[43] Declaratory Ruling Nos. DEC-ADM99-S8 and DEC-ADM03-S9.

Many projects, while they may be considered “routine” by the landowner, are rather large in scope and thus do not meet CWRM’s criteria of “routine maintenance.” These projects tend to affect longer lengths of stream channel, result in greater amounts of removed material, require the use of heavy equipment, and are typically undertaken by government agencies. As a result, CWRM supports streamlining the permitting process for specific government agencies by delegating the approval of agency SCAPs to the Chairperson.

Applications by government agencies for stream channel alteration permits to perform streambed and drainageway maintenance activities *not* considered “routine maintenance” may be delegated to the Chairperson for approval if certain criteria are met. CWRM requires that a Declaratory Ruling be approved for each respective agency seeking action under this policy. Specific Declaratory Rulings have been approved for the City and County of Honolulu (DEC-ADM99-S8) and the State Department of Transportation (DEC-ADM03-S9).

SCAP applications must meet the following criteria, as stated in the related Declaratory Rulings:

1. *The stream channel alteration permit application must contain the following:*

   a. *A copy of the Clean Water Act, Section 404 permit from the U.S. Army Corps of Engineers, and the Clean Water Act, Section 401 Water Quality Certification and Best Management Practices Plan from the Department of Health. In the event that the project is not subject to these sections of the Clean Water Act the applicant shall submit written documentation from the Corps of Engineers citing the exemption.*

   b. *Clean Water Act Section 402 (NPDES) permit if applicable.*

   c. *Written description of the scope of work including:*

      1) *A location map showing affected stream reach. Cross section(s) showing typical contours of the before and after removal of material. Photographs.*

      2) *Amount of material to be removed.*

      3) *Method of clearing including description of the types of equipment to be used.*

      4) *Location and practice of spoils disposal.*

      5) *Frequency of clearing time required for each clearing.*

      6) *Written concurrence from the State Historic Preservation Division and the Division of Aquatic Resources that the work may proceed.*

2. *Must not alter stream diversions works or interim instream flow standard.*

3. *The amount of material to be removed is less than 500 cubic yards and will take less than two weeks to complete the work.*

4. *Clearing activity does not include the placement or removal of any structures in the stream.*

5. *Clearing must not be after-the-fact.*

6. *Clearing must not be in violation of any other applicable federal, State, or county permit.*

7. *Must not restrict access to property.*

8. *Must not be subject to a Special Management Area Permit (HRS, Chapter 205A).*

9. *Chairperson approved SCAPs are subject to the following conditions:*

    a. *Standard Chairperson Approved SCAP Conditions.*

    b. *Special conditions may be added by the Chairperson including but not limited to:*

        1) *Requiring the applicant to produce a Best Management Practice Plan acceptable to the Department of Health.*

        2) *Requiring the applicant to notify the State Historic Preservation Division on start of clearing activities.*

    c. *The permit will be valid as long as the Commission does not revoke the permit or until the Commission amends this Declaratory Ruling.*

Stream monitoring is a fundamental component of surface water resource management. Monitoring of water quantity and water quality supports baseline data collection and characterization, documents changes over time, provides a scientific basis for making sound management decisions, and is an essential tool in water resource planning.

CWRM supports the establishment of stream monitoring equipment, provided the installation of such devices does not require substantial alteration of the stream channel, for example, the installation of two temporary V-notch weirs to monitor streamflow at two points within the stream during low-flow periods.44

[44] Declaratory Ruling DEC-ADM97-S6

CWRM has also delegated the approval of stream channel alteration permits to the Chairperson for surface water gaging stations that meet all the following criteria:[45]

- The gages are installed using manual construction practices only, without the use of heavy equipment.
- The length of time for the work in the stream to be completed is not greater than four days.
- No fill or discharge will be made into the stream, and no stream water will be removed from the stream channel.
- Concrete or masonry may be constructed or placed in the stream channel if it meets the following criteria:
  - It is confined to one bank of the stream;
  - It is for foundational or anchoring purposes only; and
  - The gages use natural, rather than artificial, means of flow control (e.g., it does not span the entire width of the stream channel).

I.4.1 Request for Determination

While CWRM requires a SCAP whenever a stream channel alteration is to be undertaken, given the variable nature of Hawaiian streams, it is often unclear whether or not a SCAP is required, and a request for determination may be made.

A Request for Determination (RFD) is a public request to establish the existence and location of a stream channel and/or to determine whether a project is impacting the stream channel, thereby requiring a SCAP. Initially, it must be determined whether the watercourse is actually a stream as defined in the State Water Code. Subsequently, it must be discerned whether the project is actually within the bed or banks of the stream.

I.4.2 Exemptions from Stream Channel Alteration Permit

CWRM has identified watercourses that do not meet the definition of a stream, and are therefore not subject to SCAP requirements, as follows:[46]

1. man-made or are part of an irrigation system;
2. excavated subdivision drains;
3. man-made drainage channels in low-lying coastal plain areas;
4. highway interceptor ditches;

[45] Declaratory Ruling DEC-ADM97-S6

[46] Declaratory Ruling No. DEC-ADM99-S8

5. ‘auwai; or
6. dry gulches.[47]

It is often difficult to determine the difference between a gulch that is usually dry except for periods of heavy rainfall, and a stream that may be dry much of the time but still provides for instream uses. If it can be determined that a watercourse does not provide for one or more instream uses, such as aquatic animals or aquatic vegetation, in either upstream or downstream areas, then a SCAP is generally not required. The definitions under this policy are guidelines intended to allow for prompt and proficient decisions by CWRM staff, however determinations on potential impacts to instream uses are often made on a case-by-case basis.

I.5 Stream Diversion Works Permit

The term "stream diversion" is defined by the State Water Code as the act of removing water from a stream into a channel, pipeline, or other conduit.[48] CWRM issues Stream Diversion Works Permits (SDWP) for any artificial or natural structure placed within a stream for the purpose of diverting stream water. The range of such projects include small diversions of several tens of gallons per minute by means of small pumps, medium-sized diversions such as those that supply water to taro lo‘i and other smaller irrigation systems, and large diversion intake structures that could divert all of a stream’s flow except for flood flows. A diagram illustrating the SDWP process is included in **Appendix D Permit Process Diagrams**.

Any new stream diversion, or expansion of an existing stream diversion, may require a petition to amend the interim instream flow standard (see **Section F.5.3** in **Appendix F Inventory and Assessment of Resources** for further discussion of instream flow standards), depending on the stream of interest.

A SDWP is also required when a stream diversion works is abandoned. A filing fee is not required when applying to abandon a stream diversion works.[49]

SDWPs are not required for normal maintenance activities,[50] which would include repairing pumps or replacing them with pumps of equal or less capacity, repairing and maintaining existing diversion structures, cleaning out diversion structures to restore capacity, and other repair and maintenance operations that do not expand or increase the diversion capacity of a structure beyond the original design of the structure.

[47] Declaratory Ruling No. DEC-MO94-S3

[48] HRS §174C-3.

[49] HAR §13-168-35(b).

[50] HRS §174C-93.

I.6 Recommendations for Surface Water Regulation

There are three principal issues that should be addressed to improve surface water regulation statewide:

> **Regulatory coordination:** Ongoing coordination is required between government agencies that regulate the various, and oftentimes overlapping, aspects of water resources. Laws and rules periodically change, as does the interpretation of existing laws and rules. Agency policies continue to adjust to new situations and rulings by administrators and courts. Coordination is required to prevent duplication of effort, excessive regulation, and unnecessary regulation.
>
> **Surface water use data collection and data quality:** The lack of water use data for surface water makes it difficult to resolve disputes between competing users of the resource. Without good water use records, complaints of wasting or dumping of water are difficult to substantiate or refute.
>
> **Enforcement of instream flow standards:** CWRM must develop and adopt a regulatory framework that provides guidance for CWRM staff in the monitoring and enforcement of instream flow standards. As instream flow standards are established through contested case hearing orders or administrative proceedings, CWRM staff experiences difficulties in monitoring IFS compliance due to frequent naturally-occurring, low-flow conditions along with timely regulation of water users during these times. CWRM needs to address violations adequately through a notice process and fine schedule.

Inter-agency coordination at the staff level must be ongoing to most efficiently manage and protect resources. Examples of agencies with programs related to surface water regulation include the Army Corps of Engineers, the DOH, county planning and permitting departments, and county water departments. Therefore, it is recommended that agencies organize and coordinate periodic workshops whenever new laws, rules, or policies are adopted and implemented.

Regarding data collection and data quality, it is recommended that additional staff be provided for field investigations and water use data collection and management. Funding mechanisms should be sought or enhanced to increase knowledge of resources, and to improve protection and management programs. For more information on surface water use reporting, see **Section H.3.3** in **Appendix H Existing and Future Demands**.

Finally, activities should be executed for the verification of stream diversions and abandoned diversions works. This will improve and refine data collection sites and increase the reliability of surface water use data.

I.7 General Recommendations for Ground and Surface Water Regulation

- Continue efforts to modernize internal processing of permits, including development of electronic checklists, permits, and form-letter merge files.
- Establish web-based permit application and processing and water use reporting.
- Expand and enhance the water use reporting program to include surface water use and data on chlorides present in well sources.

I.8 Penalties and Enforcement

CWRM has the authority to assess penalties for any violation of Chapter 174C or Title 13, for failure to comply with CWRM rules and orders, and for any violation of permit conditions.[51] Currently, a fine of up to $5,000 per day may be imposed. Fines may accrue daily as a separate violation for each day during which the offense is committed. Since the passage of the Water Code in 1987, CWRM has investigated 110 violations and assessed total fines in excess of $1,757,486. Most of the violations were for conducting work without the required permits.

To provide a logical and consistent means to assess penalties and guide the settlement of CWRM enforcement cases, CWRM adopted an Administrative and Civil Penalty Guideline, which was last revised in 2014 (**Appendix P**). The objectives of the guideline are to:

- Deter violations;
- Remove the economic benefit of violations;
- Provide fair treatment of the regulated community; and
- Offer the violator a chance to undertake a beneficial alternative, under proper conditions, in a partial or total replacement of a cash penalty.

Under the guideline, a minimum fine is set at $250 for a finding of a violation. The minimum fine may be increased in $250 increments if the violation has occurred in a water management area or if it involves a repeat violation (i.e., the party has previously been found to be a violator by CWRM, irrespective of the nature of the violation). Mitigative and gravity components may be applied to reduce or enhance the minimum fine based on the degree of risk or actual harm to water resources or the environment and for other specified factors. If one or more gravity components are met, a daily fine may be imposed and may accrue until either a satisfactory resolution of the violation is achieved or until the violation is remedied.

[51] HRS §174C-15 and HAR §13-167-10.

The guideline also provides for alternative settlements to allow a project to substitute for or be credited against a cash penalty. In addition, the guideline allows CWRM to consider any future applications incomplete pending the fulfillment of sanctions and/or correction of the violation. As the legislature amended the Water Code to provide for daily fines of up to $5,000 per day, the administrative rules should be amended to reflect the higher penalty amount.

Due to staffing limitations, CWRM staff has prioritized enforcement of violations in water management areas and in response to complaints. CWRM staff plans to more rigorously enforce Water Code provisions and permit conditions, particularly the water use reporting requirement, with two newly-developed tools. One is the development of CWRM's online water use reporting system, discussed more fully in **Section G.2.1** in **Appendix G**.

In addition to making monthly reporting easier for those users who wish to take advantage of this new technology, the online reporting system will automatically flag and notify delinquent reporters via email and create delinquency reports for further action by CWRM staff. With the completion of the online reporting system in 2014, and following additional outreach to water users, CWRM plans to utilize DLNR's Civil Resource Violation System (CRVS).[52] The CRVS is a new tool that may be used to bring administrative enforcement actions for resource violations of a civil rather than criminal nature, especially those minor, routine violation cases, such as failure to submit required monthly reports. The CRVS provides a fair, efficient, and cost-effective process. It will eliminate the need to bring individual enforcement cases to CWRM for action and standardize the fines for minor civil resource violations. In order to utilize the CRVS, CWRM must identify violations to be enforced through the CRVS and adopt an administrative sanctions schedule. The fines should be set at levels to encourage voluntary compliance and deter future violations.

In addition to these new enforcement tools, CWRM is also presently conducting outreach and education to facilitate voluntary compliance. In 2014, CWRM approved the hiring of a consultant to conduct ground water use reporting outreach on Oahu and the ʻĪao Ground Water Management Area on the island of Maui. In 2017, another consultant was hired to conduct similar outreach for the rest of Maui island, as well as the entire island of Molokai, which has been designated as a ground water management area. The consultants will contact each non-reporting ground water user, verify the status of the well, document the method of measuring pumpage, and assess the ability of the reporter to report use online. Where water use reporters have problems accurately measuring their use, the consultants will visit the site, assess what steps (e.g., install or repair an appropriate water meter) need to be taken to bring water usage monitoring in line with accepted practices, and make appropriate recommendations. Finally, the consultants will provide CWRM staff with status reports on a regular basis that include the numbers of reporters successfully contacted, issues resolved, issues unresolved, and number of successful water use reporting.

[52] Chapter 13-1, Subchapter 7, HAR

Another outreach and education effort that will proceed is workshops and training on agricultural irrigation system metering. This effort is part of CWRM's implementation of its recently-developed Hawai'i Water Conservation Plan. In formulating the plan, the dearth of water use data from surface water diversions across the State made it difficult to ascertain water use efficiency, devise water conservation measures, and develop target reductions. A program to educate users in simple yet reasonably accurate methods for measuring diverted surface water flow will help improve surface water use data collection and assist agricultural operators to better manage their water use. Workshops have been conducted large-scale systems, and staff is currently conducting outreach and education for smaller-scale systems statewide.

I.8.1 Recommendations for Penalties and Enforcement

- Update the administrative rules and enforcement and penalty guidlines to conform to the fine amount of $5,000 as provided in the State Water Code
- Develop and adopt a penalty schedule and begin to utilize the CRVS
- Expand water use reporting outreach as necessary to encompass non-designated areas and continue to educate the public on the rules and regulations to facilitate voluntary compliance

I.9 Complaints and Dispute Resolution

The State Water Code provides CWRM with the authority to process citizen complaints[53], and statewide jurisdiction to hear any dispute regarding water use, resource protection and management, water rights, and competing uses, or other water issues, regardless of whether the area involved has been designated as a water management area. [54]

Citizen complaints are usually related to unpermitted construction activities, stream and spring ownership disputes, and environmental and public health concerns. Disputes can be related to any water resource issue within CWRM's jurisdiction.

Pursuant to HRS §174C-13 and Chapter 91, CWRM adopted procedural rules to process citizen complaints, including the right of appeal to CWRM. If any person files a complaint that any other person is wasting or polluting water or is making a diversion, withdrawal, impoundment, consumptive use of waters, or any other activity occurring within or outside of a water management area, not expressly exempted under the State Water Code, without a permit where one is required, CWRM has authority to investigate, take appropriate action, and notify the complainant thereof.

[53] HRS §174C-13.

[54] HRS §174C-10.

In the past, citizen complaints have included the following:

- Reports of unpermitted activity (such as grading, removing material, adding material, dumping, etc.) in or next to streams;
- Reports of illegal building (such as walls, lanais, fences, etc.) in or close to a stream;
- Reports of fish kills or aquatic plant “blooms” in streams;
- Property disputes regarding locations of streams, springs, ponds, and ‘*auwai*;
- Reports of too little water in a stream;
- Reports of too much water in a stream;
- Reports of structures in streams causing flooding;
- Reports of illegal alteration of streams;
- Reports of illegal diversions of steams;
- Reports of waste and dumping of stream water; and
- Illegal well drilling, illegal use of well water, and leaky wells.

Staff responds to complaints that fall within the jurisdiction of CWRM that generally include wasting or dumping of water, and any work done in or near streams, without the required permits, that could affect instream uses. Water quality complaints are referred to the DOH[55]. Complaints concerning flooding and flooding-related maintenance of stream banks are referred to the respective counties.[56]

Complaints lead to CWRM issuing stop-work orders, where persons who start projects requiring permits, but have not yet completed them, are ordered to stop work until the proper permits are obtained. Where projects without the required permits are completed, CWRM requires the persons who did the work to apply for after-the-fact permits.

HRS §174C-10 describes CWRM’s authority in dispute resolution. The State Water Code provides CWRM with jurisdiction statewide to hear any dispute regarding water resource protection, water permits, constitutionally protected water interests, and insufficient water for competing uses, regardless of whether the area involved is designated as a water management area. Under the provisions of the State Water Code, the final decision on any disputed matter shall be made by CWRM. Unlike complaints, which are generally related to permits, disputes can occur for any problem related to water resources under the jurisdiction of CWRM.

[55] HAR §13-167-82.

[56] HRS §46-11.5.

Examples of disputes include the following:

- *'Auwai* disputes – where neighboring users on an '*auwai* system have disputes over various aspects of '*auwai* use such as maintenance of the '*auwai*, maintenance of the intake, taking too much water, altering the 'auwai, etc.;
- Location of resources – property disputes between adjacent owners regarding the location of a water resource; and
- Surface water and ground water interaction disputes – disputes that occur where the pumping of water from a well could adversely affect nearby stream flow, or where blockage (damming or diverting) of ground water could adversely affect the flow of surface water.

I.10 Declaration of Water Shortage

The State Water Code (HRS §174C-62) mandates that CWRM formulate a plan to be implemented during periods of water shortage, and describes CWRM's authority as follows:

> *The commission, by rule, may declare a that a water shortage exists within all or part of an area when insufficient water is available to meet the requirements of the permit system or when conditions are such as to require a temporary reduction in total water use within the area to protect water resources from serious harm.*

The State Water Code further states that CWRM must publish a set of criteria for identifying a water shortage, and CWRM must adopt a reasonable system for water use permit classification to be included in the water shortage plan. The water shortage plan must also set forth provisions and guidelines for imposing use restrictions on different classes of permits as may be necessary to protect the resource.

The set of criteria for identifying a water shortage is established in HAR §13-171-41. This rule specifies that CWRM can issue water shortage declarations for water management areas or portions of water management areas where CWRM has determined and publicly declared that usage has caused, or may cause within the foreseeable future, any of the following:

- Withdrawals that exceed the recharge;
- Declining water levels or heads;
- Deterioration in the quality of water due to increasing chloride content;
- Excessive waste of water which can be prevented; or
- A situation in which any further water development would endanger the ground water aquifer or the existing sources of supply.

I.10.1 CWRM Water Shortage Declaration Process

The State Water Code specifies that a water shortage declaration by CWRM must undergo rulemaking proceedings. Proposed issuance, amendment, or repeal of a rule is subject to the public hearing process, which specifies certain public notice and participation requirements. Such notice of the proposed rulemaking must be issued at least 20 days prior to the date of the hearing and must be published in "a newspaper of general circulation in the state and in each county affected by the proposed rule."[57] All interested persons and agencies must be provided reasonable opportunity at the hearing to offer evidence with respect to the proposed rule. Additionally, written protest, comments, or recommendations are accepted by CWRM within 15 days from the end of hearing proceedings. CWRM may either issue its decision on the proposed rule at the end of the hearing, or announce a date when the decision will be issued.

In general, the rulemaking process can take a considerable amount of time to complete. CWRM has never moved toward the declaration of a water shortage in any part of the state; however, in light of the above description of the rulemaking process, it is very possible that impacts due to a water shortage situation could considerably intensify before CWRM completed the rulemaking process. It should be noted, though, that the Hawaiʻi Administrative Rules include provisions for emergency rulemaking that can be invoked if CWRM "finds that an imminent peril to public health, safety, or morals requires adoption, amendment, or repeal of a rule upon less than twenty days' notice of hearing."[58] In this situation, CWRM may proceed to adopt an emergency rule "with abbreviated notice and hearing" or "without prior notice or hearing." The emergency rule can remain in effect for a maximum period of 120 days without renewal.

A declaration of water shortage and any measures adopted pursuant thereto may be rescinded by rule by CWRM.

Upon declaration of a water shortage, the State Water Code also provides that CWRM shall contact each permittee within the affected aquifer system(s) by regular mail to provide notice of the water shortage declaration and of any change in the conditions of the permittee's permit, any suspension thereof, or of any other restriction on the use of water for the duration of the water shortage. In addition, CWRM should conduct public outreach and educational programs, as needed, and coordinate efforts with county water agencies and private water system purveyors.

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[57] HAR §13-167-42.

[58] HAR §13-167-45.

I.10.2 Existing CWRM Water Shortage Plans

Lanai Water Shortage Plan

In 1991, CWRM approved Lanai Company's water shortage plan to be used in regulating water use on Lanai if an emergency condition arose due to a water shortage. The requirement to develop a water shortage plan was one of five conditions that CWRM imposed to protect Lanai's water resources without the need for water management area designation.

The water shortage plan for Lanai establishes water use priorities and specific actions to be taken within each water use group in the event of a water shortage. Usage in areas deemed to be the lowest priority would be rationed. In order of importance, the following ranking has been established:

a. Residential
b. Commercial (including resorts)
c. Agricultural
d. Irrigation
    1. Residential
    2. Large scale (such as golf course)

In the event of an emergency condition, the first action would be to reduce irrigation on projects such as golf courses. Water use would be reduced to the point at which any further reduction would result in a destruction of plant life. If further cutbacks are necessary, voluntary reductions in residential irrigation would be sought, followed by mandatory reductions as needed. Actions to accomplish mandatory residential irrigation reductions would include: 1) alternate day watering, 2) monitoring of meters, and 3) pricing mechanisms. Further reductions would impact agricultural operations by limiting usage on dry land crops (most drought-resistant), followed by vegetables and ornamentals. Restrictions on commercial activities would be voluntary at first. If further use reductions are needed, each business would be required to develop an individual plan to reduce consumption, differentiating between critical and non-critical usages. A monitoring program would be initiated to ensure compliance. Residential use, as the highest priority, would be unaffected.

Puʻuloa Aquifer System Water Shortage Plan

In 1997, the CWRM adopted a permit classification system for the non-potable Puʻuloa Aquifer System Area, located in the ʻEwa Caprock Aquifer Sector Area on Oʻahu. The permit classification system is based on type of water use. Four classes of use are identified: agriculture, golf course irrigation, landscape irrigation, and dust control. All of the permitted uses are for non-potable uses, and none have been identified as a public trust purpose. The highest priority of is agriculture, because the State's policy is to promote agriculture, and also because agricultural correlative uses are assured through the 1978 Constitutional Amendment. The second priority in water use is golf course irrigation, because of the economic impacts that may result from inadequate water supply. The lowest priority in uses are landscape irrigation and dust control.

Although it is uncertain whether a water shortage could occur in the Pu‘uloa Aquifer System Area, given CWRM's establishment of sustainable capacities for individual irrigation wells at 1,000 mg/l of chloride, a water shortage plan was formulated because of the former reliance on brackish caprock water to supply the non-potable needs of the growing ‘Ewa and Kapolei urban areas.

In the event of a water shortage in the Pu‘uloa Aquifer System Area, phased cutbacks will be implemented according to the established water use priorities and the individual users' water shortage plans. Water shortage plan cutbacks are based on the users' permitted allocation.

To keep the water shortage plan current, CWRM delegated the authority to the Chairperson to approve or modify individual water shortage plans and to approve the regional water shortage plan.

I.10.3 Recommendations for Implementing Water Shortage Provisions

The following recommendations are intended to guide CWRM actions in the development and implementation of future water shortage plan provisions and the development of an integrated water shortage program:

- CWRM should formulate and adopt rules to streamline the public hearing process for the water shortage declarations.
- All individual water shortage plans are required from water use permittees. Plans shall be submitted as part of the permit application so that CWRM can perform actions on the water use permits and updates to the regional plan simultaneously. HRS §174C-51(8) and HRS §174C-62(a) & (c) of the State Water Code provide the authority for CWRM to implement this recommendation.
- Permittees whose individual water shortage plan indicates a 0% reduction in water use shall be required to provide supporting justification. CWRM shall conduct site visits as necessary to verify the permittee's inability to reduce water use during shortage conditions. If it is determined that the permittee has the ability to reduce water use during water shortage conditions, CWRM shall modify the permittee's individual water shortage plan.
- CWRM should consider requiring all artesian wells and other free-flowing sources to be outfitted with a flow control device such as a valve.
- Proceed with enforcement of permit restrictions.

- CWRM shall request all large water users (e.g., BWS, United States military) to separate out and make known any of their permitted water uses or users that fall within identified public trust purposes.
- CWRM should pursue the development and adoption of water shortage plans, in coordination with drought, conservation, and resource augmentation plans and programs, which are practical and provide realistic conservation and response measures.

I.11 Declaration of Water Emergency

The State Water Code provides CWRM with emergency powers that can be exercised statewide during periods of water emergency, including non-water management areas and despite permitted water use allocations. Thus far, CWRM has never issued a water emergency declaration.

CWRM has broad powers to order the “apportioning, rotating, limiting, or prohibiting the use of water resources” in any area if it declares an emergency condition. In spite of having such broad powers, it is unlikely that CWRM would act precipitously or unilaterally in making decisions. CWRM is charged with conducting necessary investigations and consulting with all interested parties before taking action toward a water emergency declaration.

I.11.1 Recommendations for Implementing Water Emergency Provisions

CWRM, in consultation with county water agencies and other public/private water system purveyors who operate systems, should formulate and adopt rules specifically for the issuance of a water emergency declaration. Such rules should detail:

- Criteria for determining when a water emergency exists;
- A streamlined process for emergency declaration, notification, public comment processes;
- Extent of the regulatory authority of a water emergency declaration;
- Restrictions that may be imposed by CWRM under a water emergency declaration; and
- Suggested relief measures to be taken by county water agencies and water system operators.

APPENDIX J

Resource Conservation and Augmentation

Water Resource Protection Plan 2019 Update

J Resource Conservation and Augmentation

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J Resource Conservation and Augmentation

Through its review of existing demands, authorized planned uses, and hydrologic data, the Commission on Water Resource Management (CWRM) has found that some areas of the State of Hawaiʻi are approaching the limits of ground water resource development. Nearly all of Oʻahu, Molokaʻi, and part of Maui have been designated as Ground Water Management Areas, where ground water use and development is regulated by CWRM. North Central Maui (Nā Wai ʻEhā) has been designated as a surface water management area, having similar regulations. The current municipal water use in the state of Hawaiʻi is approximately 223 million gallons per day (MGD) and current estimates are that this total use will increase to almost 270 MGD by the year 2035. Rising development pressure and population growth, combined with the uncertainty of climate change will create more competition for water in the future. A possible future scenario with dwindling natural water supply forces our society to explore and plan for water conservation and the use of more expensive alternatives like reusing treated wastewater and stormwater, treating surface water, and desalinating brackish or ocean water.

Estimates of ground water availability throughout the State are based on the best available, albeit limited, data. There are emerging indications of threat to our ground water sources that cannot be ignored. Recent climate change research suggests that rainfall patterns in Hawaiʻi are changing, both spatially and temporally. Some research suggests that dry areas will become drier and wet areas wetter. Droughts may become more prolonged, while large rainfall events may be less frequent but have increased intensity. While not a certainty, changing rainfall patterns will have an impact on water availability across the State of Hawaiʻi. Increased demand for water and competition for water in some areas of the State force stakeholders to rethink traditional supply and demand regimes.

There are several State and county agencies that currently implement various water conservation measures. Private businesses and organizations have also incorporated varying degrees of water conservation within their operations. The State of Hawaiʻi recently developed a water conservation plan to begin a water conservation program which will coordinate the various ongoing conservation efforts and implement programs designed to improve water conservation and use efficiency across the State.

Resource augmentation should also be embraced as an important component of sustainable water resource management. Water augmentation sources include: water that is imported from neighboring regions, rainwater/storm water, gray water, and wastewater reclamation and reuse, and desalination of brackish water and seawater. Several of the county water and wastewater agencies employ reclamation techniques to process surface water and wastewater. Many privately-owned wastewater treatment facilities also recycle and reuse wastewater. However, there is no statewide water resource augmentation program.

This section reviews existing conservation and augmentation activities in Hawaiʻi and establishes goals and priorities for statewide planning programs. The State Water Code states that CWRM shall plan and coordinate conservation and augmentation programs in cooperation with other federal, State, and county agencies, and private and public entities created for the utilization and conservation of water.[1] The State should provide leadership and guidance for the establishment, development, and implementation of statewide water conservation and augmentation programs.

J.1 Goals & Objectives

CWRM, on behalf of the State of Hawaiʻi, establishes the following goals and objectives for water conservation and resource augmentation programs and projects statewide[2]:

- Foster the collaborative development, implementation, and update of short- and long-range plans for conserving and augmenting water supplies.
- Promote coordination and cooperation among agencies and private entities.
- Provide guidance, assistance, and oversight in the establishment, development, and implementation of statewide water conservation and augmentation programs.
- Encourage coordination between conservation activities and augmentation planning.
- Promote the utilization of the best available information and technology in planning and implementing conservation and augmentation projects.
- Provide the regulatory and planning framework for integrating resource conservation and augmentation into a comprehensive water management program.
- Support county and community-based conservation efforts by providing information resources and advisory assistance.
- Encourage water conservation and use of alternative water sources, whenever possible, through comments provided during land use planning and permitting review.

[1] HRS §174C-5(12) and §174C-31(d)(4).

[2] HRS §174C-5(12) and §174C-31(c)(1).

J.2 Statewide Water Conservation Program[3]

Water supply planning and water conservation programs are closely related. Conservation programs directly affect short- and long-term water requirements and help reduce the risk of water supply deficiencies. Water conservation measures are implemented to achieve the following objectives:

- Reduce the demand for water;
- Reduce energy costs and the carbon footprint associated with increased water production;
- Improve efficiency in use and reduce losses and waste of water; and
- Ensure the long-term viability of the resource.

Although government has taken the initiative in pursuing water conservation policies, the success of any water conservation program ultimately depends on public participation and cooperation. It is essential to the development and implementation of a good water conservation program that the community embraces and adopts a conservation ethic. Community leaders, elected officials, government agencies, private water companies, and environmental groups must be involved in the planning process. The following text describes the Hawaiʻi Water Conservation Plan, which was developed by CWRM 2013. Further Hawaiʻi Water Conservation Plan details can be found online (http://state.hi.us/dlnr/cwrm/planning/hwcp2013.pdf).

Need for a Water Conservation Plan

As an island state, Hawaiʻi has limited access to natural fresh water supplies. Competition for fresh water, increasing population and development pressures, the rising awareness of environmental and cultural water needs, and the impacts of global climate change require that Hawaiʻi become as efficient as possible in its uses of limited fresh water supplies. In some areas of the state, demand for water is approaching the sustainable limits of supply, and these demands are expected to increase in the future. In order to sustain and protect our water for future generations, we must strive to be as efficient as possible in all of our water uses.

CWRM is the primary steward of the water resources public trust and has broad powers and responsibilities to protect and manage Hawaiʻi's water resources. This includes the authority and duty to develop plans and programs to conserve water across the State of Hawaiʻi. While various state agencies and municipalities have developed and implemented individual programs to conserve water, there has been a lack of coordination and communication to collaborate those efforts toward a common goal.

[3] CH2MHILL. 2013. *Hawaiʻi Water Conservation Plan Final Report*. Prepared for Commission on Water Resource Management. February 2013

Hawai‘i Water Conservation Plan Purpose

The purpose of the Hawai‘i Water Conservation Plan is to identify and implement water use and delivery efficiency measures to conserve the fresh water resources of the state. The plan is intended to be a guiding document for CWRM as they develop and implement water efficiency measures that can be implemented across the state by various water user groups. In “owning” the Hawai‘i Water Conservation Plan, CWRM serves as a coordinator, funding source, and clearing house and offers technical assistance. Because CWRM is not a water purveyor, it can lead by example, but otherwise cannot directly implement water efficiency programs. CWRM depends on water purveyors and users in Hawai‘i to participate and implement the measures outlined in this plan.

It is important to note that this Hawai‘i Water Conservation Plan focuses mainly on “demand side” measures of water use and delivery efficiency measures and programs to implement them. Although other types of “supply side” measures are commonly mentioned when discussing water conservation, such as reuse of recycled water or stormwater capture for ground water recharge, these practices are not the emphasis of this plan. For the purposes of the Hawai‘i Water Conservation Plan, water conservation is defined as the reduction in fresh water use by improving the efficiency of water delivery and end water uses. However, CWRM views all water sources, including alternative sources, as valuable resources to be used wisely. Many of the recommended best management practices can be applied regardless of the nature of the water source.

Principles and Planning Process

CWRM began this process to develop a water conservation program with three overarching objectives:

1. Develop a coordinated statewide water conservation planning strategy and policy framework.
2. Develop a statewide water conservation program to implement the planning and policy framework.
3. Work collaboratively with water conservation stakeholders to achieve CWRM objectives.

The planning process for developing this water conservation plan involved forming an advisory group, defining a water use baseline, setting water conservation goals and strategies, developing recommended best management practices (BMP), defining and evaluating implementation approaches, and establishing an implementation and funding plan.

Water Conservation Advisory Group

There are numerous categories or sectors of water uses across the State of Hawai‘i. The uses range from municipal water supply to military to golf course and agriculture. Within the municipal and military sectors, there are also commercial, industrial, institutional, and other uses that are served. Realizing the need for collaboration and cooperation to succeed in a water conservation program, CWRM sought to establish an advisory group of stakeholders that would represent such a diverse water use spectrum. The Water Conservation Advisory Group (WCAG) is composed of water industry professionals and experts from across the state with knowledge or interest in water efficiency and conservation. Members represent all major water use sectors in the private industry as well as all levels of government.

During the development of this water conservation plan, the volunteer WCAG met six times over a period of 18 months to help create the statewide water conservation plan and program. During the six facilitated meetings, the WCAG contributed water use data, water conservation program information, participated in the development of sector-based BMPs, and established an initial prioritization of water conservation program elements. CWRM believes that there should be a continuation of the WCAG or some derivative group of core members to support the implementation of water conservation programs in the state and to provide expert advice during the evolution of the State Water Conservation Program.

Water Use Characterization[4]

The largest water use sectors by volume in Hawai‘i are the municipal and the agricultural sectors. The municipal (including military) water demand is approximately 223 million gallons per day. Water use data show that the residential sector is the largest municipal water use category, accounting for nearly two-thirds of all municipal water use. After that, the largest municipal water use categories are commercial, institutional, and hotel. Therefore, the categories in which municipal water conservation BMPs should be targeted include residential, commercial, institutional, and hotel use. The data also illustrate that there is a strong seasonal outdoor water use, and that outdoor water conservation BMPs should be considered.

When the plan was developed, agricultural use was estimated at well over 350 MGD (which represents both the reported and estimated unreported uses), irrigating approximately 50,700 acres statewide. However, water use data are measured at different points within each irrigation system. Most data sets represented metered deliveries from main ditches and pipelines to water use at farm/field level diversion points, so do not represent total water diversions. Almost all of Hawai‘i's remaining large agricultural irrigation systems are legacy sugar plantation delivery systems. Many of these systems have fallen into disrepair, but some are undergoing rehabilitation through State-funded efforts. Rehabilitation, modernization, and improved maintenance of these systems have the potential to improve water delivery efficiency while also

[4] CH2MHILL. 2013. *Hawai‘i Water Conservation Plan Final Report*. Prepared for Commission on Water Resource Management. February 2013. Note that water demand/uses were estimated based on best available data at the time of this report.

improving the reliability of agricultural water supplies. It is important to note that some agricultural operations also have non-irrigation water uses for pest control and to meet regulatory requirements.

There are 104 golf courses in Hawaiʻi with an estimated average water use of 53 MGD in total across the golf course sector. The data indicate that the average 18-hole golf course in Hawaiʻi covers 124 irrigated acres, has a peak month water use of 0.65 million gallons per day, and an average annual water use rate of 0.37 million gallons per day. Based on the data provided by water users and purveyors and on a per unit area basis, the average golf course irrigation water use was about half the average agricultural irrigation water use. However, the range in reported water use for individual agricultural and golf course sector sites was wide enough that a general comparison of water use across these two sectors is not possible.

Water Conservation Measures and Prioritization

During the plan development process, the WCAG formulated a list of BMPs for the municipal, military, agricultural, and golf course sectors. The idea of establishing a landscape water use sector was considered, but since landscape use is common in all these sectors, the WCAG acknowledged the Landscape Industry Council of Hawaiʻi (LICH), Landscape Irrigation Conservation Best Management Practices manual. Practices in the LICH manual can be applied within appropriate sector program elements.

A comprehensive list of sector-based BMPs was developed and the WCAG was led through a prioritization exercise to initially rank the BMPs based on specific criteria. CWRM and the project team devised implementation approaches for each of the BMPs. These implementation approaches were then prioritized based on the following factors consistent with CWRM's internal strengths and weaknesses as well as external threats and opportunities: ease of implementation, cost to CWRM, cost to "implementer," and whether the proposed BMP builds upon existing programs. The BMPs/implementation approaches were grouped into sector-based water conservation programs, and recommendations were made for program implementation and scheduling.

Implementation Plan

The Hawaiʻi Water Conservation Plan implementation section describes prioritization, scheduling, and resources needed to implement recommended water conservation programs. There must be a balance of incentives and policy to elicit changes across the water use spectrum. The cost of implementation (both staffing and financial) is a major factor on whether a program can be implemented or not. Benefit-cost analysis is one factor to consider when choosing a project for implementation. Because staff and funding are both limited, implementation of the plan will occur over time and can be advanced as more staff and funding are available. This phased approach to implementation will require wise use of State funds and may necessitate new approaches to working together to implement the BMPs.

CWRM's approach is to initially provide technical assistance and incentives where possible and to later establish or implement regulations and policies aimed at conserving and protecting our water resources. In this plan, there are a limited number of measures that are policy and/or regulation oriented and require certain actions by permitted water users over time. In most cases, however, CWRM intends to establish a conservation framework and invite voluntary participation by different user groups for purposes of awareness, demonstration, documentation, or to receive dedicated funding for water conservation. The underlying premise of the plan is to build upon existing water conservation efforts where they exist and ones that have high stakeholder interests and opportunities for cost-sharing, establish partnerships to encourage voluntary participation in CWRM-sponsored water conservation programs, and to foster understanding and support for water efficiency. Any regulatory enforcement should give the affected parties reasonable time to comply without severe economic hardship. Over time, as data collection on water use and water savings evolves, additional programs may become viable and funding may be dedicated to support additional water conservation programs.

The implementation plan describes a 10-year planning horizon. Two key implementation programs recommended for the first 2 years are: (1) procedure for conducting and requiring annual standardized water loss audit for municipal, military, and other public water systems, and (2) irrigation metering demonstration projects for agriculture irrigation systems. Providing technical assistance and guidance will help affected stakeholders prepare for and begin to comply with policy and regulatory measures over some reasonable period of time. If funding is available, CWRM will consider incentives to encourage the use of Water Sense/high efficiency plumbing fixtures and equipment as well as water efficient commercial equipment.

In addition to the recommended water conservation programs, CWRM will continue to expand its role in coordinating new and existing water conservation programs, improving our water use data collection capacity, exploring policy actions, and pursuing funding opportunities to increase program effectiveness.

Recognizing that some water users and sector groups are ahead of others in the implementation of water conservation measures, and in view of the current staffing and funding limitations of CWRM, this plan may also serve as a technical resource for water users to independently implement the prioritized BMPs identified in this plan. The recommended BMPs for each sector, along with a brief description, qualitative estimates of water savings and costs, and possible implementation mechanisms are provided in Section 7.1.2 of the Hawai'i Water Conservation Plan.

BMPs may also be considered and incorporated into long-range water use and development plans as a strategy for meeting future demands and promote sustainable water management. The various other State and County agencies responsible for developing and updating other water use and development components of the Hawaiʻi Water Plan are encouraged to incorporate appropriate water conservation BMPs as part of their long-range plans.

CWRM Role and Vision

This Hawai‘i Water Conservation Plan establishes the Water Conservation Program in CWRM. CWRM anticipates taking a lead coordination role for water conservation across the State while partnering and collaborating with the WCAG and interested stakeholders. Water conservation programs should complement existing water conservation programs or measures within stakeholder agencies and organizations. Water conservation policies should be developed and enforced giving affected parties reasonable time to comply with rules and regulations. Program success will depend on coordinating water conservation program implementation, sharing resources, and building upon small achievements. CWRM will pursue a sustainable funding strategy to implement the Hawai‘i Water Conservation Plan.

Regular water conservation plan updates and section revisions evaluate program effectiveness, reflect changes happening in the community or in governmental regulations, and other factors such as new technologies. A five-year update or revision to this plan is recommended.

Implementation

Commission staff completed the priority implementation action: irrigation metering demonstration projects for agriculture irrigation systems in 2014. This project was done in cooperation with the U.S. Geological Survey. Workshops were held on Kaua‘i, O‘ahu, Maui and the Big Island. These full-day workshops were comprised of a classroom session covering the theory of open-channel flow measurement. This was followed by a hands-on flow measurement exercise where participants learned to make velocity measurements and convert this to flow rates. Participants were invited from government and private sector.

This training effort has helped stream diverters to begin measurement of the amount of water they divert and report these measurements to CWRM on a monthly basis.

Commission staff also completed a pilot water audit training program in 2016, partially fulfilling the priority implementation action: procedure for conducting and requiring annual standardized water loss audit for municipal, military, and other public water systems. This program focused on Hawai‘i Public Utilities Commission (PUC) – Regulated drinking water utilities and reached 10 public water systems. The objective of this program was to train utility owners/operators to conduct water audits using the standardized American Water Works Association method of water audits.

CWRM’s water audit program was formally established by law when Hawai‘i Governor David Ige signed Act 169, SLH 2016, into law. Act 169 requires all county-owned public water systems, public water systems serving a population of 1000 or more, and public water systems in water management areas to submit annual water audits to CWRM. These audits are to be completed using the American Water Works Association’s free water audit software and Level 1 validated by a third-party. The Act requires CWRM to establish a water audit program and to provide technical assistance to affected utilities. The Act also authorizes federal and private funding to complete the purposes of the Act.

In 2017, CWRM began the Hawaiʻi Water Audit Validation Effort (WAVE) technical assistance and training program to help the approximately 100 affected public water systems meet the requirements of Act 169. The program includes workshops and follow-up technical sessions with the utilities culminating in completed audits for submission to CWRM. Level 1 validated audits from County-owned public water systems are due to CWRM on July 1, 2018 and Level 1 validated audits from the large capacity systems and those in water management areas are due to CWRM on July 1, 2020. The overall goal of the training is to help utilities build internal capacity to complete annual water audits and to utilize the results of the audits to address any issues discovered within their respective water systems. More information on this program is available online at www.Hawaiiwaterloss.org.

J.3 Other Water Conservation Plans and Programs

Fresh Water Initiative

Facing climate change and uncertainties in future fresh water availability, the Hawaii Community Foundation began its Fresh Water Initiative in 2013 to collaborate with multiple public and private parties to develop a water security strategy. A blue-ribbon panel of stakeholders was assembled to form the Fresh Water Council for the purpose of mapping out a secure water future for the State of Hawaii. The Council incudes representation from agriculture, government, private landowners and the scientific community. This collaboration resulted in the report: *A Blueprint for Action, Water Security for an Uncertain Future*. The report outlines three main goals statewide by year 2030: (1) 40 million gallons of water conservation; (2) 30 million gallons of water reused; and (3) 30 million gallons of increased ground water recharge. The Council has been successful working with Hawaii's legislature to pass bills supporting these three goals.

Bills passed by the 2016 Hawaii Legislature related to the Fresh Water Initiative include the following: Act 169, Relating to Water Audits; Act 170, Relating to Water Management; Act 171, Relating to Water Infrastructure Loans; Act 172, Relating to Water Security; Act 173 Relating to Hydroelectric Power; Act 174, Relating to Agriculture.

Act 172

Act 172, Session Laws of Hawaii 2016, requires the Department of Land and Natural Resources (DLNR) to establish a two-year pilot program for a Water Security Advisory Group (WSAG) to enable public-private partnerships that increase water security by providing matching state funds for projects and programs that:

1. Increase the recharge of ground water resources;
2. Encourage the reuse of water and reduce the use of potable water for landscaping irrigation; and
3. Improve the efficiency of potable and agricultural water use.

Act 172 also states that the WSAG shall advise DLNR on the priority of proposals for qualified projects or programs and recommend high-priority programs for the award of matching funds through this pilot program. The Legislature appropriated $750,000 of funding toward the implementation of Act 172.

To evaluate a proposal for a project or program that increases water security, Act 172 required the creation of a WSAG made up of:

1. The manager and chief engineer of the board of water supply for each county (or their designee);
2. The deputy director of the Commission on Water Resource Management;
3. A member with knowledge of agricultural water storage and delivery systems;
4. A member from a private landowning entity that actively partners with a watershed partnership;
5. A member with knowledge, experience, and expertise in the area of Hawaiian cultural practices; and
6. A member representing a conservation organization.

To solicit qualified individuals for the non-government seats, the Chairperson of DLNR issued a call for applicants via press a release on November 17, 2016 (http://dlnr.hawaii.gov/blog/2016/11/23/nr16-223/).

CWRM issued a request for proposals for projects under Act 172. Sixteen proposals were submitted and 11 selected for funding. These 11 proposals were approved by the Board of Land and Natural Resources at its June 9, 2017 meeting. More information is available on CWRM's website at: http://dlnr.hawaii.gov/cwrm/planning/watersecurity/ .

Under the State Water Code, CWRM is responsible for planning and coordinating a water conservation program. Outside designated Water Management Areas, the CWRM does not have clear authority to require the counties and other jurisdictions and interests to develop and implement water conservation programs and measures. County governments have the authority to institute mandatory conservation measures within their water systems, as necessary, by enacting the appropriate ordinances, rules, and regulations.

It is important for a statewide conservation program to be coordinated with the four counties, the Federal Government, and private interests. Coordinating different conservation programs requires planning and consultation, and successful program implementation requires widespread public participation and cooperation among government agencies, water users, water purveyors, and various community and special interest groups.

The basic goal of a water conservation program is to enhance the welfare of the people of the State through proper development, protection, control, and regulation of the water resources of the State for all beneficial uses. To this end, all water utilities and water agencies are encouraged to adopt policies, principles, and practices for efficient water use through a balanced approach, combining demand management with judicious source development.

To encourage water conservation programs, CWRM developed a prototype water conservation plan for five of the DLNR's facilities. The long-term intent of the *Prototype Water Conservation Plan for the Department of Land and Natural Resources* (February 2005) is to provide a framework for the development of water conservation plans for all State agencies, and to provide conservation program options and strategies for water purveyors throughout Hawai‘i. To facilitate State agency implementation of water conservation programs, CWRM developed the *Conservation Manual for State of Hawai‘i Facilities* (May 2007), which contains information on designing a program and water conservation guidelines for indoor domestic uses, landscaping uses, cooling and heating applications, and medical facility uses. The *Prototype Water Conservation Plan for the Department of Land and Natural Resources* and the *Water Conservation Manual for State of Hawai‘i Facilities* are available on CWRM's website at http://www.hawaii.gov/dlnr/cwrm/planning/conserve.htm.

J.3.1 DLNR Prototype Water Conservation Plan

The *Prototype Water Conservation Plan for the Department of Land and Natural Resources* was completed in February 2005. The plan was designed to serve as a pilot project, with potential application for the development of water conservation plans for typical government institutional facilities.

The DLNR Water Conservation Plan examines five selected facilities as models for other planning efforts. DLNR is an appropriate agency for piloting water conservation planning because the agency has multiple types of facilities and water usage characteristics (e.g., office buildings, baseyards, harbors, municipal/irrigation demands, potable/non-potable water systems). The plan addresses both potable and non-potable water demands, identifies appropriate water conservation measures, provides implementation schedules and budgets for the installation of water conservation measures, and recommends post-installation monitoring of water use.

The plan development was partially funded through the Water Conservation Field Services Program (WCFSP) administered by the U.S. Department of the Interior, Bureau of Reclamation. The WCFSP is designed to: encourage water conservation; assist water agencies to develop and implement effective water management and conservation plans, coordinate with state and other local conservation program efforts, and generally foster improved water management on a regional, statewide and watershed basis. The program emphasizes: water management planning, conservation education, demonstration of innovative technologies, and implementation of conservation measures. The Bureau of Reclamation's *Municipal and*

Irrigation (M&I) Conservation Plan Guidebook, which provides methods and measures aimed at improving overall water management, assisted CWRM in the scoping of the DLNR Water Conservation Plan.

The goals of the DLNR Water Conservation Plan are summarized for each facility as follows:

- **Kalanimoku Building:** Achieve a 15% water use reduction, estimate cost savings over the long term, and free up water supplies for additional uses.

- **Kakaʻako Waterfront Park:** Achieve a 15% water use reduction, estimate cost savings over the long term, and free up water supplies for additional uses.

- **Ala Wai Harbor:** Account for all water usage at the facility, achieve a 15% water use reduction, estimate cost savings over the long term, and free up water supplies for additional uses.

- **Honokōhau Harbor:** Account for all water usage at the facility, achieve a 15% water use reduction, estimate cost savings over the long-term, and free up water supplies for additional uses.

- **Hilo Baseyard:** Achieve a 15% water use reduction, estimate cost savings over the long term, free up water supplies for additional uses.

The plan recommends monitoring all conservation measures installed pursuant to the plan through metered water use (water billings).

As stated earlier, one of the key objectives of the project was to serve as a model for developing a statewide water conservation plan. Another goal was to develop an assessment approach and planning methodology that could be used in the formulation of facility water conservation plans. The development of facility-specific water conservation plans begins with understanding each facility's water usage. Creating and adopting a consistent assessment methodology to evaluate water usage and identify possible water conservation measures is the first step in developing a facility-specific water conservation plan. The water conservation assessment methodology could be used as a template by State agencies to conduct internal evaluations of their facilities (either by their in-house staff or by consultants).

The water conservation assessment methodology consists of the following basic steps:

1. Identify current water use at the facility:
   a. Complete a water system inventory to understand the facility's current water system layout.
   b. Gather past water consumption data (e.g., water billings, and water metering records).
   c. List all water uses including domestic, irrigation, maintenance, etc.
   d. Measure water quantities used on average in each water use category. This may require the installation of sub-metering systems to determine specific water usage throughout the facility.
   e. Identify significant water uses.

2. Identify existing conservation measures:
   a. List all existing water conservation measures.
   b. Assess existing water conservation measures and any previous attempts to implement conservation measures to understand relative success or failure.
   c. Identify areas without water conservation measures.

3. Identify applicable/practical water conservation measures:
   a. List potential water conservation measures to be considered.
   b. Discuss potential water conservation measures with facility staff.

4. Complete cost-benefit analysis and environmental assessment of potential water conservation measures:
   a. Develop projected water conservation plan implementation costs.
   b. Develop estimated water savings based on water conservation measures selected.
   c. Evaluate water conservation plan feasibility through cost /benefit analysis.
   d. Complete environmental assessment identifying resources and any possible negative impacts.
   e. final recommended water conservation plan based on cost/benefit and environmental analysis.

5. Create a conservation plan implementation schedule:
   a. Develop a timetable of interim and long-term conservation measures for agency implementation.

6. Develop initial steps to be taken by facility:
    a. Consider installing sub-metering systems to monitor water usage.
    b. Identify implementation costs, including labor.
    c. Identify activities for monitoring performance and results.
    d. Educate facility staff on water conservation measures.
    e. Post signs to educate water users on water conservation.
    f. Post signs identifying contacts if facility is in need of repair.

The State should lead by example through the development of facility-specific water conservation plans for State agencies. Cooperative efforts between the State and counties can enhance program development and expand its application. General recommendations of the DLNR Water Conservation Plan include:

- Government agencies should pursue public/private partnerships to increase public awareness and to implement and promote water conservation efforts.

- Each State facility/site should designate a project manager to develop and implement a site-specific water conservation plan.

J.3.2 Water Conservation Manual for State of Hawaiʻi Facilities

On January 20, 2006, Governor Linda issued Administrative Directive No. 06-01 requiring all State agencies and programs to increase their commitment towards implementing innovative and resource efficient operations and management. Examples of better management practices cited in this directive include:

- Reduced energy and water use;

- Reuse and recycle options;

- Improved construction and demolition waste management;

- Environmentally preferable purchasing;

- Efficient use of transportation fuels, especially greater use of alternative fuels; and

- Increased incorporation of sustainable building practices.

New State facilities and augmentations to existing facilities are to be designed and constructed to meet and achieve certification requirements of the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) standards. State agencies are specifically directed to implement water and energy efficient operational practices to reduce waste and increase conservation.

The *Water Conservation Manual for State of Hawai'i Facilities*, developed by CWRM in 2007, contains information and guidelines to help State agencies comply with Administrative Directive No. 06-01. The manual provides detailed information on how to implement water efficient practices at State buildings and facilities. The conversion of State buildings and facilities to water-efficient status will assist State agencies in their efforts to obtain LEED certification, as required by the Governor's directive.

J.3.3 State Department of Accounting and General Services

- The Hawai'i Department of Accounting and General Services (DAGS) issued an Energy Savings Performance Contract for 10 State office buildings in the Capitol District. This contract (Capitol District - Energy Savings Performance Contracting (ESPC), Phase 1 Buildings - DAGS Job No. 52-10-0599) included energy and water benchmarking, retrofit of electrical and water fixtures and devices with more efficient ones, estimation of energy and water savings. These are some project highlights: State Capitol District including 10 buildings covering approximately 1.3 million square feet.

- Buildings include: Kalanimoku, Ke'elikolani, Kekaulu'ohi, Kekuanaoa, Ke'oni 'Ana, Kinau Hale, Lili'uokalani, No. 1 Capitol District (Hemmeter), State Capitol, Leiopapa-A-Kamehameha.

- Project size: $33.9 million constructed in FY2010 and FY2011.

- Creates an estimated $1.5 million in State Tax Revenue in FY2010 and FY2011 with an additional $1.7 million over the next 20 years.

In 2013, DAGS issued another ESPC to retrofit 33 State-owned buildings across all major Hawaiian islands with energy and water savings equipment and fixtures. This project is expected to save DAGS $28 million in operational costs over the 20-year contract period.

J.3.4 County Conservation Programs

In general, the counties practice conservation by protecting watershed areas in order to realize dependable yields. Counties also practice conservation by reducing system leaks and losses, adopting universal metering, encouraging or requiring the installation of devices to reduce water use, implementing public education programs, adjusting water rates to influence demand, and as a last resort, rationing water use during severe shortages.

Water conservation can be beneficial to a water utility and its customers by reducing demand in dry years and prolonging short supplies during other emergency conditions. Efficient water use can also result in energy savings, particularly on hot-water use. It has been estimated that hot-water use can be reduced by almost one-third through effective water conservation measures.

Reduced water use also results in energy savings, as less water must be treated and distributed throughout the system. Moreover, water conservation within the home and in industry decreases the volume of wastewater flow. This, in turn, reduces treatment and collection system costs. In Hawaiʻi, reductions in pumping costs could be significant, and deferred development of new water sources will postpone capital improvement costs.

In planning a water conservation program, a water utility should consider some of the potential disadvantages involved. One of these considerations is the reduction of revenues, the effect of which is felt almost immediately. Less revenue may postpone needed capital improvements, which means the utility could later face higher construction costs.

However, water conservation can also make water available to service undeveloped areas. Water conservation and land-use planning efforts should be coordinated so as to avoid inadequate water availability for future use.

Water conservation cannot be regarded as a substitute for a utility’s obligation to maintain an adequate reserve capacity. Without adequate reserves, water shortages may become more frequent, and drought impacts may threaten public health.

Many states and municipalities throughout the continental United States have developed water conservation programs with varying degrees of success. Noteworthy programs have been implemented in cities such as Denver, Oakland, Los Angeles, and Washington, D.C.

The counties of Maui, Kauaʻi, Hawaiʻi, and the City and County of Honolulu have independently undertaken water conservation programs and strategies. Their conservation efforts are summarized below.

J.3.4.1 Maui Department of Water Supply Conservation Program

The Maui County Department of Water Supply (DWS) maintains 750 miles of water lines, 145 storage tanks with 295 million gallons of water storage capacity, six water treatment facilities, and 35 ground water sources for 35,753 customers. DWS employees maintain the water system 24/7. The DWS also works hard to sustain its water resources for the long term. We work closely with the State to ensure that our sources are protected for the public trust, that our customers will have continuous and reliable water supply.

The DWS is developing and expanding its water conservation program, which includes both supply side and demand side measures.

Supply Side Water Conservation Measures

Supply-side measures to date include leak detection, preventive and predictive maintenance, use of reclaimed water and alternate system backups and resource protective measures.

(1) Leak Detection

An effective leak detection program is critical to identify unaccounted for water in order to proactively prevent as much water loss as feasible. There are major benefits to having a leak detection program that include the ability to: respond more quickly to identified leaks; find “hidden” leaks creating ongoing water loss; reduce pressure, especially during low demand; and replace aging and weakened pipe. A total of 361 miles of transmission lines were surveyed from FY 2008 - 2013; 88 leaks were found and repaired (mostly in the Central Maui area).

(2) Preventive & Predictive Maintenance

This is two pronged. Facilities are regularly maintained and pumps are periodically calibrated. In the course of such maintenance, facilities are regularly checked for signs of wear. DWS also has a system inventory with age, diameter and material of lines and other facilities. Based upon the status and performance of system facilities, upon known inventory status and demand trends, DWS maintains a 30-year project list. This can help to reduce unaccounted-for water in the system by targeting old and substandard lines for replacement.

(3) Reclaimed Water Use

About 3.905 MGD is in use countywide with 1.8 MGD utilized in South Maui. As part of its Water Use & Development Plan process, DWS is currently investigating the costs and benefits of large scale capital investment to further expand reclaimed water use to offset potable use.

(4) Back-up Sources

In the event of a major leak, most areas of the Central system can be served by other sources so that any key portion of system could be valved off at need.

(5) Watershed & Resource Protection

DWS has provided financial support to seven Watershed Partnerships on Maui and Molokaʻi to ensure upland watersheds are fully functioning so fresh water resources can be utilized and enjoyed by the people of Hawaiʻi in perpetuity. Since 1995, we have provided $8.12 million dollars of funding to seven Watershed Partnerships comprise a total number of 54 of partners. All of these partners, including the County and State entities, are working in partnership to protect over 150,000 acres located within a key watershed area critical to future DWS water source protection, development and recharge.

The Watershed Partnerships collectively address a variety of threats to the watershed including activities such as ungulate control through fencing and targeted hunting practices; eradication of invasive weeds and plants; reforestation and vegetation of upland areas and other habitats critical to the recharge and protection of water supply; and suppression and management of wildland fires resulting in the loss of forests.

These efforts have successfully resulted in essential tangible outcomes and deliverables and include: fence installation, maintenance and monitoring resulting in a reduction in feral animal populations; eradication if invasive weeds and plants (nearly 35,000 acres); hunting programs with native species of plants and trees; documentation, protection, and research of rare species; establishment of volunteer programs in all watersheds; interpretive hikes and field studies; resource monitoring and mapping; installations of trails, camps, and helicopter landing zones; educational presentations and displays at public events and schools; and landscape level watershed protection through the protection and out-planting of native plant species and County-wide community garden projects.

<u>Demand Side Water Conservation Measures</u>
Demand-side measures to date include low flow fixture distribution, a tiered rate structure, public education and outreach programs, and regulations as well as resource protection. Ongoing planning efforts are evaluating the benefits and costs of increased aggressiveness in these efforts.

(1) Low Flow Fixture Distribution
To date DWS has given out 38,207 low flow showerheads, 40,686 bathroom aerators, 25,747 kitchen aerators, 24,016 self-closing hose nozzles, 3,957 toilet tank bags (displaces .8 gallon per flush) and many more leak detection dye tablets, vs. a customer base of about 35,000 meters.

(2) Water Audits/Retrofits
The Department co-funded its first direct install retrofits in the late 1990s with low flow toilets. However, no large scale programs were funded. More recently, smaller retrofit projects of high efficiency toilets have been installed in various County properties.

With the encouraging results of the Department of Water Supply's various retrofit projects, DWS decided to retrofit the entire Kalana O Maui (Maui County) building. DWS constantly asks the community to conserve water. Implementation of this project would show the public that the county is doing its part in conserving its finite water resources.

The Maui County Building is a nine-story structure built in 1971. Typical of most office buildings, the majority of water use within the Maui County building comes from domestic uses (e.g toilets, urinals, sinks, drinking fountains, etc.) and the surrounding landscapes which are irrigated by an existing irrigation system with 6 sprinkler heads with timer and most of the time being watered manually.

There were 45 3.5-GPF toilets, 18 - 3.0-GPF urinals, and 56 3.5-GPM bathroom faucets in the Maui County Building. These fixtures were replaced with 1.28-GPF toilets, 0.5-GPFurinals and faucets were installed with 1.5-GPM aerators. Overall savings was estimated at 63%.

The Water Use & Development Plan, currently in development, is evaluating the costs and benefits of high efficiency fixture rebates and direct installation programs as part of the Water Conservation Program. Ongoing trials will help to provide some preliminary data on the effectiveness of some of these options. Longer term options for the future may also include review of various means of sub-metering multi-family units and multi-purpose buildings. Studies indicate that metering un-metered units is among the most effective conservation measures, by billing explicitly for water use rather than hiding this cost in the rent.

(3) Water Conservation Pricing

DWS currently has a tiered rate structure to encourage conservation (Maui County Code Chapter 14.10). Data improvements under way could enable the Department to move toward a more aggressive tier structure.

(4) Regulations Related to Water Conservation

Maui County has the following existing regulation and rules that support water conservation:
1) Prohibition of discharging cooling system water into the public wastewater system (Maui County Code Title 14, Chapter 14.21A.015);
2) Plumbing code regulations that require low flow fixtures in new development (Maui County Code Title 16.20B);

3) Requirements that all commercial properties within 100' of a reclaimed water line utilize reclaimed water for irrigation and other non-potable uses (Maui County Code Title 20, Chapter 20.30.020A);
4) A water waste prohibition with provision for discontinuation of service where negligent or wasteful use of water exists (Maui County Code Title 14, Chapter 14.03.050);
5) A provision enabling the Water Director to enact special conservation measures in order to forestall water shortages (Maui County Code Title 14, Chapter 14.06.020).

In addition, a comprehensive conservation ordinance has been drafted, is planned to be included as part of the Maui Island Water Use and Development Plan and may be implemented in stages (Maui County Code Title 14, Chapters 14.02 and 14.03)

(5) Public Education & Outreach Activities

- Public Advertising - Conservation marketing efforts include public ads that run on local radio stations and newspapers to encourage water conservation. In FY 13 DWS entered into a Memorandum of Agreement (MOA) with the Honolulu BWS to implement a Summer Water Conservation Program. This program is a multi-agency partnership to conserve water in Maui County and the City and County of Honolulu. A total of 1,278 conservation ads were aired on local and cable TV stations. Similar MOA was executed for FY 14.

- Annual Water Conservation Poster Contest – This project is on its 5th year. A total of 1,713 public, private and home-schooled students participated in the last four years. Winning and honorable mention entries are featured in the DWS Water Conservation Calendar.

- Native Plant Giveaway – DWS provides native, drought tolerant plants to the public. This is to encourage the use of less thirsty and appropriate plant in their area. Plants are given away at the annual Maui County Fair, Maui Contractors Association's Home Expo, Arbor Day and other community events. Maui Nui Botanical Gardens is the source of native plants for Department outreach projects and give-aways as part of its grant agreement.

- Community Gardens – DWS supported the following community garden projects by providing native plants, irrigation materials, installation and staff hours:

- Ka Hale O Keola Homeless Resource Center; UH-Maui College –Sustainable Living in Maui Community Garden; Lahainaluna High School Garden Project; Greenhouse; Pomaikai Elementary School Garden Project; and Wahikuli Rain Garden.
- Permit Review - The permit review process is also utilized as an educational tool, with use-specific conservation and site specific recommendations included in each review.

- Community Events - The DWS participates in various public events every year, such as the Maui County Fair, Earth Day, Arbor Day, Maui Contractors Association's Home Expo, and East Maui Taro Festival.

- Expanded education and marketing efforts under consideration include targeted marketing survey and campaign development, a hotel awards program, a building manager users group, and an agricultural users group.

(6) Water Conservation and Landscaping

Located in Wailuku, Maui DWS co-funds operations of the Maui Nui Botanical Gardens, and funded construction of its nursery and portions of other facilities and displays. This provides a resource for promoting expertise in propagating and maintaining native plant materials, helps to increase the potential marketability of appropriate native plants, promotes a water conservation ethic, provides training on appropriate propagation, planting, irrigation and maintenance techniques, and generally helps to increase the likelihood of successful appropriate landscapes with a "Hawaiian Sense of Place". It also helps to protect watersheds by promoting native and non-invasive plants over potentially invasive species, providing for educational opportunities on the importance of the watershed and how to protect it, and serving as a major demonstration and educational facility.

DWS developed (with help from the County arborist committee) and disseminated a brochure entitled “Saving Water in your Yard, What and How to Plant in your Area”, which is distributed by the Maui Nui Botanical Garden as well as by the Department at events and with permit reviews. Future plans for landscape conservation include a conservation ordinance, landscape audit and retrofit program and smaller satellite demonstration projects. DWS is also investigating the costs and benefits of major capital expenditure in reclaimed water transmission to offset use of potable water in South Maui landscapes. The pending conservation ordinance includes mandatory watering schedules and irrigation efficiency measures among other requirements.

(7) The Pre-rinse Spray Valve Trade-Out Program

This program is designed to replace 200 high water use spray valves with high efficiency, low water use spray valves. Older, less efficient spray nozzles typically use about 4 to 6 gallons per minute. This program can reduce the volume of rinse water to 1.6 gallons per minute and result in substantial savings per nozzle replaced. Water use for rinsing is reduced by up to 60 percent and energy use for hot water reduced by up to 60 percent. This program will be available until there is 100% market penetration. Nozzles will be available for trade-out similar to our other fixture programs.

Ongoing Water Conservation Planning Efforts

Source options considered as part of the Water Use and Development Plan process will include consideration of extensive conservation measures as a source supply. In order to displace or delay source development an aggressive program is required. Preliminary design of such a program is ongoing as part of the Water Use & Development Plan process. Anticipated program elements include targeted audit and direct install programs, rebates and incentives, expanded conservation requirements for landscaping, and other uses, expanded marketing efforts including user groups, such as a hotel awards program, a building manager information program, agricultural user working groups/services, as well as energy production and efficiency measures, continued watershed protection and restoration and possible major capital expenditure to support reclaimed water use.

J.3.4.2 Honolulu Board of Water Supply Conservation Program

The Honolulu BWS manages an integrated island-wide water system that serves all parts of Oʻahu. The system pumps an average of 150 million gallons of ground water per day from wells, shafts, and water tunnels. To protect the long-term viability of ground water resources on Oʻahu, the Honolulu BWS has adopted an integrated approach to ensure a sustainable water supply, by balancing the needs of the community, the economy, and the environment.

Pursuant to the goal of sustainability, the Honolulu BWS’s water conservation program seeks to foster effective water management policies and practices that reduce per capita use of potable water through resource management, supply system optimization, and consumer education. The program applies the following strategies:

- Public education and outreach;
- Leak detection, repair and maintenance;
- Large water user programs;
- Regulation; and
- Alternative source development, recycling, and conservation alternatives.

The Honolulu BWS conducts extensive outreach and educational programs and participates in community events to promote resource protection and increase collective awareness of the importance of water. The Honolulu BWS strives to assist in the development of water awareness and implementation of conservation efforts through educational programs that can be described under four program headings:

- **Public Education Program:** This program targets both adults and children through printed materials, the Water Conservation Week Contest for elementary school children, public service announcements and television/radio/print interviews, public speaking engagements, and participation in a number of community events and activities. Group tours of watershed areas, the Hālawa Xeriscape Garden, and the Honouliuli Water Recycling Facility are also offered.

- **School Education Program:** Teachers and students from preschool through high school are provided with publications, brochures, and other media explaining O‘ahu's water resources. Water conservation information, statistical reports, and summaries are also provided. Other publications provide students with a comprehensive understanding of water and water systems nationwide. The Honolulu BWS sponsors a Water Conservation Week Poster Contest for public and private elementary schools on O‘ahu, and participates in the Hawai‘i State Science and Engineering Fair by sponsoring water quality and water conservation awards. Classroom visits and speaking engagements are also done by BWS staff.

- **Watershed Education Program:** This program is designed to teach people in the community about the importance of healthy watersheds to replenish ground water resources. Watershed and forest protection, active stewardship of the land, and public and private partnerships are emphasized. Participants include State, City and County of Honolulu agencies, community groups, and school and environmental organizations.

- **Community Education Program:** Community education efforts include the Honolulu BWS Neighborhood Board Liaison Program, which encourages grass roots involvement and relationships between the Honolulu BWS and O‘ahu communities. Volunteer neighborhood representatives have a personal Honolulu BWS contact for information, concerns, and inquiries. The Honolulu BWS participates in community events such as the Aloha Fun Run/Health and Fitness Fair, Building Industry Association Show, Food and New Products Show, Farm Fair, and City-sponsored "Sunset" events (e.g., Sunset on the Beach, Sunset on the Plain, Sunset in the Park).

The Honolulu BWS provides assistance to watershed partnerships, agencies, and organizations through the Watershed Management Partnership Program. Project proposals for grant awards are submitted to the Honolulu BWS for consideration. To be eligible for the program, projects must be located on Oʻahu and should be relevant to watershed studies, watershed resource protection, educational outreach for watershed management and protection, invasive species control, forest protection, or water conservation activities.

The Honolulu BWS also utilizes the agency's website for conservation education and outreach. The "Kid's Corner" page includes interactive, educational activities designed for children. The website's conservation page includes information and links for consumer conservation measures inside and around the home, information on the Ultra-Low Flush Toilet Rebate Program, xeriscaping resources and planting guide, and a registry of nurseries that grow "less thirsty" plants.

The agency also provides a Water Waste Hotline (808-748-5041) for the public to report broken water pipes, a malfunctioning irrigation sprinkler, faucets left running, or other water waste.

J.3.4.3 Kauaʻi Department of Water Conservation Program

The Kauaʻi Department of Water (DOW) operates 11 separate, unconnected water systems from Kekaha to Haʻena. Kauaʻi DOW monitors, operates and maintains 50 deep well pumping stations, 19 booster pumping stations, 4 tunnel sources, 58 storage tanks, and 75 control valve stations. Approximately 21,500 accounts are served through 400 miles of pipeline.

In 2001, the Kauaʻi DOW implemented its Water Plan 2020 project – a comprehensive long-range plan to replace or repair aging infrastructure throughout the island. The plan guides the Kauaʻi DOW for future operations and identifies the needed improvements required to continue in providing safe, affordable and reliable water service to the community in a sustainable and financially secure manner. Water conservation plays an important role in this plan and in the Kauaʻi DOW's overall mission.

Current Supply-Side Conservation Programs:

- **100% Customer Reading:** Currently all customer accounts are metered, including temporary fire hydrant meter and temporary construction meter accounts. Separate landscape meter services are available from the Kauaʻi DOW depending on the availability of adequate water supply.

- **Meter Replacement, Repair, and Defective Meter Programs:** All water supplied by the Kauaʻi DOW is measured by suitable water metering devices. The Kauaʻi DOW maintains a water-meter-shop test and repair program. According to standard operating procedures, testing of all 5/8 inch displacement water meters that were not tested within 10 years is required. Removed meters should be replaced with new or re-built meters. Large meters (compound, propeller, torrent, turbine and crest meters) should be tested every two years. Potential defective meters are reported by the Billing Section of the Fiscal Division for replacement or repaired by the Operations Division.

- **Non-metered Water Analysis Report:** The non-metered water estimates are valuable in deciding whether a leak detection program is justified. The report is designed to monitor source/supply production and customer consumption on a bi-monthly basis. The difference between metered source production and metered sales to consumers is the non-metered water that is pumped into the system but not sold. Non-metered water includes line flushing, reservoir cleaning, firefighting, sewer flushing and street cleaning, and it's also a result of leaks, unauthorized water use, and inaccurate metering. The Fiscal Division monitors the report and informs the Operations Division if non-metered water is excessive.

- **Leak Detection Program:** The Kauaʻi DOW conducts case-by-case leak detection investigations and repair for suspected section of leaking pipeline. The Kauaʻi DOW is evaluating the purchase of leak detection equipment and/or use of contracted leak detection services to expand its program.

- **Storage Tank Reservoir Overflow Alarm and Automatic Level Controls:** The Department maintains and operates tank overflow alarms and automatic valves to prevent system losses to unnecessary overflows.

Current Demand-Side Conservation Programs include:

- **Plumbing Code Regulation:** In July 1993, the County of Kauaʻi amended the County Plumbing Code to require the installation of water saving fixtures for new construction. The plumbing code also requires installation of pressure reduction valves in order to maintain a maximum 80-pound per square inch building service pressure.

- **Voluntary Emergency Water Shortage Notice:** The Kauaʻi DOW requests voluntary water conservation during dry periods and emergency water outages. High consumption during dry summers has resulted in distribution of water shortage notices for affected areas. Water customers are asked to voluntarily reduce consumption by 10-25% in systems that are unable to meet higher peak demands. During emergencies (i.e. pump failure, pipeline breaks, storm damage, etc.) water conservation notices are issued to customers.

- **Public Outreach/Education Program:** Kauaʻi DOW's existing and future water conservation programs involves targeting both adults and children through printed brochures, advertisements, public service announcements, presentations, workshops and other media. Every year, the Kauaʻi DOW coordinates an island-wide water education festival for fifth grade students called, Make a Splash with Project WET (Water Education for Teachers). Project WET is an international-interdisciplinary-environmental education program. This festival brings together parents, students, teachers, government resource agencies and enthusiasts of all kinds for a common goal: to educate and promote awareness of water resources in a fun and interactive environment. Learning stations and exhibits are set up and led entirely by volunteer Kauaʻi DOW employees, educators and community members.

The Kauaʻi DOW's current conservation promotions include:

- Low Flow Shower Head Distribution
- Low Flow Kitchen Aerator Distribution
- Shower Timer Distribution
- Leak Detection Tablet Distribution
- Public Education – Presentations; Community Events; Publications and Brochures; School Programs

Information on conservation measures and other public outreach materials listed below are accessible through the Kauaʻi DOW's website, www.Kauaiwater.org.

- Water conservation brochure "35 Tips to Save Water"
- Table tents for restaurants, "Water served on request only"
- Free low-flow water fixture forms
- Tips for conserving water around the house and outdoors
- Leak detection and instructions on fixing a leaky faucet
- Xeriscape resources and information on DOW's demonstration project at the agency's Lihue office
- Kids page with educational activities

- Public education programs for schools, clubs, and organizations

J.3.4.4 Hawai‘i County Department of Water Supply Conservation Program

The County of Hawai‘i’s Department of Water Supply provides domestic water service via 24 water systems and 67 sources located throughout the island. The individual water systems are not interconnected, except in the more densely populated districts of South Hilo and Kona. The Department of Water Supply services approximately 35,000 customers with about 8.5 billion gallons of water annually.

The Hawai‘i County water rates are designed to encourage conservation through an inverted-block rate structure, which charges higher unit costs for heavy water users. The Department of Water Supply has also published educational brochures and handouts that are available to the public. During periods of drought or low rainfall, the department may publish water conservation notices in local newspapers and include notice inserts in customer’s water bills. These notices typically call for a voluntary reduction of domestic use by 10% and restrict agricultural irrigation to the hours between 8 p.m. and 6 a.m. Water conservation notices also includes tips on how to reduce water to meet the 10% voluntary reduction. If subsequent use reductions are insufficient, the department may issue notices for mandatory use reductions until the water supply situation has stabilized.

J.3.4.5 Military Water Conservation Programs[5]

The U.S. Department of Defense does not have a department-wide water conservation program, but each division follows the respective governmental requirements. Military installations throughout Hawai‘i have been required to conserve water through various mandates including recent Executive Orders. Some examples are the installation of electric water meters and reductions of water usage by a specific amount each year. There currently is not a document adopted by all military branches that describes a water conservation plan.

Federal agencies must also improve their water efficiency and management by the following:

- Reducing potable water consumption intensity 2 percent annually through fiscal year 2020, or 26 percent by the end of fiscal year 2020, relative to a fiscal year 2007 baseline.

- Reducing agency industrial, landscaping, and agricultural water consumption 2 percent annually, or 20 percent by the end of fiscal year 2020, relative to a fiscal year 2010 baseline.

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[5] CH2MHILL. 2013. *Hawai‘i Water Conservation Plan Final Report*. Prepared for Commission on Water Resource Management. February 2013

- Identifying, promoting, and implementing water reuse strategies consistent with state law that reduce potable water consumption.

There may be opportunities to partner with military housing contractors to implement water conservation programs and practices within the housing communities.

J.3.5 Recommendations for Water Conservation Programs

As described above, several State and county agencies currently implement various water conservation programs and measures. Private businesses and organizations (e.g., Hawai‘i Green Business Program, Landscape Industry Council of Hawai‘i, Hawai‘i Lodging and Tourism Association) have also incorporated water conservation in their daily operations and program activities. The State recently developed the Hawai‘i Water Conservation Plan, which covers all sectors of water use for government agencies and private entities. The following are recommended:

- The Commission on Water Resource Management should continue to implement recommendations in its Hawai‘i Water Conservation Plan (http://state.hi.us/dlnr/cwrm/planning/hwcp2013.pdf)

- The Commission on Water Resource Management should convene the Water Conservation Advisory Group at least once a year to develop and implement water conservation initiatives and programs in all water use sectors.

- The Commission on Water Resource Management should continue to work with the State Building Code Council as well as individual County building departments to adopt higher water efficiency standards in the building and plumbing codes.

- The Commission on Water Resource Management should pursue water conservation program funding through the state budgeting process, exploring sustainable funding mechanisms, grants, and cost-sharing with other government agencies.

- The Commission on Water Resource Management should support and assist the development and implementation of individual water conservation plans for government and the private sector.

- The Commission on Water Resource Management should explore ways to incorporate water conservation planning into its regulation and permitting processes.

- Existing and developing State agency conservation efforts should be identified in the next update of the SWPP. The SWPP should also suggest specific agency conservation goals and actions.

- Water users and water system operators should consider recommended BMPs for independent implementation as water conservation has been shown to be a cost-effective strategy for stretching limited water supplies.

- The agencies responsible for preparing other Hawai‘i Water Plan components should incorporate appropriate water conservation measures as part of their resource strategies to meet existing and future demands.

- State agencies should conduct facility water audits and implement appropriate water conservation measures to reduce water demands and achieve cost savings.

- Promote Administrative Directive No. 06-01 requiring all State agencies and programs to increase their commitment towards implementing innovative and resource efficient operations and management.

- Because water in Hawai‘i is relatively inexpensive compared to energy costs, the water-energy nexus in Hawai‘i should be further studied to incentivize water conservation through the reduction of energy usage. This is elaborated further in the following section.

- Water and land use planning efforts should be coordinated to avoid inadequate water availability for future land use.

- Support the Fresh Water Initiative and goals identified in the report: A Blueprint for Action, Water Security for an Uncertain Future.

J.4 Water-Energy Nexus

Water and energy systems are inextricably linked in modern society. This is true for both drinking water and wastewater systems. For the majority of drinking water systems in Hawai‘i, energy is used to pump ground water from wells and to lift this water to elevated reservoirs in order to provide water service to customers. In the case of wastewater, energy is used to pump wastewater to treatment plants where more energy is used for the treatment and disposal and/or reuse of recycled water. Water is also used in energy production in Hawai‘i where electricity power plants use water for steam generation and cooling. This water-energy connection is referred to as the water-energy nexus.

The water needed for energy production is referred to as water “embedded” in energy and the energy needed for water supply and wastewater treatment is referred to as energy “embedded” in water. It is not precisely known how much energy is embedded in water and how much water is imbedded in energy in Hawai‘i. We do know that conserving water conserves energy both from the water supply and wastewater disposal ends of the use cycle.

Hawaiʻi Energy estimated that in 2013 the state's public water and wastewater utilities consumed an estimated 290.3 million kilowatt-hours (kWh) per year amounting to around 3.2 percent of total electrical utilities' sales.[6] The U.S. Geological Survey estimated that in 2005 statewide withdrawal of fresh ground water for thermoelectric power was 37.8 million gallons per day.[7]

The substantial amount of energy used by water and wastewater utilities and the volume of water used for energy production presents opportunities for utilities to find ways for conserving both water and energy by improving efficiencies in their production processes. Water and wastewater utilities should conduct energy and water audits to inform their decision making.

J.4.1 Programs

There are very few programs targeting combined water-energy conservation in Hawaiʻi. Some county water utilities have low-flow showerhead and/or low-flow pre-rinse spray head giveaways. This will help to save both hot and cold water and would also help to reduce energy demands to heat the water.

State and County government allows agencies to enter into energy (and water) savings performance contracts (ESPC). An ESPC is a contractual arrangement where the contractor finances a facility's capital energy and water efficiency improvements and is paid on a schedule for achieving energy and water saving performance goals in the facility. Hawaiʻi Department of Business, Economic Development and Tourism found that there were eight state and county ESPC projects initiated since 1996 including 242 buildings. These projects realized an annual cost savings of $44.0 million for all projects combined (an average of 39% savings).[8]

Hawaiʻi Energy is a ratepayer-funded energy conservation and efficiency program under contract with the Hawaiʻi PUC serving the islands of Oʻahu, Maui, Molokaʻi, Lānaʻi, and Hawaiʻi. Hawaiʻi Energy is exploring ways to partner with water and wastewater utilities to improve energy efficiency and developed the *Water & Wastewater Energy Management Best Practices Handbook, Hawaiʻi Edition, April 2014*.[9] This handbook outlines steps to be taken to develop a utility energy management program.

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[6] 2014, July 28, Hawaiʻi Energy, DLNR Release Two New Handbooks to Encourage Water Conservation and Greater Energy Efficiency [News Release], Retrieved July 29, 2014, from http://dlnr.Hawaiʻi.gov/cwrm/

[7] Kenny, J.F., Barber, N.L., Hutson, S.S., Linsey, K.S., Lovelace, J.K., and Maupin, M.A., 2009, Estimated use of water in the United States in 2005: U.S. Geological Survey Circular 1344, 52 p.

[8] Hawaiʻi Energy Facts & Figures May 2014 [slide presentation], Retrieved July 29, 2014, from http://energy.Hawaiʻi.gov/resources/Hawaiʻi-state-energy-office-publications

[9] April 2014. Hawaiʻi Energy. Water & Wastewater Energy Management Best Practices Handbook, Hawaiʻi Edition. Retrieved July 30, 2014 from http://www.Hawaiʻienergy.com/water-and-wastewater.

CWRM developed the *Hawaiʻi Water System Audits and Water Loss Control Manual, February 2014*.[10] This manual is a how-to guide for drinking water utilities to conduct a comprehensive water audit and to determine intervention strategies to reduce system water losses within its system (from the water sources up to the customers' meter). Controlling system water losses and efficiencies is referred to as internal water conservation. Water system loss control can lead to decreased pumping of water thereby reducing the amount of energy consumed by the utility.

J.4.2 Gaps

There is a limited data compiled on the actual amount of water embedded in energy and energy embedded in water. This is true for Hawaiʻi as well as across the United States. There needs to be better understanding of the energy consumption of a unit measure of water for the development, delivery, treatment and disposal of water in Hawaiʻi. This is also referred to as the energy intensity and can be expressed in terms of kilowatt-hour per million gallons (kWh/mg).

Another challenge is coordinating energy efficiency programs and water efficiency programs, which are typically run by the energy or water utilities independent of the other. There could be improved program delivery and return on investment if the energy and water programs are integrated or offered collaboratively.

J.4.3 Recommendations

While Hawaiʻi is an island state, it shares many of the challenges that the continental U.S. faces when it comes to improving collaboration between the water and energy industries and organizations. It is helpful to look for examples of work addressing these concerns. The Alliance for Water Efficiency collaborated with the American Council for an Energy-Efficient Economy to prepare the report *Addressing the Energy-Water Nexus: A Blueprint for Action and Policy Agenda*.[11] This report was a result of a series of workshops attended by a diverse group of individuals form water and energy organizations and outlines a blueprint for advancing water and energy efficiency programs and policies. The following thematic elements are from the *Blueprint for Action*:

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[10] February 2014. Commission on Water Resource Management. Hawaiʻi Water System Audits and Water Loss Control Manual. Retrieved July 30, 2014 from http://files.Hawaiʻi.gov/dlnr/cwrm/planning/hwam2014.pdf

[11] Alliance for Water Efficiency and American Council for an Energy-Efficient Economy. (2014 May). Addressing the Energy-Water Nexus: A Blueprint for Action and Policy Agenda. Retrieved July 29, 2014 from http://www.allianceforwaterefficiency.org/water-energy-intro.aspx

1. Increase the level of collaboration between the water and energy communities in planning and implementing programs.
2. Achieve a deeper understanding of the energy embedded in water and the water embedded in energy.
3. Learn from and replicate best practice integrated energy-water efficiency programs.
4. Integrate water into energy research efforts and vice versa.
5. Separate water utility revenues from unit sales, and consider regulatory structures that provide an incentive for investing in end-use water and energy efficiency.
6. Leverage existing and upcoming voluntary standards that address the energy-water nexus.
7. Implement codes and mandatory standards that address the energy-water nexus.
8. Pursue education and awareness opportunities for various audiences and stakeholders.

The elements above were developed for the continental U.S. where the energy and water infrastructure is interconnected across state lines and where western water laws apply. However, all of these thematic elements are relevant in the state of Hawaiʻi and could be adopted wholesale as recommendations for Hawaiʻi.

In addition to the general recommendations above, CWRM should gain a better understanding of Hawaiʻi's water-energy nexus by conducting detailed audits to determine water demands for the generation of electricity (embedded water) and energy demands for providing drinking water and for treating wastewater (embedded energy).

Hawaii Water Energy Nexus Report

In an effort to understand the true cost of water and energy production to utilities, the State of Hawaiʻi DLNR CWRM surveyed water, wastewater, electrical and renewable energy purveyors throughout the State. The intent of the survey was to characterize, compare and provide a baseline for water and energy use for the operation of the various utilities over the 2014 and 2015 calendar years. A total of 137 utility companies were identified and contacted for participation in the study. Entities were identified based on registration with the PUC, DOH, and/or CWRM. Systems requiring little to no energy use, such as individual wastewater systems, wind farms and solar fields, were exempt from the study. Participation in the study was voluntary.

Water and energy consumption data was obtained from 39 public and private utilities throughout the State. To quantify the water energy relationship, energy intensity, or the amount of energy required to collect, treat and distribute 1,000 gallons of water, was calculated for each individual system or facility. Likewise, for electrical systems which consume water for energy production, water intensity, or the amount of water needed to produce a unit of energy, was calculated for each facility. Marginal cost, or the cost to produce a unit of water, was used to visually represent the cost of water use to the utility. **Table J-1** summarizes the energy intensities and marginal costs for water, wastewater and recycled water industries in 2014 and 2015. **Table J-2** summarizes the water use by electrical utilities in 2014 and 2015. Cost information for electrical utilities was not available. The findings presented herein are based on the data collected from the 39 participating utilities and may not accurately represent the industry as a whole.

Table J-1 2014 and 2015 Water and Energy Use

Year[1]	Industry	Energy Intensity (kWh/kgal)		Marginal Cost ($/kgal)	
		Range	Average	Range	Average
2014	Water	0.0 – 24.6	4.4	$0.06 - $9.22	$1.66
2015	Water	0.0 – 23.9	5.1	$0.03 - $7.50	$1.70
2014	Wastewater	2.1 – 23.5	7.2	$0.49 - $8.66	$2.54
2015	Wastewater	3.1 – 24.2	12.1	$0.91 – 6.98	$3.87
2015	Recycled Water	0.1 – 6.3	3.5	-	-

[1] The number of participating utilities varied for each year; therefore, data for 2014 and 2015 cannot be compared against each other as the number of utilities or participating utilities may not be the same.

Table J-2 2014 and 2015 Electrical Water Use

Year[1]	Water Intensity (kgal/kWh)	
	Range	Average
2014	0.00 – 1.09	0.15
2015	0.00 – 1.45	0.35

The energy intensities for each industry varied from system to system, depending on system characteristics. **Table J-3** summarizes some of the primary drivers of energy and water use for each industry. Understanding the primary drivers of energy use can help utilities develop and implement energy management strategies to decrease energy use and minimize operating costs. Opportunities for energy management include optimizing the operations of the system, using renewable energy sources, mitigating energy use during peak energy demand periods and monitoring energy consumption. These strategies target energy reduction and water use by association.

Table J-3 Primary Drivers of Energy and Water Use

Water	• Pumping: elevation, distance, volume, pressure • Volume treated • Source: surface water, brackish, ocean, groundwater • Treatment technology
Wastewater	• Pumping • Volume collected and treated • Level of treatment: primary, secondary, tertiary • Treatment technology: activated sludge, UV disinfection
Recycled Water	• Pumping - distribution • Volume collected and treated • Level of treatment: R-1, R-2, R-3, R-O • Treatment technology: trickling sand filter, UV disinfection • Effluent distribution
Electrical	• Volume of electricity generated • Type of electricity production: fossil fuels, renewable energy

In addition to energy management programs, water conservation programs targeting both utilities and end users should be initiated to protect Hawaii's fresh water resources. Utilities and agencies often pursue water conservation programs independently with dispersed results. Greater collaboration between utilities and government agencies is necessary to develop effective and mutually beneficial conservation initiatives and programs, including partnerships and collaboration between energy and water utilities. Water conservation benefits everyone and as such, should be perceived as a partnership effort by all users. Strategies requiring collaboration between multiple stakeholders include promoting the use of recycled water, joint infrastructure improvements and development of appropriate water use polices. Working together in unison will yield greater net benefits and long term results for both users and the environment.

J.5 Developing a Resource Augmentation Program

To meet future water demands throughout the State, alternative water sources should be developed to augment naturally occurring water supplies. The order in which to pursue development of alternative sources is influenced by local and county-level needs and constraints. In some areas of the state, water availability is limited by the extent and capacity of the pump and distribution system, rather than a scarcity of surface and ground water resources. In other areas, increasing water demands may only be met by augmentation, alternative water sources, or water transfers. Further, scientists are observing that climate change is affecting the expected timing and intensity of rainfall patterns in Hawaiʻi. It is uncertain how this will affect water supplies and the future availability of water, but some models predict that the dry areas of the state may become drier and the wet areas wetter. Given this uncertainty, it is important to look for alternatives to augment natural ground and surface water supplies, especially if there is a chance that future water availability will be decreased due to climate change.

Judicious management of water resources is the primary tool for sustaining Hawaiʻi's people, environment, culture, economy, and lifestyle. Water can be a factor limiting growth and development and in turn, growth and development can limit and decrease the viability of the resource. Land use planning and water resource planning are thus closely linked.

Resource augmentation must be recognized as an important component in water resource management. Alternative water supplies are renewable, drought resistant, environmentally sound, and socially responsible. Goals and priorities must be established to integrate the use of alternative water resources into daily life, and to encourage the development of these supplies in an efficient and safe manner.

The State is not a water purveyor, with the exception of a few small public water systems and agricultural water systems. The county water agencies currently operate all municipal water systems and are responsible for developing municipal water sources. The DLNR Engineering Division is the agency that conducts source development for State facilities that are not able to be served by existing public water systems.

It is the State's responsibility to encourage the development and maximum beneficial use of alternative water resources to augment the water development programs of each county. The State should also provide leadership and guidance to the counties and private water purveyors in the form of goals and priorities established through an integrated resource augmentation program. Such a program would ensure that the pursuit and development of alternative-water sources is executed in an efficient and sensible manner, and would also encourage cooperation, development of implementation incentives, and innovative thinking among State, county, and private entities.

Current CWRM programs that promote the use of alternative sources include water use regulation, instream flow standard assessment, and long-range planning. In designated water management areas, applicants for water use permits must show that no alternative water sources are available to meet their needs. If an alternative source is available, CWRM will deny requests for use of public trust resources in favor of the available alternative. In setting instream flow standards, in order to minimize impacts of streamflow restoration on existing uses, the Water Code directs CWRM to consider the availability of alternative water sources, among other physical solutions.[12] Finally, CWRM's *Statewide Framework for Updating the Hawai'i Water Plan*[13] advocates the use of an integrated resource management (IRP) approach for updating the County Water Use and Development Plan components of the Hawai'i Water Plan. IRP is a comprehensive form of planning that encompasses least-cost analysis of resource management options, participatory decision-making process, and the development of water resource alternatives. IRP attempts to consider all direct and indirect costs and benefits of demand-side and supply-side management, in addition to augmentation of supply.

The State Water Code states that CWRM shall plan and coordinate conservation and augmentation programs in cooperation with other agencies and entities.[14] Planning for resource augmentation requires considerable lead-time for research and technical-resource acquisition, pilot programs and testing, and funding attainment. Resource augmentation program goals and priorities should be developed in consideration of a realistic time frame for implementation. The following section reviews various resource augmentation methods and resources and describes CWRM's role as an advisory agency for expansion and further development of augmentation programs statewide.

J.6 Water Supply Augmentation Resources

Most of Hawai'i's freshwater supplies have been developed through traditional means, including ground water wells, stream diversion systems, and surface water reservoirs. However, current and anticipated demands for water will require new source development and may surpass the volumes of naturally occurring ground and surface water in some areas of the State. In order to sustain Hawai'i's growing population and to meet the needs of industry, the State and county governments must actively pursue alternative water supplies. Alternative water sources should be developed not only to meet certain water demands, but also to help ensure the long-term viability of our ground water aquifers and watershed areas.

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[12] HRS §174C-71(1)(E)

[13] Commission on Water Resource Management. (2000). *Statewide Framework for Updating the Hawai'i Water Plan*

[14] HRS §174C-5(12) and §174C-31(d)(4).

There are several issues to consider in exploring resource augmentation; they are:

- **Reliability considerations:** The source is vulnerable to drought conditions or seasonal variations in precipitation; there is a dependence on fuel types that are susceptible to shortages or cost inflation; the economical development of the source must have sufficient capacity to meet demand.

- **Quality considerations:** The treatment process must be capable of producing water that can meet increasingly stringent water quality standards; the source should be suitable for the production of drinking water, irrigation water, or industrial water.

- **Efficiency & economic considerations:** The cost of developing alternative water sources in comparison to that of traditional source development must be considered; cost implications of alternative source development in planned stages to meet demand is also important; long-term operation and maintenance costs must be compared.

- **Technology:** An understanding of the history and dependability of related technologies must be gained; it is beneficial to investigate foreseeable advances in technology; including specialized technology and equipment requirements; public opinions/concerns regarding the technology should be solicited.

- **Environmental Impacts:** Environmental impacts of alternative water source development should be compared to that of traditional source development; utilities need the ability to mitigate negative impacts; it would also be appropriate to compare benefits of traditional source development with alternative source development.

Several alternatives could increase or extend freshwater supplies. Reclaimed wastewater can provide for non-potable demands, including irrigation and industrial applications. Reclaimed stormwater could be used for artificial ground water recharge, environmental restoration, fish and wildlife habitat support, recreation, municipal uses, irrigation, and industrial uses. Desalinated water is well-established as a source of drinking water in other parts of the U.S. and in the Middle East, Japan, and the Caribbean. Other alternatives on the household-level, including the use of grey-water systems and rain barrels for landscape watering, can also help extend freshwater supplies.

The following sections discuss the alternatives of stormwater and wastewater reclamation and desalination methods to augment ground and surface water supplies. Each method is also briefly evaluated with regard to the issues listed above. For clarification purposes, the following definitions are offered:

Wastewater reclamation:	*The treatment of wastewater such that it may be used for beneficial purposes.*
Recycled water:	*The useable end product of the wastewater reclamation process.*
Water reuse:	*The beneficial use of recycled water.*

J.6.1 Gray Water Reuse

The Hawaiʻi State DOH defines gray water as wastewater discharged from:

- Showers and bathtubs;
- Hand-washing lavatories;
- Wastewater that has not contacted toilet waste;
- 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).[15]

With the increased acceptance of water reuse in Hawaiʻi, guidelines were needed to advise homeowners, land users, contractors, and engineers on the safe use of gray water. Gray water is an attractive option to supplement the water needed for residential landscape irrigation. Gray water from sinks, tub/shower drains, and washing machines are estimated to be 50 to 80 percent of the total residential wastewater generated. By reusing this wastewater stream to meet irrigation needs, not only is household freshwater use reduced, but also the amount of wastewater entering individual wastewater systems. Some of the nutrients found in gray water from cleaners and detergents could be considered fertilizers for plants.

In 2009 the Hawaiʻi DOH published guidelines that are intended to advise users on the proper application of gray water to protect both human health and the environment. As many of the health and safety concerns from gray water reuse are associated with the bacteria that can accumulate in gray water holding systems, the guidelines recommend subsurface application and monitoring of irrigated areas to ensure ponding does not occur.

[15] Hawaiʻi DOH, Guidelines for the Reuse of Gray Water, June 22, 2009

The 2009 guidelines recommend the following for the reuse of gray water for irrigation:

- Never use spray irrigation to apply gray water. Application of gray water must be done by utilizing a subsurface system.
- Gray water should never be used to irrigate root crops, vegetables that will be eaten raw, or other crops where the consumed portion of the plant rests on the ground.
- Gray water should be used to irrigate established lawns and plants.
- Seedlings and barren areas where a potential for runoff and/or ponding exists should not be irrigated with gray water.

J.6.2 Wastewater Reclamation

Wastewater reclamation has been practiced for decades in the continental United States and other parts of the world, especially in areas where freshwater sources are limited. Water reuse should be viewed as a key component of sustainable water resource management. Recycled water can be a drought-proof and reliable supply of water. It can replace potable water currently being used for non-potable purposes. In some instances, the availability of recycled water has stimulated Hawaiʻi's economic development by attracting business activity. Water reuse also provides a mechanism for nutrients in wastewater to be utilized by vegetation, thereby reducing the need for fertilization. Finally, when compared to the traditional disposal methods through outfalls and injection wells, wastewater reclamation and reuse is recognized as an environmentally preferred method of effluent disposal. While water-reuse applications have grown significantly in Hawaiʻi in recent years, recycled water is still an underutilized resource. In 2013 CWRM updated its *Hawaiʻi Resource Survey and Report* to provide current information on water reuse programs across the state. The information presented in this section of the WRPP has been adapted from the 2004 and 2013 reports.

In 1999, approximately 13% of the volume of municipal consumption in Hawaiʻi was attributed to recycled water sources, and this figure continues to increase with the eventual implementation of planned and proposed reclamation and reuse projects. As Hawaiʻi's population increases, wastewater volumes will increase proportionally, creating more recycled water and reuse opportunities. Integration of water reuse into the statewide water use policy will be critical as water demands increase.

Recycled water must meet strict water quality standards set by the Environmental Protection Agency (EPA) and the Department of Health (DOH). These water quality standards ensure proper treatment and disinfection, although treatment levels differ depending on the end use. The EPA and DOH regulations require wastewater treatment and encourage the availability and reuse of its by-product, recycled water. In 2016 the DOH updated its reuse guidelines to streamline the approval process of reuse projects and to also provide clarity on the appropriate use of recycled water. In some cases, it may be less expensive to develop recycled water distribution systems than to develop new sources of water and continually pay effluent-disposal costs, particularly with the implementation of Total Maximum Daily Loads through the National Pollutant Discharge Elimination System permitting system. While there are significant initial capital costs for communities to develop recycled water distribution systems, the addition of recycled water to municipal water budgets will secure long-term sustainability of communities and economic growth.

The typical Wastewater Treatment Plant (WWTP) is a large facility that requires significant amounts of land and operational resources, but smaller scale applications of reclamation technology are becoming more common in subdivisions, and even serve single-family homes. Small and decentralized wastewater management systems provide local solutions for wastewater collection, treatment, and reuse. The Hawaii Legislature passed Act 229 in 2015 to encourage the State to explore the feasibility of scalping wastewater from the sewage system to reuse at airport facilities. Such studies will not only encourage innovation in the reclamation and reuse of wastewater, but could also demonstrate the avoided costs associated with the transmission of wastewater to large, regional facilities.

J.6.2.1 Recycled Water Applications

There are numerous uses for recycled water. Some of the reuse applications listed below are already taking place in Hawaiʻi on a small scale:

- Constructed Wetlands
- Ground Water Recharge
- Irrigation
- Recreational Uses
- Construction-Related Uses
- Recharge of Natural Wetlands
- In-Stream Flow Restoration
- Composting
- Toilet and Urinal Flushing
- Industrial Uses

Wastewater reuse in Hawaiʻi is being aggressively implemented in some parts of the state, such as Maui County and the ʻEwa Plain on Oʻahu. However, wastewater recycling is not a priority in other areas. As stated earlier, the integration of water reuse into the statewide water use policy will become more critical as our potable water demands increase.

In 2013, CWRM updated the *Hawaiʻi Water Reuse Survey and Report* to monitor the utilization of recycled water in Hawaiʻi. The report inventories and describes existing reuse projects in the state, and more importantly, identifies opportunities for future reuse projects in Hawaiʻi. The results of the *2013 Hawaiʻi Water Reuse Survey and Report* and the updated DOH reuse guidelines should be incorporated into a guidance document to assist county reuse initiatives. Recycled water remains an underutilized resource with many opportunities for expansion. *Volume II: Recycled Water Projects* of the 2016 *Reuse Guidelines* (http://health.hawaii.gov/wastewater/home/reuse/) identify areas where recycled water can be utilized on each island.

Recycled water at different levels of treatment is widely used for agricultural and landscape irrigation on the U.S. mainland. There are also direct and indirect potable reuses of recycled water, where recycled wastewater is "purified" through advanced treatment and introduced into the potable, drinking water system. In direct potable reuse, the purified recycled water is added to a drinking water system as an additional source water input to the potable treatment phase or at some point in the distribution system. The State of Texas is studying direct potable reuse to meet its water supply needs.[16] Indirect potable reuse involves an intermediate storage phase prior to the purified recycled water being added to the drinking water system. Unplanned indirect potable reuse is very common in the U.S. Communities that are situated along major waterways, such as the Mississippi River, have historically produced potable water from river sources that have circulated through multiple cycles of withdrawal, treatment, and discharge.[17] U.S. EPA's 2012 Reuse Guidelines provides examples of planned indirect and direct potable reuse in the U.S. and elsewhere.[18]

J.6.2.2 Guidelines for Treatment and Use of Reclaimed Water

The DOH issued the *Guidelines for the Treatment and Use of Reclaimed Water* (Guidelines) in November 1993 and most recently updated the Guidelines in January 2016. They are now referred to as the *Reuse Guidelines*. The document is divided into two volumes and identifies requirements for both purveyors and the users of recycled water. Volume I: Recycled Water Facilities identifies the technical requirements that must be met for the distribution of recycled water. Volume II: Recycled Water Projects outlines the application process required to utilize

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[16] Texas Water Development Board. *Evaluating the Potential for Direct Potable Reuse in Texas.* Retrieved from http://www.twdb.state.tx.us/innovativewater/reuse/projects/directpotable/index.asp

[17] Asano, T. (1998). *Wastewater Reclamation and Reuse: Water Quality Management Library, Vol. 10,* Boca Raton, Florida: CRC Press LLC.

[18] U.S. Environmental Protection Agency, Office of Wastewater Management. (2012, September). *Guidelines for Water Reuse*. (EPA/600/R-12/618).

recycled water and identifies areas that are approved for its application. The Guidelines are referenced in Chapter 11-62 of the Hawaiʻi Administrative Rules (HAR).

To guide the safe application of recycled water, DOH has defined three categories for areas of its application: Restricted areas, Conditional areas, and Unrestricted areas. Restricted areas are defined in the 2016 *Reuse Guidelines* as:

1. Areas within the Zone B capture zone delineation (CZD) for public drinking water sources that draw water from a shaft excavated along the surface of the water table where ground water travel to the shaft is two years or less;

2. Areas within a 1,000 foot radius of zones designated as Ground Water under the Direct Influence (GWDUI) of surface water (also a Zone B CZD); and

Areas within 1,000 feet of wetlands, ponds or enclosed bays that fall within a designated reserve or protected conservation district.

If recycled water is to be used in Restricted areas, it is subject to the following requirements:

1. Notification of agencies or entities, such as drinking water purveyors or protected conservation district or reserve managers, involved with or connected to the potentially impacted area.

2. Chemical analysis of designated constituents in the effluent recycled water for treatment plants supplying more 10,000 gallons per day.

3. Hydro-geologic study to predict the impact of recycled water.

4. Possible soil or ground water monitoring based on the results of the items 2 and 3 above.

Conditional areas are defined as:

1. All public drinking water CZDs;

2. Designated reserves; and

3. Protected conservation districts, excluding those specifically designated under Restricted Areas.

If recycled water is to be used in Conditional areas, it is subject to the following requirements:

1. Notification of agencies or entities, such as drinking water purveyors or protected conservation district or reserve managers, involved with or connected to the potentially impacted area.

2. Chemical analysis of designated constituents in the effluent recycled water for treatment plants supplying more 10,000 gallons per day.

Recycled water use in unrestricted areas is not subject to the requirements of Restricted and Conditional areas.

All Waste Water Recycling Facilities (WWRF) that purvey recycled water must meet the recycled water quality standards established by the DOH Guidelines. However, WWRFs constructed prior to the passage of the original 1993 Guidelines may have certain components of their treatment system “grandfathered,” making them exempt from the Guidelines. For example, the County of Maui’s Lahaina WWRF’s UV disinfection system was designed and constructed prior to the 1993 Guidelines. The UV system does not have the backup capacity required by the Guidelines so it was “grandfathered” by DOH since it was approved prior to 1993.[19]

All projects that use recycled water must first receive DOH approval. The DOH approval process has certain design and site inspection requirements. Purveyors of recycled water are required to keep operational records of the daily volumes and water quality produced by their water reclamation facilities. These records are subject to review by DOH during annual operation and maintenance inspections of each facility.

Maui County was the first county in Hawaiʻi to establish rules for recycled water use in 1997. In 2002, the Honolulu BWS adopted rules governing the use of recycled water in the City and County of Honolulu. Both sets of rules incorporate the DOH Guidelines. The Maui County rules include sections on establishing recycled water service, design standards for on-site and off-site recycled water facilities, operational guidelines, monitoring and enforcement provisions, and fees and charges. Honolulu BWS rules establish requirements to ensure protection of water sources and public health.

Further information on the current DOH Reuse Guidelines can be found at: http://health.hawaii.gov/wastewater/home/reuse/

[19] CWRM. 2013 Update of the Hawaiʻi Water Reuse Survey and Report. 2013

J.6.2.3 Recycled Water Classifications, Definitions, and Allowable Uses

Recycled water is classified as either R-1, R-2, or R-3 based on the level of treatment it has received. The first step in wastewater reclamation is primary treatment, which removes settled or floating solids. In secondary treatment, organic matter is removed, usually through “biological cleansing” using bacteria. Tertiary-treated recycled water is filtered and disinfected to remove up to 99% of impurities and suspended solids. Purveyors of recycled water must meet the treatment and water quality standards summarized below for R-1, R-2, and R-3 waters.

R-1 water is tertiary-treated recycled water that has undergone a significant reduction in viral and bacterial pathogens and meets the highest recycled water standards. R-1 water is oxidized, filtered, and exposed to disinfection processes to remove bacteria and viruses. It is of non-potable quality, but it is deemed safe for human contact. R-1 water is now approved for a number of applications including spray irrigation of golf courses, parks, athletic fields, school yards, residential properties that are managed by an irrigation supervisor, road sides and medians, and for vegetables and fruits that are eaten raw. The number of projects in Hawaiʻi utilizing R-1 water has increased significantly in recent years.

R-2 water is disinfected, secondary-treated recycled water. R-2 water has been oxidized and disinfected; however, the disinfection criteria are not as stringent as that of R-1 water. Therefore, the reuse applications of R-2 water are limited. Spray irrigation using R-2 water is limited to evening hours, and a 500-foot buffer zone between the approved-use area and adjacent properties is required. Several golf courses in Hawaiʻi are irrigated with R-2 water, although some are exempt from the 500-foot buffer zone requirement because they existed before the DOH established the Guidelines. Food crops that are irrigated with R-2 water must be either irrigated via a sub-surface irrigation system or, if irrigated with spray irrigation, must undergo extensive commercial, physical or chemical processing determined by the DOH to be sufficient to render it free of viable pathogenic agents, before it is suitable for human consumption.

R-3 water is undisinfected secondary-treated recycled water, and there are severe limitations on its use. Currently, the Parker Ranch pasture-irrigation project on the Big Island and the Puʻu O Hoku Ranch constructed-wetlands project on Molokaʻi are the only projects in Hawaiʻi that utilize R-3 water.

Reverse osmosis (R-O) is a method of treatment that is used in wastewater reclamation and in seawater or brackish water desalination. R-O water is wastewater that has undergone secondary treatment, followed by purification through an ultra-fine membrane that allows only water to pass. R-O water is then disinfected prior to use.

A complete list of the allowable uses of recycled water is summarized in the DOH Guidelines under Chapter III – Uses and Specific Requirements for Recycled Water.

J.6.2.4 Wastewater Reclamation Issues and Constraints

In the development of water reuse programs and projects, there are several issues that can delay progress. Certain planning and preparatory efforts must be carried out to address economic issues, legislative constraints, and public acceptance. Jurisdictional and regulatory obstacles, however, cannot be surmounted without first addressing the issue of public perception of water reuse.

To realize success, a water reuse program or project should incorporate the following elements:

1. Gain public acceptance.

2. Encourage cooperative planning among agencies.

3. Overcome regulatory hurdles.

4. Strategize on funding sources.

5. Grow a customer base and encourage demand.

The following sections provide information and strategies for achieving these program elements and for facilitating water reuse projects.

1. **Gain public acceptance**

   Sound and proactive communication and education programs are essential for water reuse projects and programs to succeed. Failure to educate the public early on may delay or even stop the implementation of water reuse projects or programs.

   Two key concepts must be emphasized in public outreach programs:

   - *Recycled water can be an important component of the community's overall water supply.* The main reason for implementing water recycling programs is to supplement limited freshwater supplies.

   - *Recycled water is safe for approved uses.* The community must gain a basic understanding of how wastewater is treated and made safe through the recycling process. The community may have concerns regarding the safety of using recycled water for landscape irrigation, especially in locations such as parks, school yards, shopping centers, hotels, and condominiums. Agricultural producers may also share similar concerns. Proactive public education programs, with emphasis on disinfection, monitoring, and quality assurance, will help the community feel more comfortable with the idea of using recycled water.

Target audiences for education and outreach programs include politicians, schools, the general public, community organizations, and new and potential recycled water users. The educational outreach program described below is based on the County of Maui Department of Public Works and Environmental Management, Wastewater Reclamation Division program, and may be used as a template for other outreach programs throughout the state. The following are examples of outreach methods that are appropriate for each target audience:

Government Officials: A significant amount of time should be expended educating local government officials on the benefits and applications of recycled water through presentations at council meetings and other public meetings. Literature and testimony from local and national water reuse experts are also effective, and personal meetings allow elected officials to ask questions and broaden their knowledge of reuse.

Schools: Educating young people is the best way to establish long-term support for the concept of recycling water, and to develop behavior that will enhance sustainability within the community. Outreach programs should first notify school administration and teachers of the availability of an environmental-education program on water conservation and wastewater reclamation and reuse. Components of the program could include classroom presentations, water quality lab activities, wastewater reclamation facility tours, career-day speaker appearances, and assistance with school science projects. Desktop demonstrations, slide shows, videos, poster boards, and information booklets can be incorporated into the program, along with the distribution of promotional items such as rulers, stickers, magnets, and water conservation kits.

General Public: In addition to printed informational materials and promotional items, the general public can benefit from tours of wastewater reclamation facilities, where information can be shared on-site and face-to-face. Educational videos can be broadcast on community-cable access television, and copies of the video can be made available for loaning upon request. Additionally, press releases announcing improvements and expansions to recycled water programs and facilities and media coverage can help spotlight and reinforce the importance of recycled water.

Community Organizations: Presentations can be developed and shared with community groups such as the Rotary Club and other community associations, the local Chamber of Commerce, hotel and other business associations, and engineering, architecture, and contractor associations, which often have regular meetings and welcome guest speakers. These speaking engagements can be utilized to provide the most current information on recycled water programs, and can encourage public involvement by raising interest and identifying groups who will champion the program.

New and Potential Recycled Water Users: Educational presentations that focus on the production, safety, and proper management of recycled water can be made to the owners, managers, and employees of new and potential water reuse projects. Such presentations should emphasize water quality monitoring of the recycled product, including turbidity monitoring, automatic diversion of substandard recycled water, and fecal coliform monitoring. The presentations should also discuss best management practices and examples of successful local and national water reuse projects. Facility tours should be offered as a follow-up to these presentations, along with educational pamphlets and promotional items.

2. **Encourage cooperative planning among agencies.**

   Water reuse provides benefits in both water supply and wastewater disposal. A common issue encountered by municipalities in the early stages of a water reuse program is the determination of which agency, the water supplier or the wastewater-services provider, will champion and administer the program. Recycled water is the link between water and wastewater. Therefore, no matter which agency takes the lead in the development and operation of a reuse program, the other agency should support the program in some capacity.

   To implement recycled water use, county agencies must also coordinate permitting and management actions. For example, designing office and commercial buildings with dual water supplies for the purpose of flushing toilets and urinals with R-1 recycled water represents an excellent opportunity to displace the use of large amounts of potable water. The DOH Guidelines allow R-1 water to be used for toilet and urinal flushing, if the county plumbing code incorporates language pertaining to dual water supplies within buildings. Therefore, all counties in Hawai‘i should incorporate Appendix J of the 1997 version or later of the Uniform Plumbing Code into their respective county plumbing codes. Appendix J includes the provisions required to meet DOH Guidelines. Failure to update county plumbing codes for dual water supplies within buildings could result in the DOH denying projects that want to utilize recycled water for toilet and urinal flushing.

   The Central Oahu Non-Potable Water Master Plan Study was completed in 2013 and was intended as a blueprint for cooperative planning amongst non-potable water stakeholders in Central Oahu. The primary focus of the study was planning for the distribution of non-potable water supplies to augment the needs of agriculture operation in one of the main growing regions of the State. The study is described in further detail below.

3. **Overcome regulatory hurdles.**

   There are at least two state regulatory issues in Hawai‘i that restrict recycled water from use in potentially high-volume applications. Both of the issues are related to the DOH regulations and are summarized as follows:

1. The DOH Wastewater Branch does not permit the use of R-1 water for single-family lot irrigation; and

2. The DOH Clean Water Branch does not permit the discharge of recycled water into State waters.

In examining the first issue, it should be emphasized that yard and landscape irrigation consumes significant amounts of potable water, and such use can comprise up to 65% of a home's consumption on the leeward sides of the islands. The DOH Guidelines state that R-1 water may be used for "any form of irrigation served by fixed irrigation system supplied by buried piping for turf and landscape irrigation of a residential property where managed by an irrigation supervisor." In the past, the DOH has approved the use of R-1 water for multi-family residential developments.

However, the DOH has not approved projects proposing the use of R-1 water for irrigation in single-family residential developments. The Guidelines do not allow the use of recycled water on privately owned single-family residential lots and do not address specific requirements for dual-plumbed, recycled water facilities.

The DOH also is concerned that, even if the irrigation system for an entire single family development is managed by an irrigation supervisor, the agency cannot ensure adequate protection of public health due to insufficient staff. The agency feels that they lack personnel to properly monitor for conditions such as cross connections to the potable water system and overspray of R-1 irrigation water.

Concerns regarding monitoring and R-1 overspray can be addressed through reporting requirements and design requirements for irrigation systems. Future planned communities wishing to utilize R-1 water for irrigation could be required to provide the DOH with periodic cross connection inspection reports by a licensed plumber. Further, the development's single-family lots should be designed and built with subsurface drip irrigation systems. Maintenance of the common-area irrigation components should be performed by one contractor, and homeowners in the development would be required to use the same contractor for any necessary irrigation system repairs within their property.

As for the second issue regarding the discharge of R-1 water to State waters, it should be noted that recycled water is commonly used on the continental U.S. and in foreign countries for recharging natural wetlands and for instream flow restoration. The U.S. Bureau of Reclamation encourages the use of recycled water for these purposes. In Hawai‘i, this type of application of recycled water is not permitted as it is considered an unauthorized discharge to State waters.

Chapter 11-54-04 of the HAR, which lists the basic water quality criteria, also states that all waters shall be free of substances attributable to domestic, industrial, or other controllable sources of pollutants, including substances, or conditions or combinations thereof, in concentrations which produce undesirable aquatic life. The DOH Clean Water Branch's primary concern with the use of recycled water for recharging natural wetlands or restoring stream flows is that nutrients in the recycled water could result in excessive algal growth in the receiving waters.

The nutrient levels in recycled water can be reduced through a process called anoxic zone biological nutrient removal. Wastewater recycling facilities can be designed or retrofitted with anoxic zones that significantly reduce nitrogen and phosphorus concentrations in wastewater. Maui County has added this nutrient-removal process to the treatment at all three of the County's wastewater reclamation facilities.

To encourage the safe application of recycled water, the 2016 *Reuse Guidelines* identified areas where recycled water application is either restricted, conditional or unrestricted.

4. Strategize on funding sources.

To find effective funding sources, an understanding of the economics of recycled water must be attained. An important component of implementation of water reuse programs is to determine how to pay for recycled water reuse projects. Water reuse projects in general, with the development of recycled water distribution systems in particular, are expensive to construct and operate. The revenues earned from selling recycled water are often insufficient to pay for the full capital and operating costs associated with the production and delivery of the recycled water. This is especially true if the recycled water purveyor sets the recycled water rate comparable to the user's existing water rate. Setting recycled water rates at levels that will allow the purveyor to recover the full capital and operating costs of the recycled water system will most likely result in rates that are significantly higher than the rates paid for traditional water sources. Thus, there would be no economic incentive for a user to convert to recycled water.

Rather than laying the entire financial burden on the recycled water user, it is preferable to spread the cost of financing water reuse projects. There are four main potential sources of funds for water reuse projects:

- Recycled water users
- Potable water users
- Sewer users
- Government grants

Fees from recycled water users can be charged through recycled water rates (dollars per thousand gallons of recycled water used) or through direct, up-front payment of a portion of the project costs. These up-front payments are called assessment fees, capacity fees, connection fees, impact fees, or system-development fees, but they all basically represent a “joint venture” between the recycled water purveyor and the user to pay for all or a portion of the capital costs of the project.

Potable water users may be charged an appropriate portion of recycled water project costs, if they benefit from the implementation of the recycled water program (e.g., if water reuse results in reduced chances of potable water rationing). Similarly, sewer users may be charged a fee for water reuse projects if they receive benefits from reuse. Because future injection wells or outfall discharges of effluent in Hawaiʻi may be limited in the future by regulatory agencies, water reuse becomes an acceptable alternate disposal method, and it is appropriate for sewer users to pay for a portion of water reuse projects.

Government grants currently represent an unlikely source of funds, due to limited state and federal budgets, but recycled water purveyors in Hawaiʻi should be vigilant in the search for potential sources of government grants from various state and federal agencies. (Government loans are not considered sources of funds because they must be repaid. They do, however, represent a low-cost method of obtaining construction funding and are desirable for that reason.)

A good way to encourage reuse and public support of any fees associated with a reuse project is to develop the rate structure and fees with significant community input. A successful example is the County of Maui’s recycled water rate structure. The community-based committee formed to help develop the rate structure consisted of representatives from large landowners, the Maui Chamber of Commerce, the Maui Hotel Association, the Maui Realtor Association, members from the County of Maui’s Wastewater Reclamation Division and Department of Finance, and the County’s consultant. The committee decided upon a “composite” rate structure for its water reuse program that identified three main user classes: Major Agriculture ($0.10 per thousand gallons), Agriculture, including golf courses ($0.20 per thousand gallons) and All Other ($0.55 per thousand gallons). The recycled water rates were set to levels that were somewhat less expensive than the conventional alternative water sources used by the three user classes. Connection fees and meter fees were also developed. Because effluent disposal was an important factor driving Maui’s water reuse program, sewer user rates were also slightly increased.

Maui’s approach has allowed recycled water to become an attractive non-potable water source because it is less expensive than conventional alternative water sources. At the same time, sewer users help pay for the water reuse program because it is believed that they must be held responsible for not only the collection and treatment of wastewater they produce but for its ultimate disposal, whether it be through injection wells or though water reuse. It is recommended that recycled water purveyors in Hawai‘i attempt to recover the capital and operations cost of their respective water reuse programs by having recycled water users, sewer users and potable water users all contribute through their bimonthly user fees.

5. **Grow a customer base and encourage demand.**

   Ordinances that require commercial properties to utilize recycled water for irrigation or other purposes have been used in several states to establish a strong customer base and maximize recycled water usage. Mandatory use ordinances are established because of a shortage of potable water resources or due to environmental problems associated with effluent disposal. Several cities in the continental U.S. have passed ordinances as part of their water reuse programs. Thus far, Maui County is the only county in Hawai‘i to have a mandatory use ordinance in place. The DOH Wastewater Branch attempted to establish such an ordinance in 2001, but it was not approved by the Legislature.

   Maui County’s mandatory use ordinance was passed in 1996, primarily as a means to reduce the use of injection wells for effluent disposal, and secondarily to proactively supplement the limited potable water supplies within the County. Although the bill was eventually passed, it faced substantial opposition from some landowners, and an extensive public education and outreach effort was required. The ordinance required commercial properties within one hundred feet of the County’s recycled water distribution system to connect to the system within one year of the system’s availability, and to use the recycled water for irrigation. Thus, the ordinance was successful in reducing effluent, supplementing the water supply, and building a broad customer base for recycled water.

   The passage of mandatory use ordinances in the other three counties could accelerate the development of water reuse programs. The DOH could also propose a statewide, mandatory reuse ordinance to support the agency’s goal of increasing Hawai‘i’s recycled water use. For an ordinance to be passed at the State or county level, a comprehensive, educational effort should be undertaken as early as possible to convince lawmakers and the general public of the many benefits such an ordinance can provide. At a minimum, any proposed mandatory use ordinance should contain sections on connection requirements, cross-connection control measures, an inspection policy and penalties for violation, system-reliability requirements, water quality requirements, and fees and rates for recycled water service.

J.6.2.5 Pharmaceuticals and Personal Care Products as Pollutants

Pharmaceuticals and Personal Care Products (PPCPs) are "any product used by individuals for personal health or cosmetic reasons or used by agribusiness to enhance growth or health of livestock. PPCPs comprise a diverse collection of thousands of chemical substances, including prescription and over-the-counter therapeutic drugs, veterinary drugs, fragrances, and cosmetics."[20] The PPCPs that are not entirely absorbed by the body are excreted and end up in the wastewater stream or stormwater runoff. Research has shown that PPCPs are present in waterbodies in the U.S. mainland and that PPCPs may cause ecological harm; however there have been no studies linking PPCPs in the environment to adverse human health effects.[21]

Since PPCPs can be found in our wastewater, there are potential ways for these PPCPs to enter our aquifers. Septic tanks, cesspools, and leaky municipal sewer pipes can leach PPCPs directly into the ground. Conventional wastewater treatment is not designed to remove PPCPs. There is also a risk that wastewater reuse can introduce PPCPs into our aquifers. It is important to ensure that we minimize the chance that wastewater reuse (e.g., through irrigation, ground water recharge) contaminates our precious drinking water aquifers.

PPCPs are currently unregulated by the U.S. Environmental Protection Agency, however the EPA is working with drinking water systems to determine the level of PPCPs in drinking water systems. The EPA may in the future decide to include PPCPs as regulated contaminants in the future.[22]

CWRM supports research into characterizing treated wastewater to identify any PPCPs present, and to assess whether the reuse of the treated wastewater can introduce PPCPs into our drinking water aquifers. The Honolulu BWS and the U.S. Geological Survey are beginning to investigate the presence of PPCPs in Hawai‘i's wastewater and if wastewater reuse is transmitting PPCPs into our aquifers.

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[20] Environmental Protection Agency, Pharmaceuticals and Personal Care Products (PPCPs) accessed on February 27, 2014, http://www.epa.gov/ppcp/

[21] Environmental Protection Agency, Pharmaceuticals and Personal Care Products (PPCPs) accessed on February 27, 2014, http://www.epa.gov/ppcp/

[22] American Water Works Association, Pharmaceuticals and Personal Care Products in Drinking Water, accessed on February 27, 2014, http://www.drinktap.org/home/water-information/water-quality/pharmaceuticals-ppcps.aspx

J.6.2.6 Act 229 Requiring the State Department of Transportation to Conduct a Feasibility Study on the use of Water Scalping Technology at State Airport Facilities

In 2015, Governor Ige signed into law Act 229, SLH 2015 which requires the State Department of Transportation (DOT) to conduct a feasibility study to determine if water scalping technologies can be implemented at State airport facilities. The purpose of this Act is to explore the sustainability and conservation potential of extracting and treating wastewater from the sewer network and putting towards supplementing non-potable demands. This Act also promotes a decentralized wastewater treatment system, thereby relieving the demand on a centralized treatment and disposal facility. Wastewater scaping has been successfully implemented in Australia and is currently being explored in several cities across the U.S.

J.6.2.7 Act 170 Requiring the Hawaii Water Plan to Utilize Recycled Water in State and County Facilities

In 2016, Governor Ige signed into law Act 170, SLH 2016. This Act amends the Hawaiʻi Water Plan section of the State Water Code to add an additional objective of utilizing reclaimed water for non-potable uses in 100% of all State and County facilities by December 31, 2045. This provision is problematic since it would be prohibitively expensive to retrofit all State and County facilities to utilize on-site reclaimed water and even more so to connect to any available wastewater recycling facilities (due to mostly remote proximity). A more reasonable requirement would be to require new State and County facilities or renovated State and County facilities to utilize reclaimed water.

J.6.2.8 Act 248 Prohibiting the Discharge of Treated or Raw Sewage into State Waters

In 2016, Governor Ige signed into law Act 248, SLH 2016. This Act amends Chapter 342D, Hawaii Revised Statutes, prohibiting any discharge of treated or raw sewage into State waters after December 31, 2026 with the exception of sewage treatment plants that utilizes sewage to produce clean energy or those receiving a variance from the Director of Health.

J.6.2.9 CWRM Programs to Encourage Wastewater Reuse and Resource Augmentation

The State has completed two efforts since the last update of the WRPP toward the planning and development of recycled water sources: The *2013 Update of the Hawaiʻi Water Reuse Survey and Report* was prepared to assist in planning efforts for wastewater reuse; and the 2013 *Central Oʻahu Non-Potable Water Master Plan – Appraisal of Opportunities Report* examined the potential for non-potable supplies to support agricultural demands in Central Oʻahu. These projects and subsequent findings are described below.

The Central Oʻahu Non-Potable Water Study

There has been a significant shift in land use in Central Oʻahu over the past 20 years. Monocrop plantation agriculture has declined significantly, leaving vast tracts of agricultural lands lying fallow. Projected future uses of these lands include diversified agriculture, biofuel production, military base expansion, and new urban developments. There is a significant non-potable water demand associated with each of these activities. Use of non-potable water sources to meet the non-potable needs of these planned activities will protect and preserve potable ground water for higher uses.

About 25 MGD of ground water from the Central and Pearl Harbor Aquifer Sector Areas are currently permitted for non-potable water use. Twelve MGD are from the Wahiawā Aquifer System and 13 MGD are from the Waipahu-Waiawa Aquifer System. If alternative water sources could serve these non-potable water uses, over 25 MGD of ground water could be preserved for future potable use.

There are numerous sources of non-potable water in the Central Oʻahu region, including surface water, agricultural irrigation ditches, recycled wastewater, and stormwater. Infrastructure for the production, conveyance, and distribution of non-potable water is increasing, yet in most cases development of this infrastructure is being done by separate entities and without consideration of integration. The benefits of coordinated planning and integration include optimization of water use, pollution reduction, increased environmental compliance, energy savings, shared costs, and preservation of high quality ground water.

Recognizing the potential for a regional solution that leverages partnerships among area stakeholders, results in economies in savings and avoided costs, and provides a myriad of environmental benefits, CWRM undertook efforts to explore and identify available options and opportunities for development and integration of alternative non-potable sources.

The key objectives of the study included:

1. Consult with key stakeholders and water experts to help guide this study.

2. Inventory current and potential sources of non-potable water in the Central Oahu area, including, but not limited to Wahiawā Reservoir (i.e., Lake Wilson), City and County of Honolulu Wahiawā Wastewater Treatment Plant (WWTP), Schofield Barracks WWTP, stormwater capture and reuse, Waiāhole Ditch water, and existing (and future) urban wastewater systems. The inventory should assess current and potential water quantities, current and potential service areas, water quality characteristics, water service constraints, system storage and conveyance appurtenances, and any other source characteristics important to regional non-potable water master planning.

3. Identify current and future demand for non-potable water in three general areas in Central Oahu, including but not limited to agricultural demands in the Kunia Road

Corridor, the former Galbraith Estate property, and landscape, park, and golf course irrigation demands along the Kamehameha Highway Corridor, and other non-potable uses in the residential, military, and commercial sectors.

4. Explore options for matching the sources of non-potable water identified in Objective 2 with the water demands identified in Objective 3.

5. Identify selected scenarios for integration of available and potential non-potable water supplies.

Additional sub-objectives of the plan included:

- Maximize the use of available non-potable water supply options.

- Identify options which facilitate improvement of water quality in Wahiawā Reservoir, whereby future irrigation water supply from the reservoir is not regulated as reclaimed water.

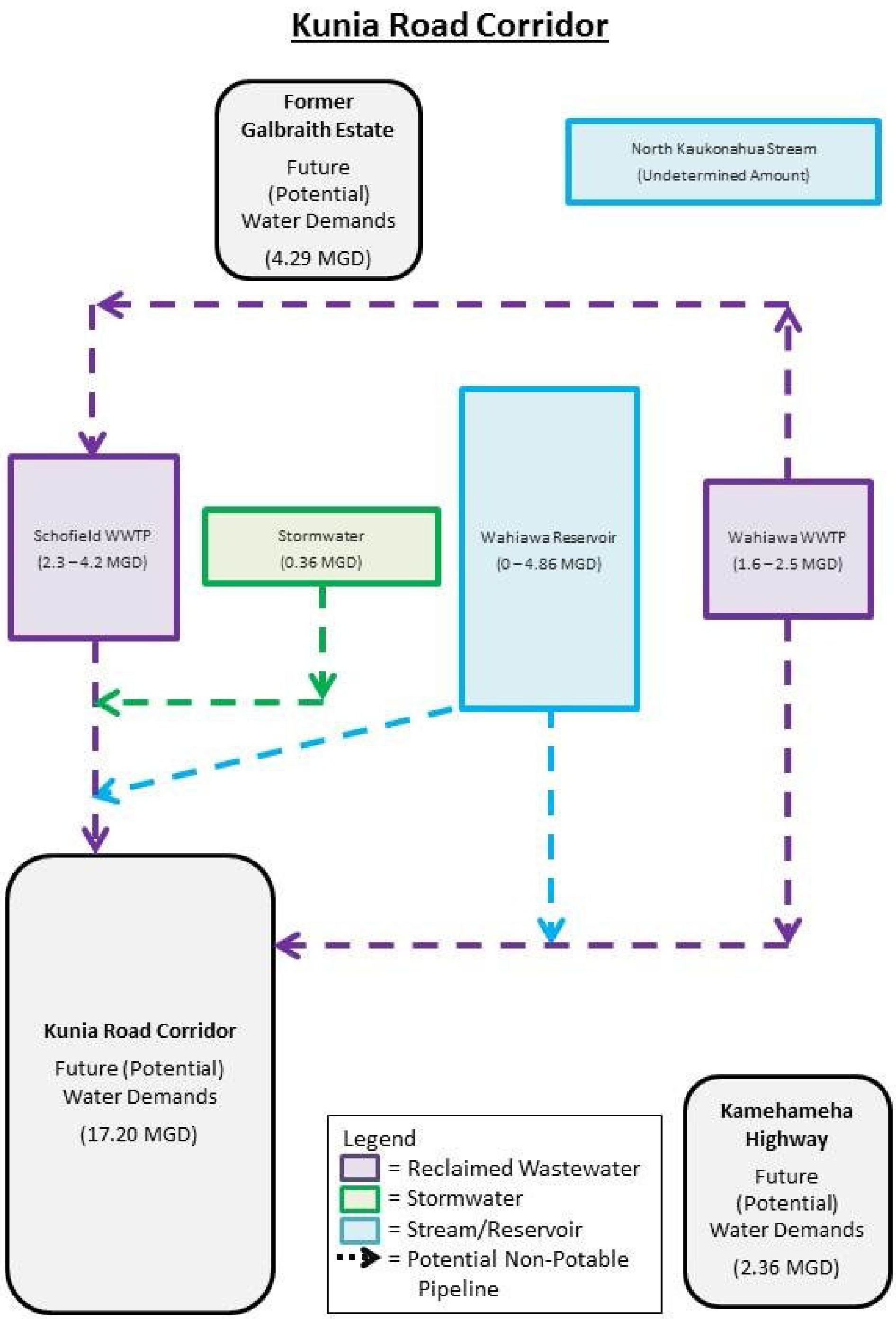
- Assess current non-potable water supply constraints relative to service area location, available storage and conveyance infrastructure, and rough estimates of required infrastructure capital costs based on best available information.

The Study found that future non-potable water demands are projected to increase based on agricultural parcels being put into cultivation on the former Galbraith Estate lands. Additional non-potable water demand may also come from expanded agricultural irrigation within the Kunia Road Corridor on lands not currently served by Waiāhole Ditch or ground water sources.

A single preferred water supply option was not identified for any of the selected study areas. Instead, a more holistic approach was taken to arrive at a grouping of technically feasible alternatives, many of which can be more fully integrated with each other to develop a long-term and adaptive water supply system (**Figure J-1**).

The Study also found that greater coordination and integration of water supply planning and project implementation should be established. The HBWS is currently undertaking such efforts as part of its development of the North Shore Watershed Management Plan (WMP) and the Central Oahu Watershed Management Plan as it relates to both potable and non-potable water supply and demand. The Central Oahu Non-Potable Study should help to inform the WMPs with regard to non-potable water use and development. The WMPs will also provide a mechanism for integration of regional planning between agencies such as Hawai‘i Department of Agriculture (DOA) and Agribusiness Development Corporation (ADC), as well as private entities.

Figure J-1 Schematic of Potential Kunia Corridor Non-Potable Sources and Demands



Leadership is needed to sustain the momentum achieved by this plan and to motivate stakeholders toward implementation of one or more of the integrated opportunities. DOH, DOA, and CWRM are all suited to facilitate this process.

2013 Update of the Hawaiʻi Water Reuse Survey and Report

The objective of the *2013 Update of the Hawaiʻi Water Reuse Survey and Report* is to update the status of recycled water projects and assess any future recycled water projects in the state. It is the policy of CWRM to promote the viable and appropriate use of recycled water in so far as it does not compromise beneficial uses of existing water resources or contaminate potable water aquifers. The updated report provides CWRM with a current picture of recycled water use in the State to better coordinate resource augmentation planning.

The report contains an overview of the current status of water reuse in Hawaiʻi and descriptions of the existing water reuse projects within each respective county. Opportunities for future water reuse projects and ideas for future recycled water applications are also examined. New reuse opportunities, created through expansion of existing recycled water distribution systems, will significantly increase the volume of recycled water that is utilized, thereby improving the economies of scale for reuse program costs. The procurement of funding will determine if, and when, the existing systems will be expanded.

In addition to identifying reuse opportunities, the report discusses obstacles that restrict the growth and implementation of reuse projects, and their possible solutions. Finally, the report provides an overview of federal funding sources that may be applied to the development of reuse projects, and a directory of the existing projects in Hawaiʻi. The report recommends regular updates every five years to inform and assist CWRM in the reuse-planning component of sustainable resource management.

J.6.3 Stormwater Reclamation

Stormwater flows are part of the urban water cycle. Stormwater consists of the runoff water from the impervious surfaces in cities and developed areas, such as streets, sidewalks, roofs, parking lots, and other areas where water cannot percolate into the subsoil.

Stormwater reclamation, sometimes referred to as rainwater harvesting, can potentially provide water for numerous uses. Non-potable water demand for uses such as irrigation and toilet flushing can be supplied by reclaimed stormwater. Many communities in the southwestern region of the U.S. already incorporate stormwater reclamation and reuse into green buildings and developments. The lack of water sources in these areas has made stormwater reclamation an important component of water resource planning and management. It is important to note that there are no guidelines for the treatment and use of reclaimed stormwater in Hawaiʻi.

In addition to the various use benefits, stormwater reclamation reduces the amount of pollutants that are deposited into waterways and nearshore waters, and also provides for flood control and containment. Since most urban areas are already applying programs for flood control and the reduction of non-point source pollution, stormwater reclamation and reuse can be viewed as a sensible extension of the urban water cycle. These flood and pollution controls could help provide an alternative water source for non-potable demands.

Stormwater quality can vary dramatically depending on the rainfall amount, frequency, and collection location. Contaminants such as petroleum products, fertilizers, and animal feces are picked up by stormwater runoff. Therefore, stormwater reuse applications require different treatment levels, depending on the risk of public exposure to the recycled water. Secondary treatment with disinfection removes solids and organics, and produces recycled water of adequate quality to meet many non-potable water demands. Tertiary treatment (which removes nutrients) may be required for applications where people are more likely to come in contact with the recycled water. The risk of exposure to pathogens and contaminants is further reduced through measures such as regular pipe and system maintenance, reliable disinfection, application controls, and crop-irrigation restrictions. County and public health agencies ensure the protection of public health through management programs that delineate risk-reducing management and monitoring actions. In addition to treatment and disinfection requirements, stormwater reuse programs provide rules and recommendations for application methods. For example, stormwater reused in irrigation may need to be applied through sub-surface drippers, rather than surface sprinkler systems. Furthermore, irrigation may be restricted to non-food crops.

Another risk-reducing management action is to provide guidelines and rules for stormwater reuse in various soil types. Soil influences the effect that nutrients, salts, heavy metals, and organic hydrocarbons may have on the environment and nearby surface water bodies. It may be necessary to implement controls to prevent excess irrigation runoff from entering nearby streams or the ocean.

J.6.3.1 Methods for Stormwater Reclamation

On the household scale, rain barrels can be used to collect, store, and distribute stormwater in landscaping. Rain gardens, or vegetated infiltration basins, constructed in the vicinity of the home to take advantage of natural site drainage patterns are another means of containing stormwater runoff that facilitates infiltration. These methods of stormwater reclamation can be classified as “source reuse” and “small lot reuse” technologies. There are five categories used by the U.S. Bureau of Reclamation (Reclamation) to classify stormwater runoff reclamation technologies. **Table J-4** lists and describes each of these technologies.

Water-impounding reservoirs, which are regulated by DLNR’s Dam Safety Program, have been used for irrigation and flood control purposes in a few areas across the state. These include Hawai‘i Island’s Pu’ukapu Reservoir, Kaua‘i’s Wailua and Kapahi Reservoirs, the Waikamoi and Olinda reservoirs on Maui, and the Wahiawā reservoir on O‘ahu.

In the past, a number of projects were envisioned to impound surface water for treatment and domestic use. Although these projects were not completed, the Kohakohau River Dam project on Hawai‘i and the Kōke‘e Water Project on Kaua‘i were two outstanding project ideas. Proposed surface water impoundment projects, however, can significantly impact the environment and ecosystem. For example, the diversion of water from its natural course or the construction of a dam would have direct and cumulative impacts on stream flows, aquatic habitats, riparian habitats, land use patterns, public health, farming operations, and other downstream and stream-related uses. However, proper planning, site selection, design, construction, and operation of an impoundment facility could be appropriate for certain areas, allowing the capture, containment, and treatment of stormwater to provide for non-potable demand. With this benefit in mind, programs for dam safety, flood control, and stormwater capture should be designed to be mutually complementary.

Table J-4 Stormwater Reclamation Technologies

Technology	Description
Source Reuse	Use rain barrels or cisterns to collect precipitation or stormwater runoff at the source to provide water for a variety of non-potable purposes or, with treatment, potable water.
Small Lot Reuse	Manage precipitation or runoff as close to source as feasible. Examples: infiltration planter boxes, vegetated infiltration basins, eco roofs (vegetated roofs), porous pavements, depressed parking lot planter strips for biofiltration, narrowed street sections with parallel or pocket bioswales.
Stormwater Capture	Employ ditches, storm drainage system interception, dry wells, infiltration galleries, and injection wells to capture stormwater.
Stormwater Storage	Use aquifer storage and recovery, stream-bank storage, detention basins, and surface reservoirs to store stormwater.
Stormwater Distribution	Distribute stormwater via gravity ditch or pipe networks, operated/regulated ditch systems, pressure pipe networks, onsite wells.
Source: CH2MHill. *Hawai‘i Stormwater Reclamation Appraisal Report*. Prepared for the U.S. Bureau of Reclamation and the State of Hawai‘i Commission on Water Resource Management. July 2005	

Related to stormwater impoundment are other types of structures used to facilitate stormwater infiltration into the subsurface. These structures are sometimes built primarily for the purpose of artificially recharging ground water aquifers. Artificial recharge is the process by which the natural infiltration of surface water or precipitation into a ground water body is supplemented by infiltration induced by man. It is typically accomplished via three methods:

- Water spreading
- Infiltration pits, shafts, or tunnels
- Injection or disposal wells (sometimes called recharge wells)

Water spreading promotes the recharge of ground water aquifers by encouraging infiltration. Water is spread over a large surface area and allowed to percolate into the ground. This can be accomplished by diverting runoff into shallow basins or depressions, ditches, or open irrigation systems. Another method of water spreading is to build dams across stream channels, in order to increase the wetted perimeter and spread the stream over a larger cross section of the stream channel and banks.

Where space is limited or in areas where impervious layers near the surface tend to restrict the infiltration of water, artificial recharge is achieved by diverting water into infiltration pits, shafts, or tunnels. These excavations are used to either penetrate the impervious layer or to provide direct access to the ground water body.

In the 1990s, numerous injection (disposal) wells were constructed throughout the state. The primary purpose of these wells is to dispose of stormwater runoff, and the amount of recharge that results from these disposal wells is uncertain.

Throughout the era of sugar and pineapple plantations, artificial recharge was incidental to irrigation practices, but in some areas contributed largely to ground water recharge. Leakage from reservoirs and ditches, together with percolation from irrigated fields, constituted a considerable amount of recharge. Some agricultural users returned excess irrigation water to the ground water sources. For example, the 75-mile long East Maui Irrigation Co. ditch system collects and transports 160 MGD on average of surface waters originating in East Maui watersheds to the 27,000 acres of Hawaiian Commercial and Sugar (HC&S) former sugarcane fields in central Maui. Pumpage from the Kahului Aquifer System Area in central Maui is far in excess of the aquifer's established sustainable yield based on natural recharge estimates. The twelve-month moving average withdrawals from the Kahului Aquifer System Area in December 2012 was 37.56 MGD, 3,756% of its estimated sustainable yield of 1 MGD. The current contribution of return irrigation recharge from leakage from reservoir's and ditches is estimated to contribute an additional 10 MGD to the Kahului Aquifer System Area.[23] The disposal of stormwater in wells, pits, and tunnels currently contributes very little recharge to our ground water supply. Regulations restrict the construction and use of injection wells for storm water disposal to coastal areas to avoid potential contamination of drinking water aquifers.

Several reservoirs, such as the Waiawa reservoir, probably lose some seepage to the ground water body, but supporting hydrologic data is not available. The Honolulu BWS operates four open reservoirs in Nuʻuanu Valley, but it is doubtful that seepage from these reservoirs reaches the basal water body. In 2015 they initiated a partnership with the University of Hawaiʻi at Manoa to evaluate the potential and risks of utilizing the reservoirs for aquifer recharge through the construction of injection wells.

[23] May 25, 2010 CWRM Staff Submittal

J.6.3.2 Rainwater Catchment

Rainwater catchment through rain barrels or larger residential cisterns allow homeowners to implement stormwater reclamation and reuse. For some, the lack of access to a public water system necessitates the need for a rainwater catchment system. It is estimated that 30,000 to 60,000 people in the state are dependent on these systems for their water needs[24]. However, current State plumbing codes do not acknowledge rainwater catchment systems unless they are part of a public water system. To address this shortfall the State Building Code Council is working to adopt an updated plumbing code that may include provisions for rainwater catchment systems. Encouraging rainwater catchment helps to offset a household's water demands, thereby creating a more sustainable residence.

J.6.3.3 Urban Runoff Recycling: A Model Facility

The first full-scale, dry-weather, stormwater runoff recycling facility began operating in Santa Monica, California in December 2000. This project is truly innovative, because it contributes to the Santa Monica's Sustainable City Program goal of reducing urban runoff into the Santa Monica Bay. It also provides a significant public education opportunity that takes advantage of the plant's location in the tourist area near the Santa Monica Pier.

The Santa Monica Urban Runoff Recycling Facility (SMURRF) is an outstanding example of how a public facility can be constructed to integrate educational and art components that are responsive to the immediate neighborhood, and serve to enhance community pride. The facility is open to the public and is designed to move visitors through the plant via an elevated walkway, descending from one end of the site to the other, also providing an alternate access to the beach. Each piece of equipment is emphasized with a prominent base, dramatic lighting, and colorful tile work, and the visitor is directed past the plant components in a logical manner. Visitors are able to observe the results of the treatment process at five locations throughout the plant, and information plazas teach visitors about the workings of the facility, the local urban watershed, and the public's role in preventing stormwater pollution. By investing in architecture, landscaping, and art, the project was successfully integrated into the lively atmosphere of the Santa Monica Pier, while showing a sense of respect for the local community and achieving a positive effect on public perception in the community and among the governing bureaucracy.

SMURRF uses conventional and advanced treatment components to remove debris, sediment, oil, grease, and pathogens from stormwater collected by the city's storm drain system. The plant can treat a maximum of 500,000 gallons per day (gpd) of runoff from a 5,100-acre drainage area that produces stormwater flows averaging 265,000 gpd. The treatment processes include: coarse and fine screening to remove trash, plant material, and debris; degritting systems to remove sand and grit; dissolved-air floatation to remove oil and grease; microfiltration to remove turbidity; and ultraviolet radiation to kill pathogens. The treated product water meets the

[24] Macomber P. S. H. *Guidelines on Rainwater Catchment Systems for Hawai'i*. 2004. College of Tropical Agriculture and Human Resources, University of Hawai'i at Manoa

standards of the California Department of Health Services and California’s Title 22 requirements. The treatment train was recommended because it was able to meet current reclaimed water requirements, while allowing for future expansion with reverse osmosis, to meet ground water recharge requirements.

The product water is distributed for landscape irrigation and toilet flushing. Landscape-irrigation water is provided to street-median landscaping, city parks, and a cemetery. Dual-plumbed customers using the product water for indoor use (flush toilets) include the City of Santa Monica Public Safety Facility and the City’s Water Garden.

The project was funded by the City of Santa Monica, the City of Los Angeles, the State of California Water Resources Control Board, the Metropolitan Water District, Federal Intermodal Surface Transportation Efficiency Act grant funds, and Los Angeles County Proposition “A” grant funds. Capital costs totaled $9 million: plant costs totaled $6.3 million, and distribution system costs were $2.7 million. Approximately $2 million of the plant costs are attributed to the 500,000-gallon concrete storage tank, which had to be designed and constructed for tight site considerations (with one side of the tank serving as a retaining wall for a freeway onramp). Approximately $750,000 of the plant cost can be attributed to architectural components designed to incorporate public art and education. The actual cost of the stormwater treatment system is estimated at $2.9 million ($5.80 per gallon).

J.6.3.4 Act 42 Stormwater Utilities

In 2015 Governor Ige signed into law Act 42, SLH, which authorizes the counties to charge user fees to create and maintain stormwater management systems or infrastructure. This Act therefore gives the counties the means to establish stormwater utilities to reclaim and reuse stormwater generated from urban areas. There are currently no known efforts under way at any of the counties to establish a stormwater utility.

J.6.3.5 Hawai‘i Stormwater Reclamation Appraisal Report

The *Hawai‘i Stormwater Reclamation Appraisal Report* was completed in June 2005 by The U.S. Bureau of Reclamation in consultation with CWRM. The report documents Reclamation’s appraisal-level (planning-level) investigation of potential stormwater reclamation and reuse opportunities under Title XVI Program of Public Law 102-575, as expanded by Section 104(b) of the Hawai‘i Water Resources Act of 2000 (Public Law 106-566). Title XVI projects include reclamation water reuse and recycling, and Reclamation policy identifies the following uses as appropriate for funding under Title XVI: environmental restoration, fish and wildlife, ground water recharge, municipal, domestic, industrial, agricultural, power generation, and recreation. Within those broad categories, more specific uses, particular to stormwater capture and local needs, are identified.

In preparing the report, agency consultation meetings were conducted to collect stormwater reuse opportunity ideas, and this resulted in the identification of 31 opportunities for consideration. In this study, opportunities are specific locations where significant benefits may be gained from pairing supply and demand for reclaimed stormwater. Such opportunities must also be consistent with the goals of Title XVI and the desires of participating stakeholders.

The initial set of 31 opportunities was reduced to nine using a two-step screening process (preliminary and detailed). Preliminary screening criteria included factors such as implementability (institutional, regulatory, and land use), demand constraints, and generalized stakeholder acceptance. Detailed criteria such as operational flexibility, long-term permit compliance, flow augmentation, ground water recharge opportunities, and reuse potential were also considered.

The nine projects that came out of the screening process were evaluated and ranked on the basis of: ease of delivery and operation, dependability of water supply, simplicity of storage and water treatment, institutional considerations, the degree to which prior investment has been maximized, and cost. Specific areas of investigation included: basin land use, vegetation, soil, and slope characteristics; existing irrigation conveyance and natural stream networks; precipitation; expected demand area and size; and hydrology. Institutional factors were also assessed to identify potential direct and indirect effects on the institutional environment closest to the opportunity area. Existing knowledge and threshold-level information obtained informally during the study were used to establish the social and cultural context of the projects. Finally, preliminary cost estimates generated from rough general designs were examined and compared.

The nine candidate opportunities included locations on Molokaʻi, Kauaʻi, Oʻahu, Hawaiʻi, and Maui. However, feasibility has not been established for all the opportunities described in the study. To move the opportunities toward funding for construction under Reclamation's Title XVI program, several key elements must be addressed:

- Congressional authorization needs to be obtained for Reclamation involvement in conducting feasibility studies.
- A project sponsor must be identified. In some cases, there is already an organization or entity that has taken responsibility for success of the project. In others, discussion with local stakeholders to date has focused on whether the project represents a "good idea" and is valuable and viable. It is vital to this process to investigate interest in ownership and market the opportunities to local groups capable of completing the funding and construction process.

- Owing to the significant nonfederal funding contribution required, additional education and outreach to local stakeholders is needed. In many cases, matching contributions for a project will be allocated by nonfederal, elected representatives. To maximize the chances of success, key constituent groups would have to be identified and approached regarding the potential benefits of the project. Such groups must be given ample opportunity to explain concerns and needs for making the project successful for all involved.

J.6.3.6 2008 Appraisal of Hawaiʻi Stormwater Reclamation and Reuse

In 2008 Reclamation, in partnership with CWRM, completed a refinement of the 2005 Hawaiʻi Stormwater Reclamation Appraisal Report. This study produced three study element reports under the broad title of *2008 Appraisal of Hawaiʻi Stormwater Reclamation and Reuse*. Much of this appraisal explores opportunities to capture and reuse stormwater to augment potable supplies with a secondary benefit of improving water quality discharged to our streams and near-shore coastal waters during storms. In refining the 2005 report, the 2008 delved into further details of the regulatory framework, stormwater treatment methods, prioritization of opportunities, and evaluation criteria for overall ranking of opportunities. Newly identified opportunities were analyzed considering factors such as proximity to existing infrastructure, needed infrastructure, benefits and stakeholders. The opportunities were further evaluated for potential reuse demand, potential stormwater volume, partnerships, likelihood of implementation, institutional constraints, and coarse cost estimates.

The 2008 *Appraisal of Hawaiʻi Stormwater Reclamation and Reuse* consists of three study elements:

Study Element 1 has two components: (1) Develop a statewide framework for identifying and resolving institutional barriers to stormwater reclamation and reuse, and (2) develop a handbook for reclamation and reuse technologies and best management practices for existing and new developments.

Study Element 2 consists of an appraisal of opportunities for ground water recharge of stormwater over a brackish water (caprock) aquifer in a dry, but rapidly developing area on Oʻahu called the ʻEwa Plain.

Study Element 3 consists of an appraisal of statewide opportunities for augmenting ground water supplies with stormwater, including ground water recharge.

This report addresses the statewide framework and identifies issues that are potential barriers to stormwater reclamation and reuse, and opportunities for overcoming these barriers. Study Elements 2 and 3 are discussed in *An Appraisal of Stormwater Reclamation and Reuse in the ʻEwa Plain of Hawaiʻi* and *An Appraisal of Stormwater Reclamation and Reuse in Hawaiʻi*, respectively.

The three report elements combined identified 21 potential opportunities for stormwater reclamation and reuse:

E-1 – Makakilo Ridge
E-2 – Kapolei Flood Control Channel
E-3 – Fort Barrette Road Swale
E-4 – Honouliuli Recharge Trench
E-5 – Fort Weaver Road Swale
E-7 – Waiāhole Ditch Conveyance to ‘Ewa Recharge Trench
O-1 - Wheeler Army Air Base and Schofield Barracks
O-2 – Mililani North Stormwater Channel
O-3 – Mililani South Stormwater Channel
O-4 – Waipahu Stormwater Channel
O-5 – Waikele Stormwater Channel
O-6 – Nu‘uanu Valley Surface Water
O-7 – Pālolo Stream Stormwater Channel
E-7 – Waiāhole Ditch Conveyance to ‘Ewa Recharge Trench
M-1 – Waiale Road Stormwater Drainage
M-2 – Kahului Flood Control Channels
M-3 – Kahoma Stream Flood Control
M-4 – Lahaina Flood Control Channel
K-1 – Nwilwili Diversion
K-2 – Lihue Airport
H-1 – Lower Hāmākua Ditch

In order for any of these opportunities to be implemented, there needs to be a project champion(s), stakeholder collaboration, and funding sources. There would likely be an intermediate step of a feasibility study and environmental review prior to the engineering, design, and construction phases. Significant challenges to stormwater reuse, which can be overcome, include uncertainty of stormwater treatment and water quality requirements for reuse, infrastructure needs, and the unreliability of storm events. Climate change impacts to rainfall patterns in Hawai‘i make stormwater reclamation and reuse an attractive option as an alternative water supply source. A successful stormwater reuse project would take advantage of the surfeit of water runoff during large rainfall events by capturing, treating, storing and distributing the water for some beneficial reuse.

In addition to producing the three-part report, a handbook of best management practices (BMP) for stormwater reclamation and reuse in Hawai‘i was produced.[25] The handbook is intended to be a guide to homeowners, developers, and planners for managing stormwater as a resource rather than as a nuisance to be disposed of. Alternative stormwater BMPs and technologies for

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[25] Commission on Water Resource Management. (2008). *A Handbook for Stormwater Reclamation and Reuse Best Management Practices in Hawai‘i.*

new developments, retrofits of existing developments, open space, rural, and agricultural areas are presented. The handbook focuses on five different land uses – individual homes, neighborhoods, commercial & institutional, green space/recreational, and rural/agricultural - and identifies BMPs for each. Some of the BMPs and technologies apply to more than one type of land use. Applying these technologies and practices will support ground water sustainability, improve surface water and near-shore water quality, reduce erosion, and mitigate flooding. In addition, The Office of Planning's CZM Program developed a low impact design guide that can be found on their website at: http://planning.hawaii.gov/czm/initiatives/low-impact-development/. Further study of the obstacles, constraints, and opportunities to increase stormwater recharge statewide from mauka to makai should be undertaken.

J.6.3.7 Stormwater Reclamation Issues and Constraints

Stormwater reclamation is not commonly practiced in Hawai'i. This section provides an overview of the broader issues related to establishing the economic, social, and technical climate to expand water reuse and develop reclaimed stormwater as an alternative water supply. The discussion below is adapted from the June 2005 *Hawai'i Stormwater Reclamation Appraisal Report,* prepared by the U.S. Bureau of Reclamation in cooperation with CWRM, to investigate opportunities for stormwater reclamation in Hawai'i (**Section J.6.3.6** provides a summary of the project).

Demand and Pricing: Reclamation and reuse of stormwater often provides opportunities for multipurpose benefits, for example, flood control and ground water recharge. In many ways, these activities have potential to mitigate impacts of development or provide water supply to maintain or increase traditional land uses such as agriculture. With the exception of some types of urban or industrial runoff, quality of reclaimed stormwater is often good and does not share the same stigmas associated with reclaimed wastewater.

For these reasons, there have not been significant obstacles identified in establishing a market for reclaimed stormwater. With a few exceptions, demand for reclaimed stormwater is primarily a function of scarcity of the resource in general, rather than any particular association with the supply. One significant exception to this finding is use of urban or industrial runoff for drinking water.

At the same time, this appearance of a commodity status for reclaimed stormwater places it more firmly in competition with more traditional methods of supply based on price alone. This must be evaluated case-by-case, but emphasis must be placed on long-term economic benefits associated with reducing the need to establish new sources of supply. In urban areas, increased development may actually increase the potential yield of reclaimed stormwater, without the need to develop new sources, based on changing land use conditions. The passing of Act 42, which allows the counties to collect fees to establish stormwater utilities may provide a favorable cost-benefit to reclaiming and reusing stormwater.

Needed Research and Demonstration Studies: It is necessary to establish that public health and safety are maintained with the use of reclaimed stormwater. It is also necessary to proceed in an environmentally sound manner. The areas of greatest concern regarding reuse of stormwater are: potential contamination of aquifers and other potable water supplies by poor-quality runoff, and environmental or habitat degradation resulting from diversion of surface flows from the natural hydrologic regime. From a water quality perspective, urban runoff, particularly associated with industrial processes or transportation corridors, contains the highest concentration of contaminants, often hydrocarbons or heavy metals. In more rural areas, agricultural runoff can carry high concentrations of nutrients, pesticides, and in some areas, salts. Additional research and pilot studies are needed to demonstrate economical methods of adequately treating stormwater prior to injection into aquifers or introduction in potable water systems.

Seasonality: The fundamental challenge of most methods of stormwater reuse is that stormwater is primarily available in excess during the rainy season and most needed in the dry season. Therefore, it must be stored for at least a season, in sufficient quantity to justify the cost of construction of the impoundment. This relationship informs expectations regarding the size of storage needed. The closer beneficial reuse mimics the pattern in which stormwater is available, the less storage is needed. In such a case, the opportunity is primarily one of diversion to an alternate flow path, rather than storage.

Volume: For a reuse opportunity to be successful, the runoff volume that can be consistently collected for beneficial use must be in concert with the demand for water use. In some cases, such as aquifer recharge, it has been assumed that whatever stormwater is available can be absorbed into the aquifer, given an adequately designed infiltration or injection system. In other cases, such as storage for reuse as fire suppression, the amount of collected water is likely to be very small, compared to the expected stormwater runoff. This poses no problem, unless the intent of the opportunity is, for example, to provide flood control, which is not likely to be adequately addressed by such a limited reuse demand.

On the other hand, if the purpose of the opportunity is to provide irrigation to certain crops, a cost-benefit relationship exists between the expected crop yield increase due to irrigation and the cost of opportunity construction. It is important to understand how much stormwater may be available and the related storage requirements to evaluate the efficiency of the reuse alternative.

Timing: A distinction has been made among long-term seasonality, year-to-year hydrologic variability, and large-event conditions. The latter is termed “Timing”, as flood events are, virtually by definition, difficult to adequately capture. Large volumes of excess runoff are available during these infrequent events, but often it is not cost effective to construct storage to capture all that is available. Similarly, to have a positive impact on flooding, capture of a large volume of water is often required; however, it may be difficult to revise such volumes in an efficient way.

Spatial Separation: Hawai‘i has a complex infrastructure of under-used old drainage and irrigation-conveyance elements that may alleviate the challenge of water transfer from capture point to use. Nevertheless, it may be a significant challenge to improve and maintain such infrastructure to provide reliable transfer water across basin boundaries. Aquifer recharge can also alleviate this challenge by using subsurface connectivity to transmit water to the point of use.

Changing Conditions: Rapid development of urban areas (or, to a lesser extent, changes in agricultural land uses) has the potential to change the stormwater runoff hydrology of a basin, as well as the expected demand for a beneficial reuse. Estimates of the potential impact are only as accurate as estimates of the expected changes.

Sediment: For ambient water quality, habitat development, or potable water use, source water quality and sediment load can be a significant issue. In addition to soil particulates, urban runoff can contain a wide variety of contaminants associated with sediments, including heavy metals and hydrocarbons.

Temperature: Ambient water quality and habitat development often have associated temperature criteria. Releases from reservoirs, which may have stratified conditions, can lead to release temperatures that do not match ambient and seasonal conditions. Alternatively, increasing base flow by infiltration and percolation through stream beds and stream banks can restore more natural temperature management to stream systems.

Capture Location and Mechanism: Stormwater must be captured before it enters a natural stream system. In rural areas, this can present a significant challenge. In most cases, existing irrigation systems may be used to intercept surface runoff along hill slopes. In urban areas, storm drainage systems can be intercepted before the outfalls, but cost and space constraints can make it prohibitive to retrofit facilities.

Area of Application: Some types of uses may require small volumes of water distributed over wide areas. Others may have more localized demands.

Delivery Location and Mechanism: Some uses require subsurface delivery; others may require surface systems. The contents of the report and assessment methods are discussed in more detail in **Section J.6.3.6**.

J.6.4 Desalination

Desalination can remove dissolved minerals, including but not limited to salt, from the source water. Seawater, brackish water, or treated wastewater can be processed through several desalination methods: distillation, vacuum freezing, reverse osmosis, and electrodialysis. Distillation and reverse osmosis are the more popular methods, and significant advancements in these technologies have been made since the 1980s.

Desalination plants can process a variety of input water, or feedwater types. Seawater can be taken up through offshore intakes or wells drilled into the beach or seafloor. Brackish ground water, which is generally less costly to process, and reclaimed water are other sources of feedwater. Pretreatment and post-treatment processes are also used for disinfection and elimination of other types of pollutants, including microbes and pathogens.

A variety of pretreatment processes are used to remove materials that interfere with desalination. Biocides, usually chlorine solutions, are used to remove algae and bacteria. Ozone or ultraviolet light treatments can be used to remove marine organisms. Some distillation plants must remove metals from the feedwater to prevent system corrosion. Reverse osmosis membranes can be impaired by chlorine, suspended solids, and particles. Thus the feed water must be further pretreated with dechlorination techniques, coagulation, and filtration.

Desalination plants that produce water for domestic use have post-treatment processes to ensure that the product water meets health standards and recommended aesthetic and anti-corrosive standards. The purity of desalinated product water is usually higher than drinking water standards, and the lack of dissolved solids and minerals creates acidic pH levels that are corrosive to pipes. Therefore, desalinated water for municipal use is mixed with water that contains minerals or is otherwise adjusted for hardness, alkalinity, and pH prior to distribution.

J.6.4.1 Methods for Desalination

Common desalination methods can be described in two categories: phase change (distillation) methods, and membrane separation methods. These methods are generally described below.

Thermal Separation Methods

Distillation (Evaporation): Distillation involves heating saline or brackish water until it forms water vapor. This vapor, which is largely salt-free, is condensed to liquid form for storage and distribution. Common methods of distillation are multistage flash, multiple effect distillation, and vapor condensation. Some distillation plants produce freshwater, using a hybrid production process that employs two or more of these technologies. The waste product of distillation methods is a highly concentrated brine solution.

Freezing: This phase-change method is characterized by the formation of ice crystals with the dissolved salts remaining in the solution. Fresh water is produced by separating the ice crystals from the solution and melting the crystals. This process uses much less heat than the distillation method, but it has substantially higher operating and maintenance costs.

Membrane Separation Methods

Reverse Osmosis: Osmosis occurs when water passes through a semi-permeable membrane, separating two solutions of different salt concentrations. In natural osmosis, water moves out of the diluted solution until the concentrations of the two solutions become equal, or when the pressure on the concentrated-solution side of the membrane rises to the same osmotic pressure. The osmotic pressure may be referred to as the osmotic head, or the difference of the depths of the liquid surfaces of the two solutions. When a pressure greater than the osmotic pressure is exerted on the more concentrated solution, reverse osmosis occurs. The result is the movement of water from the more concentrated side of the membrane into the more dilute solution. In the reverse osmosis process, the concentrated solution can be either seawater or brackish water. The osmotic-pressure gradient is induced to move more water into the diluted solution. This water is then collected, stored, and distributed to various users.

Electrodialysis: Salts in solution disassociate into positively and negatively charged ions called cations and anions. Electrodialysis depends on the action of semi-permeable membranes than can selectively pass either cations or anions. When stacks of alternating cation- and anion-permeable membranes are placed in a direct current electric field and feed water is passed between the membranes, the cations migrate to the negative electrode (cathode) and the anions move to the positive electrode (anode). The membranes trap the ions in cells between the membranes, and the resulting solution is removed as waste brine. Water passing through the membranes is collected and removed for use as desalted water.

J.6.4.2 Desalination Issues and Constraints

The issues and constraints associated with different desalination methods are summarized then evaluated in the following paragraphs. A general discussion of environmental issues and challenges related to desalination follows. Other issues and considerations may also be relevant depending on the particular site or application.

Thermal Separation Methods

Distillation (Evaporation): Although distillation methods are capable of handling large quantities of saline water, there are disadvantages including, high thermal-energy requirements, high capital costs, high operating and maintenance costs, and severe scaling and corrosion problems. Scaling is a condition that results from the buildup of salt deposits on plant and pipe surfaces, and is caused by the high-salt concentration of seawater. Scaling increases in high-temperature environments, and in distillation plants it results in reduced plant efficiency and greater pipe corrosion. Scales can be removed by chemical or mechanical means and can be reduced by introducing additives to inhibit crystal growth, reducing temperatures or salt concentrations, removing scale-forming constituents, or seeding to form particles. In addition to problems with plant scaling, the intake and outfall structures and pipes can become corroded or fouled with marine organisms, and must be mechanically or chemically cleaned.

Distillation, in some cases, may not be competitive with other desalination methods. In Hawaiʻi, the feasibility of using waste heat from a nuclear-power plant was considered by the Honolulu BWS and Hawaiian Electric Company (HECO) in the 1960s, but it was concluded at that time that the proposal was premature.

Freezing: The freezing method has limited applications, is relatively new, and is capable of producing only up to 100,000 gpd on a practical basis. Although it requires only about 15% of the energy used by the distillation process and results in minimal scaling and corrosion problems, its operating and maintenance costs are high. These costs are incurred in separating the ice from the brine, washing the ice crystals, and melting the crystals to form fresh water. As technology improves, the freezing method may have a future, especially in areas where only poor-quality water sources are available and where large quantities of product water are not required.

Membrane Separation Methods

Reverse Osmosis: Because reverse osmosis requires the use of permeable membranes, the feedwater must be pretreated to remove particles that can build up and clog the membranes. The quality of the product water depends on the pressure, the salt concentration of the feedwater, and the membrane’s salt- permeation constant. Water quality can be improved by sending the product water on a second pass through the membranes.

The filters used for pretreatment of feedwater must be cleaned via backwashing, to clear accumulated particles and solids. The reverse osmosis membranes must also be cleaned several times a year with alkaline cleaners to remove organic fouling, and with acid cleaners to remove scale and inorganic precipitates. Membranes must be replaced every three to five years, and replacement procedures require partial or complete plant shut down.

Because reverse osmosis plants operate with lower temperatures, plant scaling is not as serious a problem as in distillation plants. However, reverse osmosis plant intakes and outfalls can also become corroded or fouled with marine organisms, and must be mechanically or chemically cleaned.

Electrodialysis: An electrodialysis reversal (EDR) system has been developed, which reverses the polarity of the electrodes several times an hour. This reversal process minimizes scaling and other adverse effects on the membranes. It should be noted that electrodialysis does not remove bacteria and other uncharged particles. Accordingly, it is necessary to stabilize and disinfect the product water before use.

J.6.4.3 Evaluation of Desalting Methods

Desalting methods must be compared with considerations to economics, location of area of need, availability and quality of feedwater, operational problems, energy demand, quantity and quality of product water needed, and environmental impacts. The most practical approaches for desalination in Hawai‘i would be electrodialysis and reverse osmosis. For the foreseeable future, we may conclude that Hawai‘i’s municipal needs cannot be met through distillation, freezing, and ion exchange methods, although improving technology may make these methods more attractive in the future.

Environmental Issues

While Hawai‘i is surrounded by a virtually unlimited supply of salt water, desalination is the option of last resort because of its high economic and environmental costs relative to other alternatives. Open water intakes can harm fish and other marine organisms as they are trapped in the screen or killed during the processing of the salt water. While subsurface intakes can minimize impacts, the disposal of highly-concentrated brine byproduct, which may contain other chemicals and pollutants used in the processing, are another environmental challenge.

In Hawai‘i, brine is disposed via injection wells. Because it is denser than seawater, hypersaline brine will tend to sink and spread out slowly along the ocean floor. However, injection well regulations in Hawai‘i are focused on ensuring the protection of inland drinking water sources, not the marine environment. Monitoring of daily flows, injectate quality, and annual/periodic tests of well performance are conditions of injection well permits. If the monitoring data show that corrosivity standards for salt have been exceeded, then it is deemed a hazardous waste, and the DOH’s Hazardous Waste Branch will become involved. Neither of these two programs address the issue of marine environmental impacts associated with brine disposal. There is a gap between the science of generalized flows to the ocean and the mixing of ocean discharges in receiving waters. While the water quality standards for marine waters require (all estuaries except Pearl Harbor) that salinity not vary more than ten percent from natural or seasonal changes considering hydrologic input and oceanographic factors,[26] injection wells are not addressed under current water pollution control permits.[27]

J.7 State and County Resource Augmentation Programs

J.7.1 The Importance of Dams and Reservoirs for Resource Augmentation

Historically, dams and reservoirs in Hawai‘i were predominantly developed by the agricultural industry in the early 1900s as part of their large irrigation systems. Today, dams and reservoirs continue to be used by the agriculture industry, in addition to providing storage for drinking water, flood control, hydro-electric, recreation, and other purposes.

Reservoirs are a vital component of any resource augmentation program. Their ability to store large capacities of water can buffer the effects of the variability in the supply and demand of an alternative water source. For example, non-potable water for irrigation may not always be needed due to changes in the climate or growing cycle, but it is always being produced. Without reservoir storage this would not be a viable resource to meet agricultural water demands.

[26] HAR 11-54.

[27] HAR 11-55 Appendices B through L.

Reservoirs also provide a means to mitigate the effects of climate change. Climate change research suggests that extreme precipitation events will become more prevalent in the near future. Reservoirs enable the capture of rainfall and surface flows during storm events, and can supplement natural water sources during drought conditions.

Table J-5 Reservoir Storage Capacity Ranked by Storage Per Unit Area lists the number of reservoirs by island and their normal storage capacity as reported to the DLNR Dam and Reservoir Safety Program. However, to properly assess the storage potential that exists to compliment any resource augmentation program or to mitigate the effects of climate change, the rate of sedimentation for these reservoirs must be known.

Table J-5 Reservoir Storage Capacity Ranked by Storage Per Unit Area

Island	Normal Storage Capacity (acre-feet)	% of State Total	Number of Reservoirs	% of State Total	acre-feet per acre
TOTAL* **(5 main islands)**	**36,210**	<100	**133**	95	0.009
Kauai	15,553	43	52	37	0.044
Oahu	10,803	30	16	11	0.028
Molokai	4,365	12	1	1	0.026
Maui	4,347	12	54	39	0.009
Hawaii	1,242	3	10	7	<0.001

Note: Data from State inventory lacks normal storage capacity for seven reservoirs out of 140 statewide.
Source: Penn, D., 2013, NWRI Progress Report: Acquire Sedimentation Data to Promote Reservoir Sustainability and Advance Watershed Science. University of Hawaiʻi Water Resource Research Center.
http://www.wrrc.hawaii.edu/research/project_penn/sedimentation.pdf

Sedimentation of Hawaiʻis reservoirs is a constantly occurring process that can reduce the functionality of a reservoir if not regularly addressed. Officially recorded storage volumes are based on design specifications for the initial installation of the reservoir. Regular bathymetric surveys are required to determine the rise in reservoir bed elevations that occur over time to therefore determine the normal operating capacity of a reservoir.[28]

[28] Penn, D., 2013, NWRI Progress Report: Acquire Sedimentation Data to Promote Reservoir Sustainability and Advance Watershed Science. University of Hawaiʻi Water Resource Research Center. http://www.wrrc.hawaii.edu/research/project_penn/sedimentation.pdf

The most recent effort to determine reservoirs sedimentation rates was undertaken by the University of Hawai‘i’s Water Resource Research Center (WRRC). Their initial investigation found that data on actual sediment delivery, trapping efficiency, accumulated volume and release is limited.[27] Therefore, further research is needed before an assessment of reservoir capacities can be made to compliment any resource augmentation program(s).

The primary means of collecting any information on reservoirs in Hawai‘i is through the DLNR Dam and Reservoir Safety Program. Dams and reservoirs must be properly maintained and managed to mitigate any potential threat they may pose to those who live in their vicinity.

J.7.1.1 DLNR Dam and Reservoir Safety Program

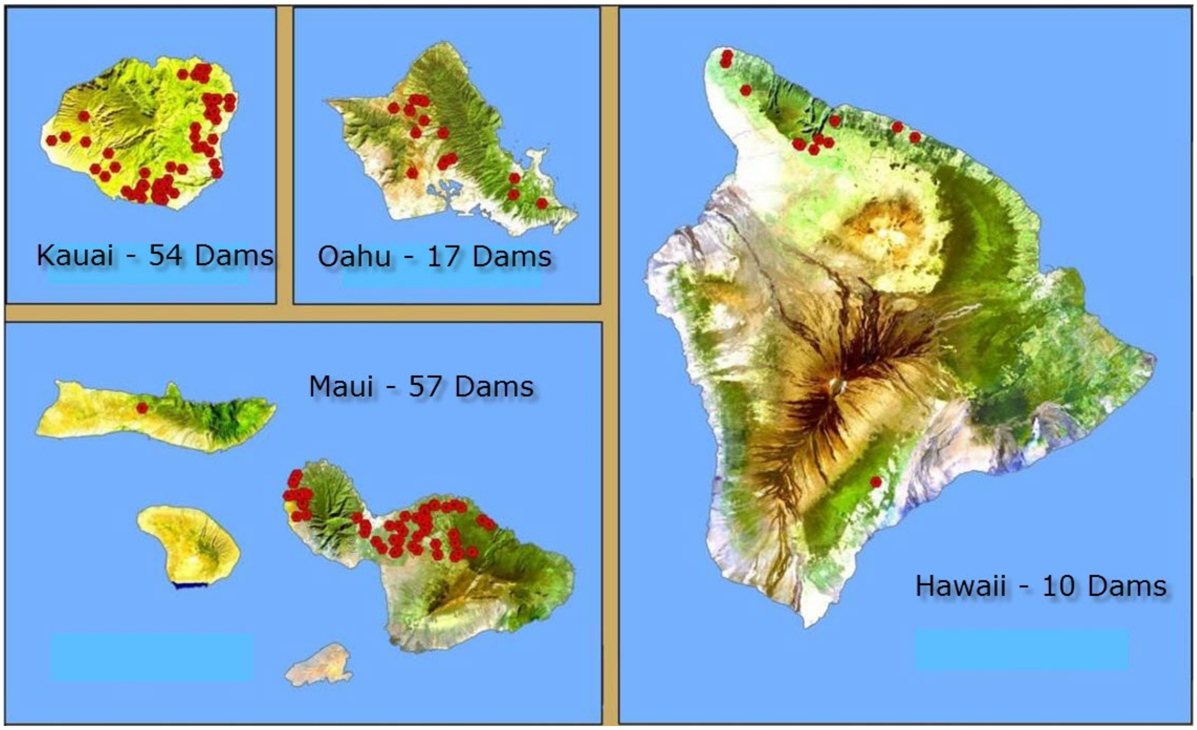
The DLNR Engineering Division administers the Hawai‘i Dam and Reservoir Safety Act of 2007 (Chapter 179D HRS), which along with HAR Chapter 13-190.1 governs the design, construction, operation, maintenance, enlargement, alteration, repair, and removal or dams, reservoirs, and appurtenant works in the Hawai‘i.

Only dams that meet a certain size criteria of height and volume are regulated by the DLNR. Regulated dams are identified as having artificial barriers which are 25-feet or more in height or have an impounding capacity of 50-acre-feet (approximately 17 million gallons) or more. Dams less than 6-feet in height, regardless of storage capacity, or that have a storage capacity not in excess of 15-acre-feet (5 million gallons) regardless of height do not fall under the jurisdiction of DLNR, unless otherwise specified. A permit from the Board of Land and Natural resources is required for all dam construction, alteration, enlargement, modifications or removal work. To assist dam owners and designers DLNR has developed guidance documents and a standard set of general permit requirements. These can be found online at: http://dlnreng.hawaii.gov/dam/.

DLNR maintains a database of regulated structures, which includes classifications regarding size, hazard potential, and overall condition. DLNR staff routinely inspects these structures to keep the database current. The Hawai‘i Dam and Reservoir Safety Act of 2007 authorizes the DLNR implement enforcement actions for failure of owners to comply with the requirements of Act, non-compliance with dam safety permit terms and conditions, and non-compliance with certificate to impound terms and conditions.

As of 2013 there are 138 regulated dams and reservoirs throughout Hawai‘i. **Figure J-2** breaks this figure out by island. The majority of the regulated dams and reservoirs in the state are privately owned (69%), with the state and county governments owning only 31%.

Figure J-2 Locations of Regulated Dams and Reservoirs (2013)



J.7.1.2 DLNR General Flood Control Plan Program

DLNR developed the State General Flood Control Plan in September 1983 in order to coordinate floodplain management initiatives. The goal of the State General Flood Control Plan (SGFCP) is to assist the State in decision-making regarding flood hazards and prioritize areas to best focus limited resources. The last Statewide inventory of flood history and flood studies was performed in 1994. Therefore, an update of the SGFCP is necessary, and is authorized by Hawai‘i Revised Statutes Chapter 179.

The SGFCP is currently being updated and will utilize digital database and website technologies to provide educational information and public awareness tools on flood risks, flood histories, hydrologic data, mitigation initiatives, a library for flood studies and post-flood reports, and other related information. The SGFCP update will also implement geospatial and internet technologies that will allow partner agencies to share, communicate, and utilize collected information[29].

[29] https://dlnreng.Hawai‘i.gov/fcds/gfcp/

J.7.2 County Resource Augmentation Programs

The following sections describe resource augmentation programs currently administered by the counties, as well as other private projects. The County of Maui has a well-developed and successful wastewater reclamation program. In the City and County of Honolulu, wastewater reclamation and desalination are being championed by the BWS. Wastewater reclamation is also being practiced at a smaller scale in the counties of Kauaʻi and Hawaiʻi.

J.7.2.1 County of Maui

Wastewater Reclamation

The County of Maui's Wastewater Reclamation Division is considered to be a water reuse leader in Hawaiʻi. In 1990, Maui County developed a plan and embarked on a long-range program to reuse millions of gallons of a valuable resource, high-quality recycled water, which previously had been disposed into injection wells. To lay the foundation for the county's program, several key components were initiated including: water reuse feasibility studies; a community-based rate study; the creation of a Water Recycling Program Coordinator position; upgrades to the Kihei (South Maui) and Lahaina (West Maui) wastewater reclamation facilities to R-1, tertiary-treatment capability; passage of an ordinance mandating the use of recycled water at commercial properties; adoption of rules for recycled water service; and the creation of a recycled water rate structure, which recovers monies spent on distribution-system development from both recycled water and sewer users.

Program Development: The impetus behind the development of Maui County's water reuse program was a regulatory-agency belief that Maui's effluent-disposal practices were causing environmental problems. The United States Environmental Protection Agency and local environmental groups expressed a concern that injection wells may contribute nutrients that cause alga blooms in coastal waters. In 1995, the EPA placed a limitation on the amount of effluent that could be disposed into the injection wells at the county's Lahaina Wastewater Reclamation Facility (WWRF). This factor played a major role in the passage of the bill, which led to the mandatory recycled water use ordinance on Maui. Increased recycled water use on the island and the results from scientific studies, which indicated that other non-point nutrient sources might be the cause of the periodic alga blooms, have eased this concern somewhat. Nevertheless, effluent disposal will continue to be a factor driving the County of Maui's water reuse program, since most of its wastewater reclamation facilities rely on injection wells. As performance of these injection wells eventually decline, increasing the use of recycled water from the respective facilities, rather than drilling additional wells, may be required by regulatory agencies.

Potable Water Supply: Water supply is now a factor driving the County of Maui's water reuse program. The island of Maui has limited supplies of available fresh water. The island's main water source, the ʻĪao Aquifer System Area, supplies most of Central and South Maui with potable water. Much of this water is used for landscape irrigation at parks, schools, condominiums, hotels and single-family residences. Due to increasing development in these areas, the ʻĪao Aquifer System Area is showing signs of overpumping. Over the past several years, monitoring of the aquifer's wells has indicated that chloride levels are increasing and freshwater levels are decreasing. As a result, CWRM designated the ʻĪao Aquifer System Area as a Ground Water Management Area. The nearby Waiheʻe Aquifer System Area has also been the subject of designation concerns. CWRM designates water management areas to ensure the long-term sustainability of the resource by establishing administrative control over the withdrawal of ground water in the area.

Recycled Water Infrastructure: Wastewater Reclamation Division uses recycled water from all five of its facilities. Distribution systems have been developed in South Maui and West Maui. South Maui has the most complete distribution system at this time and as a result, the most water reuse projects. The South Maui system now provides recycled water to eighteen separate projects, with more scheduled to connect to the distribution system in the near future. Uses include landscape irrigation, agricultural irrigation, fire control, industrial cooling, composting, construction activities, and toilet and urinal flushing.

West Maui distribution is limited, due to insufficient recycled water storage, but it does service Maui County's largest water reuse project, the Kaanapali Resort. Up to 1.2 MGD is utilized by the resort for golf course and landscape irrigation. Plans are now being developed to expand this system to provide R-1 water to condominiums and hotels in the Kaanapali area. R-1 water is also pumped to Maui Pineapple Company, but use has been limited due to above-average rainfall since the distribution system was built. Maui Pineapple Company will also phase out pineapple production in west Maui in the year 2006.

In addition to the major distribution systems described above, recycled water is utilized from Maui County's facilities on Lanai, Molokaʻi, and in central Maui. On Lanai, wastewater is processed to R-3 quality utilizing stabilization ponds, and then the entire plant flow of approximately 0.25 MGD is sent to an auxiliary WWRF owned and operated by the Lanai Company where it is upgraded to R-1 quality and used for golf course irrigation. On Molokaʻi, the State Department of Transportation utilizes R-2 water for landscape irrigation along the Maunaloa Highway. Finally, in central Maui, R-2 water is used to irrigate coconut trees and native Hawaiian plants at the Kanaha Cultural Park, which is adjacent to the Kahului WWRF.

Economics: Since water supply and wastewater disposal were both important factors driving Maui County's water reuse program, both recycled water users and sewer users share the costs associated with recycled water production and delivery. A portion of the sewer fees collected from all commercial and residential users of Maui County's sewer system is used to pay for the recycled water program's operation, maintenance, and infrastructure costs. Maui County officials believed that sewer users must not only pay the costs associated with wastewater collection and treatment, but must also help bear the costs of effluent disposal, whether it is through the use of injection wells or through water reuse. This approach allowed Maui County officials to set the price of recycled water at rates that encourage users to connect to the distribution system. The following user classes, with corresponding costs of recycled water, were created:

- Major Agriculture (> 3.0 MGD): $0.10/1000 gallons;
- Agriculture (including golf courses): $0.20/1000 gallons; and
- All Others: $0.55/1000 gallons.

The rates were set at levels slightly below the costs of the water sources typically used by the three recognized user classes. An “avoided cost” category was also created which allows recycled water consumers to pay the same rate for recycled water as they were paying for other non-potable water sources. Connection fees for the south and west Maui areas, where major R-1 distribution systems were developed, were also established to help pay for the recycled water program.

Public Education and Outreach: Proactive public education has played an important role in the success of Maui County’s water reuse program. The Wastewater Reclamation Division’s (WWRD) Water Recycling Program Coordinator conducts up to 100 presentations per year on water conservation, wastewater treatment, and water reuse to schools, community groups, and the general public. Tours of the County’s wastewater reclamation facilities are also provided. In addition, the coordinator issues press releases announcing new projects that use recycled water and expansions to County recycled water distribution systems. Promotional items such as bumper stickers, magnets, rulers and pamphlets are also utilized. Generally, the public has supported the concept of reusing wastewater within the community. As a result of its proactive approach to public education, the County has encountered little opposition to its water reuse program.

Most of the water reuse projects in Maui County are provided recycled water by the County of Maui’s WWRD. There are also private systems, including resorts and housing developments that treat their own wastewater and utilize the recycled water for golf course irrigation. The Pukalani and Makena Golf Clubs on Maui, the Challenge at Mānele on Lanai and the Kaluakoʻi Golf Club on Molokaʻi blend recycled water with other non-potable sources to satisfy their respective irrigation demands.

Lanai has changed its economic base from pineapple cultivation to tourism in recent years. Two resorts, the Lodge at Koele and the Mānele Bay Hotel, are located on the island and both recycle their wastewater at their respective golf courses. Water reuse is important on Lanai, because the island typically receives below-average rainfall and Maui County prohibits the use of potable water for golf-course irrigation.

Moloka‘i is lightly populated and one of the least-visited islands in the Hawaiian chain. The bulk of the wastewater produced is treated at the County of Maui’s Kaunakakai WWRF and disposed of via injection wells. A small volume is used for landscape irrigation along the Mauna Loa Highway. The Kaluakoi Resort on the west end of the island also recycles its wastewater for use on its golf course.

Pu‘u O Hoku Ranch is located in south-east Moloka‘i in Kaunakakai and recently commenced operation of a constructed wetlands system in the year 2004. The system is relatively small and is designed for only 3,700 gpd. Wastewater is collected from the ranch and treated to R-3 quality using septic tanks, effluent screening, and a constructed wetland. The R-3 water is used to irrigate trees and shrubs via a sub-surface drip irrigation system. The ranch benefits from the improved wastewater treatment capability and the creation of a drought-proof supply of water that satisfies much of its irrigation requirements.

Program Expansion: The County of Maui has two existing R-1 recycled water distribution systems, both of which have the potential to be expanded. The South Maui system is the most complete, as it has recycled water storage both at the Kihei WWRF and offsite at an elevated, covered storage tank. The West Maui system does not have adequate storage, and is thus limited in the number of projects that it can serve.

J.7.2.2 City and County of Honolulu

Wastewater Reclamation

In contrast to the County of Maui, where water reuse has been championed by the municipal-wastewater agency, Honolulu BWS has emerged as the lead agency for water reuse in the City and County of Honolulu. The use of recycled water has increased significantly on O‘ahu since the Honolulu BWS developed a comprehensive water reuse program in the late 1990s. The Honolulu BWS recognized that recycled water is a resource valuable to extending O‘ahu’s potable water supplies.

Program Development: Most water reuse growth on the island has occurred in the arid ‘Ewa district of southwest O‘ahu, where significant development has occurred in recent years. Sugar cane cultivation has given way to numerous residential, commercial, and industrial developments. The change in land use has adversely affected the region’s water resources. The recharge of the region’s caprock aquifer has been significantly reduced by the elimination of sugar-cane irrigation, and the construction of impermeable surfaces. Also, the amount of potable water used in the region has dramatically increased, placing a strain on O‘ahu’s aquifers.

Development in the ‘Ewa area includes: a number of golf courses that use brackish water from the caprock aquifer for irrigation; residential subdivisions, which use potable water for irrigation of yards, parks and median strips; and the Campbell Industrial Park that uses potable water for industrial processes.

Recycled Water Infrastructure: The City and County of Honolulu was required to build the secondary treatment facilities at the Honouliuli Wastewater Treatment Plant (WWTP) to comply with a 1993 consent order by the DOH. The main objective of the consent order was to establish secondary treatment at the plant, and to reuse portions of the treated effluent. Improvements to the facility were completed in 1996, with approximately 2.0 MGD of recycled water being used for in-plant demands. In 1995, EPA, the DOH, and the City entered into a consent decree that required the City to develop a water reuse system that would allow the City to recycle 10 MGD of water by July 2001. The Honouliuli WWTP was selected for implementation of the water reuse requirements, because of the increasing demands on the ‘Ewa aquifer, the reduction of recharge due to the cessation of sugar cane cultivation, and the close proximity of the facility to potential users of recycled water.

The City and County of Honolulu selected Veolia Water North America (formerly U.S. Filter Corporation) to oversee construction, own, and operate the Honouliuli Water Recycling Facility (WRF). Recycled water distribution systems were built to deliver R-1 and R-O water to the potential users. CWRM adopted a policy to champion direct and indirect water reuse in the ‘Ewa plain. Recognizing that recycled water is a valuable resource in the ‘Ewa plain, and knowing that R-1 water would ultimately be available in the area, CWRM issued interim water use permits to the planned golf courses and other non-potable users in the area, and conditioned these water use permits on conversion to R-1 water once it became available and acceptable for use.

The Honolulu BWS purchased the Honouliuli WRF in 2000 from Veolia Water North America, with the intent of integrating water reuse into a plan to conserve water resources through conservation and the development of new water supplies. The Honouliuli WRF receives secondary effluent from the Honouliuli WWTP and produces both R-1 and R-O grades of recycled water. R-1 water is now delivered to eight golf courses, three parks, and a median strip, where it is used for landscape irrigation. R-O water is delivered to refineries and power generation facilities in Campbell Industrial Park. Hawaiian Electric Company’s Kahe power plant and the proposed Campbell peaking power plant are scheduled for connection to the RO water system within the next two years. Veolia Water North America operates and maintains the Honouliuli WRF on a contractual basis, while the Honolulu BWS operates and maintains the distribution system.

Program Economics: The Honolulu BWS has individual agreements in place with its recycled water customers. In general, golf courses and other landscape irrigation customers pay less than industrial customers. The initial rates for R-1 water were set significantly lower than what it costs the Honolulu BWS to produce and deliver the recycled water to the golf courses. Once the agreements expire, the Honolulu BWS may need to increase its recycled water rates, to recover the costs associated with production and delivery. The rate increase may place an economic hardship on the golf courses, and they may decide to revert back to less-expensive caprock wells for irrigation. Irrigation use is allowed, as long as well pumpage remains within permitted allocations and chloride levels in well water do not exceed 1,000 milligrams per liter. If the golf courses do revert back to ground water sources for irrigation, the Honolulu BWS recycled water program could be affected.

Public Education and Outreach: The Honolulu BWS's water reuse program is staffed by a recycled water program manager and three recycled water program coordinators. As in the case with the County of Maui, proactive public education has been an important component of the Honolulu BWS's water reuse program. The Honolulu BWS hired a public relations firm to develop a strategy and promotional/educational items to gain public acceptance of its program. The program's recycled water coordinators play a key role in outreach efforts. The coordinators participate in outreach efforts, conduct numerous tours of the Honouliuli WRF, and provide presentations to the community on a regular basis.

Program Expansion: Water reuse has been successfully practiced on Oʻahu for decades. The oldest Hawaiian reuse project is at Waialua Diversified Agriculture, where recycled water has been blended with stream water and used for irrigation of sugar cane and diversified agriculture since 1928. Other projects with successful track records include the Marine Corps Base Hawaiʻi Kaneohe Klipper Golf Course, where R-2 water has been used to irrigate the base golf course since 1966, and Hawaiʻi Reserves, Inc., where R-1 water has been used to irrigate diversified agriculture and the athletic fields at the Brigham Young University Hawaiʻi campus since 1995. The Army's Schofield WRF provides R-2 water to the Dole ditch where it is used for agricultural irrigation on the North Shore. Most of the growth in water reuse on Oʻahu has taken place in the ʻEwa district of southwest Oʻahu, due to the Honolulu BWS's water recycling program. Of the City and County of Honolulu's eight WWTPs, the Honouliuli and Wahiawā WWTPs are under consideration for expansion. A third facility, the Waianae WWTP on the Leeward Coast, is under consideration for a future water reuse project.

Desalination

Desalination on a municipal scale has been considered intermittently in the past. In the 1960s, the Honolulu BWS conducted studies on the feasibility of desalination using seawater and brackish water. At that time, the estimated cost of desalting brackish water (water containing up to about 1,500 parts per million chloride) was $0.50 per 1,000 gallons, and for seawater, the cost was about $1.00 per 1,000 gallons.

In 2003, the Honolulu BWS completed construction and testing of a seawater-desalination pilot plant that could eventually produce 5 MGD of potable water. The plant is part of the BWS's strategy to diversify water sources, and it is located between Campbell Industrial Park and Barbers Point Naval Air Station in ʻEwa Beach. The Honolulu BWS intends the desalination plant, which employs reverse osmosis technology, to provide water for drought mitigation and to meet projected water demands for the ʻEwa and Kapolei areas. When completed, the $40 million facility will contain an administrative building and visitors center, a chemical storage building, a reverse osmosis building, injection and source wells, a brine pond, and parking, as well as an off-site electrical substation.

If brackish ground water is pursued for desalination, the sustainable yield of caprock-brackish water on O‘ahu is limited to probably not more than 15-20 MGD. For basal-brackish water, the supply is greater, but care must be exercised in the use of this source because of possible jeopardy to the basal ground water body and nearby wells.

J.7.2.3 County of Kaua‘i

Wastewater Reclamation

The County of Kaua‘i has not formalized its water reuse program. R-2 recycled water from three of its facilities is provided at no cost to nearby projects. For years, effluent from County wastewater reclamation facilities was used to irrigate sugarcane. Transmission systems, consisting of ditches and reservoirs, were used to transport the effluent to the sugarcane fields. These same transmission systems are still used today to deliver R-2 water to the Kaua‘i Lagoons Resort and to Kikiaola Land Company. The County now has agreements in place with the Kaua‘i Lagoons Resort and Kikiaola Land Company to accept effluent from the Lihue and the Waimea WWRFs, respectively. The Wailua WWRF’s effluent is reused at the adjacent Wailua Municipal Golf Course. This is a convenient situation for both the Wailua WWRF and the golf course, since the County of Kaua‘i owns both facilities. As these projects are the primary disposal sites for the effluent from the County wastewater facilities, the County has no plans at this time to charge for the recycled water.

Kaua‘i has abundant surface water resources, and water from rivers and streams has been diverted through ditch conveyance systems to provide non-potable irrigation water for many golf courses and agricultural projects. As a result, recycled water use at most of Kaua‘i’s water reuse projects is considered more of a convenient wastewater effluent disposal option, rather than a water supply resource. A total of six projects utilize recycled water for golf course irrigation. A seventh project at Kikiaola Land Company blends R-2 recycled water from the Waimea WWRF with stream water for seed-corn irrigation.

There are no plans in place at this time to expand any of the County of Kaua‘i’s recycled water distribution systems.

J.7.2.4 County of Hawai‘i

Wastewater Reclamation

The County of Hawai‘i is developing a water reuse program, and currently provides R-2 recycled water to only one project, Swing Zone Golf Practice Facility in Kona. In this case, the owner of Swing Zone installed the recycled water distribution system from the County’s Kealakehe WWRF to the practice facility at his own expense. The County’s Wastewater Division is contemplating developing a distribution system to provide recycled water from its Kealakehe WWRF to a number of irrigation projects, including parks and future golf courses. Lack of available funding, however, has delayed implementation of these ideas. Technical-planning assistance has been provided to Hawai‘i County by Reclamation, to plan and design a proposed constructed wetlands system that will utilize recycled water from the Kealakehe WWRF. Federal authorization is being pursued in Congress for funding of this project, along with two other county water reclamation projects (on Maui and O‘ahu). Federal funding shall be subject to authorization and subsequent Congressional approval for appropriation of funds on a cost-shared basis.

Water reuse on the Big Island mainly takes place at five private, resort developments where wastewater is treated at resort-owned wastewater reclamation facilities, and then blended with other water sources and reused for irrigation of the resorts' golf courses. Other projects include the State Department of Transportation's Keahole International Airport, where R-1 water is used for irrigation of the airport's landscaping, and at Parker Ranch, where R-3 water is used for pasture irrigation. Swing Zone is a unique reuse project, because the owner installed a recycled water transmission system at his own expense to convey 0.06 MGD of R-2 water to the Swing Zone property, where it is used to irrigate the facility's turf grass.

The County of Hawai‘i's Wastewater Division is in the planning stages of developing a recycled water distribution system that will utilize recycled water from the Kealakehe WWRF. Phase one, which will satisfy the requirement of a consent decree for the County to use recycled water, involves constructing a pipeline to deliver recycled water to the Honokōhau Harbor for landscape irrigation. This phase was to be completed by June 2005, and could also serve a future development by the Department of Hawaiian Home Lands. Phase two is in the design stage, and involves the development of a pipeline and reservoir system that could deliver recycled water to a possible future golf course as well as a future development. The Wastewater Division will continue to attempt to obtain federal funding for a constructed wetlands system to upgrade the Kealakehe WWRF to produce an R-1- quality water system.

J.7.3 Recommendations for Water Resource Augmentation Planning

The State Water Code states that CWRM shall plan and coordinate programs for the conservation and protection of water resources.[30] The Water Code also states that the Hawai‘i Water Plan shall include programs to conserve, augment and protect the water resources.[31] Therefore, it is recommended that CWRM act in an advisory capacity, guiding policies and planning efforts for augmentation projects.

The State Water Code also enables CWRM, via conditions placed on water use permits, to require the use of dual line water supply systems in new industrial and commercial developments located in designated water management areas.[32] Under this provision, the county boards of water supply, in consultation with the DOH, must adopt standards for non-potable water distributed through the dual line water supply systems and rules regarding the use of non-potable water in order to protect existing water quality and public health and safety. As of

[30] HRS §174C-5(12).

[31] HRS §174C-31(d)(4).

[32] HRS §174C-51.5(a).

the date of this draft, standards and rules have yet to be adopted. CWRM should coordinate with county agencies to obtain regular updates for recycled-water service areas and capacities, and apply the dual line water supply system requirement to permit applications within the portions of water management areas served by recycled water distribution systems.

It is also recommended that CWRM explore partnerships with governmental agencies and stakeholders in order to coordinate resource augmentation planning and policies. Suggested agencies for involvement include, but are not limited to: water agencies, energy agencies, coastal-management agencies, natural-resource management agencies, economic-development agencies, and public-utility commissions. County water departments, county wastewater departments, county planning departments, DBEDT, DLNR, DOH, Coastal Zone Management program and Special Management Area program administrators, the Bureau of Reclamation, and the EPA should specifically be consulted. Environmental groups, private industry, and economic interests should also be invited to participate in creating a vision for the program. Furthermore, government agencies involved in resource augmentation planning should be encouraged to establish cooperative relationships with professional organizations like the American Water Works Association, the American Society of Civil Engineers, the American Public Works Association, the Water Environment Federation, the American Planning Association, the American Counsel of Engineering Companies of Hawai‘i, and other such organizations that have extensive industry expertise and skilled, knowledgeable membership bases.

The water resource augmentation planning efforts and policies must be designed to complement the water conservation program recommendations in **Section J.2 Statewide Water Conservation Program**, and incorporate the intent of these recommendations whenever appropriate. A long-term goal for CWRM should be to establish a resource augmentation planning program and framework to identify augmentation goals, objectives, and priorities to promote the use of alternative water resources and to encourage the development of these supplies in an efficient and sensible manner. Reiterating the assertion noted in **Appendix H Existing and Future Demands** of the WRPP, land use planning and water resource planning should be accomplished with ongoing, mutual consultation in order to be successful and sustainable.

J.7.3.1 Recommendations for Wastewater Reclamation in Hawai‘i

It is recommended that the goals and strategies discussed above, as well as the results of the *2013 Update of the Hawai‘i Water Reuse Survey and Report,* should be used by the counties as a guidance document to assist county reuse initiatives. It is recommended that county governments examine the potential recycled water expansion and application projects identified in the *2013 Update of the Hawai‘i Water Reuse Survey and Report*. Counties should use the report to help strategize ways to develop and expand water reuse within their jurisdictions.

Furthermore, counties should include their current water recycling program, or strategies for program development, into subsequent updates of the County WUDPs to maintain consistency with the WRPP.[33] County recycled water rates should be published or made available upon inquiry to users, potential customers, and the general public.

J.7.3.2 Recommendations for Stormwater Reclamation in Hawai‘i

The amount of stormwater runoff from urban areas is indeed significant, as is evidenced by existing storm drain systems and flood control installations. This water could be captured, treated, and applied to beneficial uses; however, the feasibility of stormwater reclamation and reuse, on a small or large scale, remains to be assessed. Further study of the obstacles/constraints and opportunities to increase stormwater recharge statewide from mauka to makai should be undertaken.

Decision makers need to understand the risks, cost, and benefits of investing in stormwater reclamation and reuse as a viable water resource alternative. To enhance the viability of stormwater reuse, a report by the National Academy of Science identified five research themes that should be addressed: Risk and water quality, treatment technology, infrastructure, social science and decision analysis, and policy and regulatory issues[34]. The following paragraphs summarize and incorporate the recommendations from the report.

<u>Risk and water quality:</u>
The fate and occurrence of pathogens and chemical contaminants in stormwater can represent a significant risk in the application of reclaimed stormwater for non-potable uses. The DOH administers the National Pollution Discharge Elimination System and Total Maximum Daily Load programs that regulate the discharge of stormwater. However there are no guidelines or standards governing stormwater reclamation and reuse at the State or Federal level. Unlike wastewater, the characterization of stormwater is difficult because it is site specific and can vary with the land use of the contributing watershed. Further studies should be done to establish a methodology for determining standards and risk-based water quality guidance for various uses. Monitoring technology and strategies should also be developed to ensure compliance with any reuse criteria that is established.

<u>Treatment technology:</u>
In the absence of guidelines for the reclamation and reuse of stormwater, many types of technologies have been applied for various levels of treatment. The lack of a standardized guidance for treatment process may result in additional costs in the development and modification of any pilot projects. Demonstration projects should involve extensive data collection to synthesize findings into standard practices for treatment technologies.

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[33] HRS §174C-31(b)(1).

[34] The National Academies of Sciences, Engineering, and Medicine. 2015. *Using Graywater and Stormwater to Enhance Local Water Supplies: An Assessment of Risks, Costs, and Benefits*. Washington, DC: The National Academies Press.

Additionally, the long-term performance and reliability of systems at different scales needs to be understood. The needs of different types of stormwater reclamation systems should be understood to properly design operation and management strategies.

<u>Infrastructure:</u>
State and county government should encourage the use of stormwater reclamation and reuse measures that could be used to meet some of these program requirements.

The *2008 Appraisal of Hawai'i Stormwater Reclamation and Reuse* report identified possible opportunities for stormwater reclamation. The accompanying *Handbook for Stormwater Reclamation and Reuse Best Management Practices in Hawai'i*, describes stormwater reclamation technologies and practices, such as rain barrels, permeable pavement, and green roofs, which can be easily implemented at residences and scalable for different sized facilities. Landscape features, such as rain gardens for infiltration, can also be incorporated into building and parking lot design.

Therefore, it is recommended that county governments encourage the use of small-lot and source-reuse technologies to manage precipitation and runoff as close to the source as feasible, and to provide water for a variety of non-potable uses. Government facilities can provide excellent demonstration sites for these simple technologies. The county could also provide incentives, in the form of water credits or speedy-permit processing, to encourage the implementation of on-site stormwater reuse.

State and county agencies as well as non-government organizations should also examine the potential stormwater reclamation opportunities described in the *2008 Appraisal of Hawai'i Stormwater Reclamation and Reuse* report for future implementation or adoption of the methods for assessing potential stormwater projects. Additionally, counties should look beyond the recommendations in the 2008 report when formulating potential local reclamation opportunities, and be able to contribute new or updated information to future report updates.

J.7.3.3 Recommendations for Desalination Programs in Hawai'i

Desalination plants are in use in other parts of the country, but it is only recently that technological developments have reduced the costs and energy requirements to be comparable to that of new well construction in many coastal areas of the continental United States. Coastal communities generally lack experience in evaluating the environmental impacts or public-resource issues associated with the construction and operation of desalination plants, and this remains a matter of concern as the number of desalination plants increase.

In 2004, approximately 24 desalination facilities were being planned for various locations along the California coast. Recognizing the need to anticipate information and evaluation requirements for proposed desalination plants, the California Coastal Commission published a report in March 2004 titled *Seawater Desalination and the California Coastal Act.* The report clearly emphasizes that the "concerns about desalination are due primarily to its potential to cause adverse effects and growth that are beyond the capacity of California's coastal resources." The purpose of the report is to provide information on issues related to desalination and its possible effects on coastal resources and coastal uses, describe existing and proposed facilities, identify and discuss policies of California's Coastal Act that apply to desalination programs, and identify information required during coastal development permit review for proposed facilities.

Many of the report's primary findings may be considered in terms of their applicability to water augmentation and desalination facility planning in Hawai'i. It is recommended that all permitting agencies address the potential negative impacts associated with desalination and that proposed county and private desalination facilities evaluate the potential impact on coastal resources and uses, including cultural uses and practices.

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APPENDIX K

Drought Planning

Water Resource Protection Plan 2019 Update

K Drought Planning

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K Drought Planning

Droughts have affected the islands throughout Hawai‘i’s recorded history, with the most severe events occurring in the past 15 years associated with the El Niño phenomenon. Drought is a persistent and extended period of below normal precipitation where abnormal moisture deficiencies induce a variety of adverse effects. Impacts due to drought, both direct and indirect, manifest as changes in the environment, economy, public health, and long-term water supply. The impacts of climate change may exacerbate drought and its impacts in Hawai‘i. There is some uncertainty about how drought may be affected, however recent research has shown that there may be a continuing trend towards declining annual rainfall in Hawai‘i. This chapter reviews drought mitigation planning efforts undertaken in the State of Hawai‘i.

K.1 Goals and Objectives

The State Water Code recognizes the need for comprehensive water resource planning to address water supply and conservation. Drought planning activities are integral to water conservation and resource protection. The State Water Code identifies the *Water Resource Protection Plan* as the document in which to include programs to conserve, augment, and protect the resource, as well as other elements necessary or desirable for inclusion. Although HRS §174C does not require drought planning, the *Statewide Framework for Updating the Hawai‘i Water Plan* (2000) specifically recommends drought planning to be included in the Hawai‘i Water Plan update, and reinforces the need for drought planning in support of water conservation and water shortage planning.

The drought from 1998 to 2003 had devastating impacts throughout the islands, including numerous wildland fires, record-low rainfall, cattle losses, and major crop damage. In mid-2000, a statewide drought declaration was issued by the Governor, and the State, together with federal and county agencies, private organizations, and affected stakeholders, identified and executed various drought response projects. Initiatives were also undertaken towards the development of a drought plan for the State to mitigate and plan for the long-term effects of drought. The Commission on Water Resource Management assumed the role of lead agency in the development of the State’s emerging drought program.

The Hawai‘i Drought Council and its subcommittees were established in 2000 to oversee drought response and mitigation efforts. The chairperson of the Hawai‘i Department of Land and Natural Resources and the chairperson of the Hawai‘i Department of Agriculture (HDOA) serve as co-chairs of the Hawai‘i Drought Council. CWRM provides administrative support to the Hawai‘i Drought Council and its committees, and provides coordination support to the county-level drought committees through the State Drought Coordinator, who is a CWRM staff member. The Hawai‘i drought program has grown considerably since its inception in 2000, resulting in the solidification of agency coordination, communication, and involvement at both the State and county levels. CWRM remains committed to drought mitigation, and has set forth the following goals for the drought program:

- Fulfill the State's responsibility, as trustee of water resources, to protect and ensure the long-term viability of resources through implementation of the drought program and regular updates of the Hawai'i Drought Plan (HDP).
- Support legislative budget appropriations that strengthen the drought program and achieve the HDP priority implementation actions, provided that this does not affect the State's executive budget priorities.
- Expand and improve outreach and public education programs, including the Hawai'i Drought Monitor website and the production and distribution of drought awareness public service announcements in multiple media formats.
- Support and encourage the efforts of the Hawai'i Drought Council through the efforts of the State Drought Coordinator.
- Continue to provide advisory and liaison support to county drought committees in communications with State and federal agencies, and encourage implementation of county drought mitigation strategies.
- Seek to improve drought risk assessment methods, drought impact assessment methodologies, and apply new information in developing and updating drought mitigation strategies.
- Maintain and foster positive relationships with federal agencies involved with drought hazard mitigation, response, and relief including the National Drought Mitigation Center, National Integrated Drought Information System, Federal Emergency Management Agency (FEMA), the U.S. Bureau of Reclamation (Reclamation), and the USDA.
- Cultivate partnerships with business, agriculture, and environmental organizations and professional associations to expand participation in drought planning and mitigation activities and increase public awareness and support of drought issues.

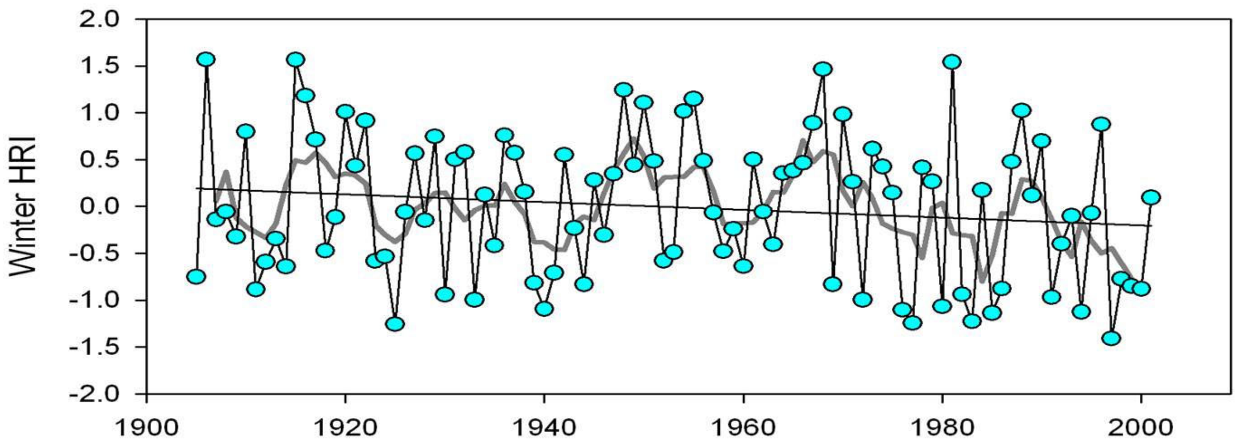
K.2 Overview of Drought

Drought is a normal and temporary climate abnormality, but it can have profound effects on the environment and the lifestyles of affected communities. Drought diminishes natural stream flow, depletes soil and subsoil moisture, and the resultant variety of social, environmental, and economic impacts can be numerous and widespread.

K.2.1 Climate Change and Drought

According to the U.S. Drought Monitor, Hawai‘i has experienced D2 (severe) drought conditions somewhere in the state since June 2008.[1] The report for the Pacific Islands Regional Climate Assessment (PIRCA) shows that there has been an increase in average air temperature in the Hawaiian Islands from 1916-2006. The report also shows that there has been a downward trend in rainfall across the state since the beginning of the 20th century and an even steeper negative trend since 1980. The main Hawaiian Islands have seen an increase in the number annual consecutive dry days from the period 1950-1970 compared to 1980-2011, indicating a tendency for more prolonged dry periods.[2]

Figure K-1 Interannual and Interdecadal Rainfall Variations in the Hawaiian Islands[3]



The data also shows a decrease in stream base-flow across the state since the early 1900s, which indicate a decrease in ground water recharge and storage, which coincide with the trend of decreasing rainfall. The PIRCA report also includes research projections of future rainfall in the Hawaiian islands. One statistical downscaling model predicts decreasing wet-season rainfall and increasing dry-season rainfall. As with any projection, there is uncertainty with this model prediction, but results seem to line up with a trend in increasing winter drought in Hawai‘i since the 1950s. Data and research suggest that Hawai‘i should be prepared for a future with a warmer climate, diminishing rainfall and declining stream base flows.

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[1] National Drought Mitigation Center, U.S. Drought Monitor, accessed February 28, 2014, http://droughtmonitor.unl.edu/MapsAndData/DataTables.aspx

[2] Keener, V. W., Marra, J. J., Finucane, M. L., Spooner, D., & Smith, M. H. (Eds.). (2012). *Climate Change and Pacific Islands: Indicators and Impacts. Report for The 2012 Pacific Islands Regional Climate Assessment*. Washington, DC: Island Press.

[3] Chu, P.-S., and Chen, H. 2005. Interannual and interdecadal rainfall variations in the Hawaiian Islands. Journal of Climate 18: 4796-4813

K.2.2 Understanding Drought

The National Drought Mitigation Center (NDMC) uses two main types of drought definitions: conceptual and operational. Conceptual definitions of drought are general and help people understand the concept of drought. Operational definitions help to define the onset, severity, and end of a drought. Operational definitions of drought include the following:

- Meteorological Drought: Meteorological drought is usually an expression of the precipitation level’s departure from normal over some period of time. Meteorological measurements are the first indicators of drought.
- Agricultural Drought: Agricultural drought occurs when there is inadequate soil moisture to meet the needs of a particular crop at a particular time. Agriculture is usually the first economic sector to be affected by drought.
- Hydrological Drought: Hydrological drought refers to deficiencies in surface and subsurface water supplies, reflected in declining surface and ground water levels. There is lag time between a lack of rainfall and the observed decrease of water levels in streams, rivers, lakes, reservoirs, and aquifers; therefore, hydrological drought will not be reflected until precipitation is deficient over an extended period of time.
- Socioeconomic Drought: Socioeconomic drought occurs when a physical water shortage affects people such that the demand has exceeded supply, as a result of a water deficit. This can affect human and animal population and growth rates, water and fodder requirements, agricultural drought impacts, and various industries.

K.2.3 Drought Impacts

The direct impacts of drought include: reduced cropland, rangeland, and forest productivity; increased fire hazard; reduced water levels; increased livestock and wildlife mortality rates; and damage to wildlife and fish habitat. Indirect drought impacts are the consequences of direct impacts.

Drought impacts can also be categorized by the sector that experiences the impacts. These types of impacts are economic, environmental, or social. Many of the economic impacts occur in agriculture and related sectors, due to their reliance on rainfall and on surface and ground water supplies. In addition to losses in yields to both crop and livestock production, impacts can be indicated by income loss to farmers, which has a ripple effect, impacting income to retailers and others who supply goods and services to farmers.

Environmental impacts refer to the losses incurred as direct or indirect results of drought, such as wildfire damage to plant and animal species. Direct and indirect negative impacts can include: degradation of wildlife habitat; degradation of air, water, and landscape quality; loss of biodiversity; and soil erosion. Social impacts involve public safety, health, water use conflicts, quality-of-life issues, and socio-spatial inequities in the distribution of impacts and disaster relief. Many impacts that have economic and environmental effects have social components as well.

The Eastern portion of the Hawaiian Islands seem to have been most severely impacted by drought events since around the year 1999. This includes the Hawaiʻi Island and the County of Maui, comprised of Molokaʻi, Lānaʻi, Kahoʻolawe, and Maui Islands. While drought has continued to affect Kauaʻi and Oʻahu, the severity and duration of drought there has not been as bad as in Maui and Hawaiʻi Counties.

Much of the impacts of drought during the past 15 years or so have been to the cattle industry. Drought withers pastures and makes it difficult to provide drinking water for livestock. Without healthy and sufficient pasture, livestock cannot obtain adequate nutrition through grazing. Supplemental cattle feed such as hay is extremely expensive in Hawaiʻi and is usually financially unsustainable for ranchers. The result is ranchers destocking and selling off portions of their herd in order to reduce expenses. Once the drought is over, it can take several years for the operation to grow their herd back to its size before the drought, causing hardships for the ranching operation.

Other significant drought impacts are to unirrigated agriculture, such as the Kona Coffee industry, where the timing and amount of rainfall is crucial for a successful crop. Irrigated agriculture can also be impacted by drought. Reduced surface water inflows to irrigation systems during drought can cause system operators to reduce the amount of water available to its customers through voluntary reductions or mandatory restrictions.

K.2.4 Drought Response versus Mitigation

The term “drought response” refers to emergency actions that are implemented directly in response to drought conditions. In contrast, “drought mitigation” is defined as short- and long-term actions and/or programs that may be implemented prior to, during, and after drought events to reduce the degree of risk to human life, property, and the economy. Examples of response actions and corresponding examples of mitigation actions are listed in **Table K-1 Associated Drought Response and Mitigation Actions,** below. Effective drought planning and mitigation programs can reduce the need for extensive federal, state, and county emergency response and relief expenditures to rebuild local economies and reduce competition for water during drought.

Table K-1 Associated Drought Response and Mitigation Actions

Drought Response	Drought Mitigation
Alert appropriate agencies of emerging rainfall deficits.	Expand current network of rain gages to improve rainfall monitoring.
Implement agency-coordination actions enumerated in an existing drought plan.	Develop a drought plan to coordinate drought response between agencies.
Alert appropriate agencies of declining ground and surface water storage.	Establish alert procedures for declining water level conditions.
Implement voluntary and/or mandatory water use restrictions.	Establish conservation programs to reduce water consumption.
Mobilize contractors to truck water to ranches without sources.	Establish contingency water-hauling programs for livestock.
Modify and utilize monitor wells to provide emergency sources of water.	Seek authorization and funding for development of additional storage, alternative water sources and new water supply sources.
Utilize models and monitoring data to assess drought recovery or escalation of drought conditions.	Identify areas at risk to drought and plan for regional response actions and strategies.
Release regular and timely media advisories.	Develop and implement drought-related public awareness programs.

K.2.5 Hawaiʻi's Need for Drought Mitigation

Drought can lead to difficult decisions regarding the allocation of water, as well as stringent water use limitations, water quality problems, and inadequate water supplies for fire suppression. In Hawaiʻi, droughts and wildland fires threaten all islands in any given year. Also, there are additional issues such as growing conflicts between agricultural uses of surface water and instream uses, "surface and ground water" interrelationships, and the effects of growing water demands on traditional and cultural uses of water.

In the past, drought was addressed as a temporary emergency. Actions were taken in response to impacts, in a reactionary fashion. The most important lesson learned in recent years is that the best time to reduce the impacts of drought is before they occur. Therefore, it is important to develop drought planning programs that advocate a proactive management approach.

Droughts have been prevalent in the past and will continue to adversely affect the environment, economy, and the citizens of the State, due to Hawaiʻi's strong dependency on rainfall and the lack of adequate water supply and/or infrastructure in certain areas of the State. Historical patterns indicate that Hawaiʻi will continue to suffer damaging droughts, and the loss potential will only increase as the need for economic growth and revitalization amplify pressures upon the State's limited water supply. Aggressive planning and the utilization of alternative resources are necessary to avoid a situation where future population and economic growth cannot be sustained, due to insufficient quantity and quality of water resources. Since water is limited and precise rainfall predictions are not possible, effective water resource planning and management is critical to the long-term sustainability of our island communities.

K.3 Existing Drought Planning Context

State efforts to establish a drought plan were undertaken in recognition of and in coordination with the various federal agencies that administer drought assistance programs, including FEMA, Reclamation, the USDA Farm Service Agency, the Natural Resources Conservation Service, the U.S. Forest Service, and the Small Business Administration. The following sections provide background information on federal legislation and the resultant State and county actions that have contributed to the development of Hawaiʻi's drought program.

K.3.1 Federal Disaster Management Act

Hazard mitigation is an action or number of actions taken to reduce or eliminate long-term risk to people and their property from the effects of natural hazards. The purpose of hazard mitigation is two-fold: 1) to protect people and structures from harm and destruction; and 2) to minimize the costs of disaster response and recovery. Hazard-mitigation planning is the process that analyzes a community's risk from natural hazards, coordinates available resources, and implements actions to reduce risks.

In the past, funding for hazard mitigation was typically available only following a disaster declaration, based on a percentage of the estimated damages. Since the early 1990s, FEMA and Congress have witnessed large increases in disaster response and recovery costs and have provided funds to communities, counties, and states to reduce impacts from natural hazards through hazard mitigation. The Federal Disaster Management Act of 2000 requires each state and territory to conduct hazard mitigation planning and to implement projects to reduce hazard impacts prior to a disaster occurrence. This Act marked a fundamental shift in policy. Rather than placing primary emphasis on response and recovery, FEMA's focus broadened to incorporate mitigation as the foundation of emergency management.

K.3.2 State Hazard Mitigation Planning

Changes in federal laws have resulted in pre-disaster mitigation project funding and mitigation planning requirements. However, future funding for public assistance subsequent to disasters will be largely contingent upon mitigation plan completion. Additionally, states are required to have an approved Standard State Mitigation Plan in order to receive additional pre-disaster mitigation funds for state or local mitigation projects after November 1, 2004. Planning efforts are independent of any specific hazard event.

The Standard State Mitigation Plan will also be required for non-emergency assistance provided under the Stafford Act, including Public Assistance restoration of damaged facilities and Hazard Mitigation Grant Program funding. A state with a FEMA-approved Enhanced State Mitigation Plan at the time of a disaster declaration is eligible to receive increased funds under the Hazard Mitigation Grant Program, based on 20 percent of the total estimated eligible Stafford Act assistance. Therefore, the development of State and local hazard mitigation plans is key to maintaining eligibility for future FEMA mitigation and disaster-recovery funding.

K.3.3 Hawaiʻi State Hazard Mitigation Plan

In order for the State of Hawaiʻi to be eligible for certain types of FEMA funding (Hazard Mitigation Grant Program and Public Assistance), it must have an approved Multi-Hazard Mitigation Plan.

The Hawaiʻi State Hazard Mitigation Forum, which is composed of county, State, and federal agency representatives, as well as private individuals with interest in hazard mitigation planning, agreed that the Hawaiʻi State Hazard Mitigation Plan should be a multi-hazard plan. For the purpose of the plan, the term "multi-hazard" shall not be limited to discrete natural hazards, and will include anthropogenic activities that could exacerbate hazard event impacts and potentially threaten the life and safety of the citizens of Hawaiʻi. The goal of the plan is to mitigate the impact of such potential disasters.

The Hawaiʻi State Hazard Mitigation Plan encompassed the broadest possible scope of disaster occurrences, focusing on nine natural hazards: hurricanes, tsunami, earthquakes, floods, volcanic eruptions and lava flow, coastal erosion, landslides, wildfire, and drought. For each of these specific categories of disasters, additional mitigation plans or strategies targeted at these disasters will be appended to the Hawaiʻi State Hazard Mitigation Plan. Several of these hazard categories have current advisory boards or task forces that have developed recommendations and strategies.

In September 2003, CWRM completed a statewide Drought Risk and Vulnerability Assessment. This document is referenced in the Hawaiʻi State Hazard Mitigation Plan. The Drought Risk and Vulnerability Assessment illustrates the extent and severity of drought risk for different impact sectors throughout the islands, and will facilitate the development of drought response and mitigation strategies.

The State Hazard Mitigation Plan must highlight any gaps in data collection and analysis, as well as propose or recommend specific projects to address such gaps as well as short- and long-term drought risk reduction. Therefore, the Drought Risk and Vulnerability Assessment is an important tool for future drought hazard mitigation planning. The Hazard Mitigation Plan incorporates the results of the risk and vulnerability assessment. These results provide input and context for drought response actions and drought mitigation strategies. FEMA requires that State Multi-Hazard Mitigation Plans be updated and reapproved every three years.

Hawaiʻi Emergency Management Agency (HI-EMA) has taken the lead for the State of Hawaiʻi Multi-Hazard Mitigation Plan. The Plan covers different hazards including hurricanes and strong winds, flood, drought, wildfire, climate change, earthquakes, tsunami, volcanoes, coastal erosion, landslides, dam failure, hazardous materials, homeland security and terrorism, and health-related. The Plan assesses risk and vulnerability to each hazard, reviews current mitigation actions and capabilities, and develops a mitigation strategy for each hazard including mitigation projects and actions.

HI-EMA completed its most recent update of the State of Hawai‘i Multi-Hazard Mitigation Plan which was submitted to FEMA and approved in October 2013. This update includes additional analysis on Threat Hazard Identification and Risk Assessment (THIRA). The THIRA process is:

1. Identify Threats and Hazards of Concern: Based on a combination of experience, forecasting, subject matter expertise, and other available resources, identify a list of the threats and hazards of primary concern to the community.
2. Give the Threats and Hazards Context: Describe the threats and hazards of concern, showing how they may affect the community.
3. Establish Capability Targets: Assess each threat and hazard in context to develop a specific capability target for each core capability identified in the National Preparedness Goal. The capability target defines success for the capability.
4. Apply the Results: For each core capability, estimate the resources required to achieve the capability targets through the use of community assets and mutual aid, while also considering preparedness activities, including mitigation opportunities.

K.3.4 County Multi-Hazard Mitigation Plans

As noted above, the Disaster Mitigation Act of 2000 requires that each state develop a hazard mitigation plan in order to receive future funding following a disaster. This requirement provides some funding for each state to engage in planning activities and plan preparation. Federal law also requires the development of local or county plans for that particular county to be eligible for post-disaster funding. The purpose of these requirements is to ensure that there are local programs and projects in place that will help minimize the loss of life, property, and total cost of disasters.

As is the case with the State-level plan, the county Multi-Hazard Mitigation Plans are multi-hazard plans. These county plans follow steps similar to the State Multi-Hazard Mitigation Plans during their development and have a five-year update cycle. All four county Plans are current and are required to be updated every five years:

- Kaua‘i- August 2015
- Honolulu- September 2017
- Hawai‘i- October 2015
- Maui-October 2015

K.3.5 Hawai‘i Drought Plan, Phase I

As drought conditions emerged and continued through the late 1990s, CWRM and the USDA, with assistance from Reclamation and cooperation from affected agencies, organizations, and stakeholders, undertook efforts to develop a statewide drought planning document.

One of the major objectives of the HDP, Phase I was to develop a planning framework in which to address a multitude of drought-related issues. The plan, completed in 2000, was structured to be dynamic in nature, utilizing a “living document” approach to address more than just response-oriented actions. Under this approach, provisions were established to accommodate changes in the drought leadership structure established by the plan, as well as to allow for periodic evaluation and revision to the plan itself.

K.3.5.1 Drought Risk and Vulnerability Assessment and GIS Mapping Project

In 2003, CWRM, on behalf of the Hawai‘i Drought Council and as part of the priority implementation actions recommended in Phase I of the HDP, completed a geographic and sector-based risk assessment and vulnerability analysis with applications toward statewide drought planning.

The Drought Risk and Vulnerability Assessment and Geographic Information System (GIS) Mapping Project was designed to focus drought mitigation planning by delineating risk areas through the analysis of interrelated parameters. Follow-up mitigation planning would provide for protection of resources, public safety, property, and the economy by allowing for the implementing specific projects in identified risk areas.

The Drought Risk and Vulnerability Assessment and GIS Mapping Project utilizes mapping techniques to incorporate geographic, environmental, and social data to determine areas at risk to meteorological, hydrologic, and agricultural drought, as well as environmental and socioeconomic impacts that may occur due to drought conditions.

The report results include maps of drought frequency, vulnerability, and at-risk areas for each county, as well as recommendations for both mitigation actions and future studies. The maps are intended for public dissemination and use by the counties and local stakeholders in the development of mitigation strategies and projects. Recommendations for future studies and actions include:

- Develop new and improved methods for drought forecasting, tailored to Hawai‘i. More accurate forecasts will facilitate early identification of impending drought conditions and reduce the vulnerability of climate-sensitive activities like agriculture, water resource management, public health, and forestry.

- Conduct advanced drought frequency analysis and GIS mapping. Compile data from State and federal rain gage networks to improve accuracy and reliability of drought frequency analyses and to resolve microclimate variations.

- Conduct multi-year drought frequency and recurrence interval analyses. Study the frequency, as well as the spatial and temporal variations associated with longer-duration drought events (on the order of several years).

- Analyze drought patterns and severity during El Niño and La Niña years. Conducting such studies would help in anticipating drought patterns and severity as El Niño and La Niña events are developing. It would also be of interest to investigate the changes in drought frequency and patterns during different phases of the Pacific Decadal Oscillation, as a guide for future long-term, drought risk management.

- Conduct drought impact studies to understand how people are impacted and how best to reduce these impacts. An accurate accounting system of economic data on drought loss, including qualitative information and anecdotal reports, would be useful in quantifying, or even qualifying, the degree of drought severity from event to event.

K.3.6 Hawaiʻi Drought Plan Update

The *Hawaiʻi Drought Plan, Phase I* was completed in August 2000 and submitted to the U.S. Bureau of Reclamation for review. Reclamation subsequently provided comments and recommendations for refinements that would facilitate the plan's eventual submission to and acceptance by the United States Congress. CWRM, on behalf of the Hawaiʻi Drought Council and with additional technical and financial assistance from Reclamation, revised the plan to address Reclamation's comments and well as to include additional information on drought related projects and programs that developed between 2000 and 2005.

The updated document is entitled the *Hawaiʻi Drought Plan, 2005 Update*. It provides the most up-to-date, statewide drought response and mitigation plan for Hawaiʻi as of its publication date. This plan strives to retain the dynamic structure and flexibility of the previous drought planning effort, while delineating program-specific actions and recommendations for planning future activities, within a document that is user-friendly and that facilitates action implementation.

Since the development of the *Hawaiʻi Drought Plan, Phase I* in 2000, the State has completed several actions toward the implementation of the plan and further development of the drought program:

- Requested and received Emergency Drought Assistance from Reclamation under Title I of the Reclamation States Emergency Drought Relief Act of 1991, in addition to technical/planning assistance under Title II of the same Act;

- Participated as a member of the Western Governors Association’s Drought Working Group, to help draft the proposed National Drought Preparedness Act of 2003 for submission to Congress;

- Established in 2002, through successful legislative authorization, a permanent State Drought Coordinator position within the Commission on Water Resource Management;

- Applied for and received a FEMA Pre-Disaster Mitigation grant to develop a Statewide Drought Risk and Vulnerability Assessment and GIS Mapping Analysis in support of the Hawai‘i Drought Plan and the State/County Hazard Mitigation Plans;

- Developed public outreach and education tools, including the completion of the Hawai‘i Drought Monitor Website and the production and distribution of drought awareness public service announcements in both radio and television;

- Established County/Local Drought Committees (CLDCs);

- Developed a DLNR prototype State Agency Water Conservation Plan with assistance from Reclamation for application across State government agencies.

- Developed the Hawai‘i Water Conservation Plan in 2013

CWRM continues to serve as the lead agency for the State’s overall drought program and the update/implementation of the HDP. The drought program has grown since 2000, resulting in the solidification of agency coordination, communication, and involvement at both the State and county levels. The HDP describes: the drought program leadership structure for the State of Hawai‘i; the purpose, responsibilities, and involvement of agency and stakeholder representatives on various drought committees; and the communication protocol for effective drought response, monitoring, recovery, and post-drought evaluations.

K.3.7 Hawai‘i Drought Plan, 2017 Update

The HDP has been updated for use by the Hawai‘i Drought Council to improve coordination and implementation of drought management strategies for the State of Hawai‘i. The revised plan is intended to serve as a “framework” through which State and local entities can work together to proactively implement mitigation measures and appropriate response actions during periods of drought. Effective coordination of these activities can help reduce and minimize the effects upon the people and natural resources of Hawai‘i.

The HDP was designed as an informative guide to help reduce the negative impacts that drought conditions cause for the State of Hawai‘i. It addresses an overview of drought in Hawai‘i along with the threat of future droughts, the coordination of Hawai‘i’s Drought Program, methods for drought monitoring, forecasting, and impact assessment, and strategies for drought planning and mitigation. Drought mitigation has been emphasized in this plan as a proactive approach to lessen the intensity of dry periods.

Since the initial HDP in 2000 and its 2005 Update, much progress has been made with drought planning, particularly with regard to implementation of specific recommended actions. In the future, continued implementation of recommended plan provisions will remain a key challenge to the Hawaiʻi Drought Council and its member agencies and stakeholder representatives. Appropriate government and private sector resources will need to be identified to address the recommended priority mitigation actions identified in the plan. The success of the plan will ultimately be measured by the ability of government agencies, stakeholders, and the general public to function as a team in achieving the necessary goals and objectives for successful mitigation of drought impacts for the state.

CWRM sought out and received valuable input from members of the respective County Drought Committees and members of the Hawaiʻi Drought Council during this revision of the Plan. Some key changes in the 2017 update include:

- Revised and simplified provisional impact sector drought risk maps
- Revised recommended drought response actions from Governmental agencies
- Revised drought communication structure, abdicating the Water Resources Committee
- Summary of drought mitigation projects completed
- Inclusion of climate change as a factor in drought mitigation planning
- Revised recommendations

This plan has been designed as a dynamic "living" document, which should be utilized and updated to reflect changing conditions, new information, and an evolving leadership structure encompassing the Hawaiʻi Drought Council, U.S. Drought Monitor, Hawaiʻi Author, and the County/Local Drought Committees. The plan is available on the Hawaiʻi Drought Website[4] to facilitate public access and the review of future plan updates.

K.3.8 County Drought Mitigation Strategies

In 2004 and 2005, a series of county meetings were held involving agencies and stakeholders who agreed to participate in the CLDCs. Through these meetings, county drought mitigation strategies were developed to coordinate government agency and stakeholder actions, and projects were identified for integration within the *County Hazard Mitigation Plans*. Implementation of these projects would be championed by the CLDCs. The HDP emphasizes

[4] http://dlnr.hawaii.gov/drought/

local drought response, mitigation, and organizational efforts at the county level. While the Hawaiʻi Drought Council and the State Drought Coordinator seek to assist local government agencies and stakeholders in coordinating drought response and mitigation, project implementation is dependent upon input and action by the CLDCs, who provide local and regional knowledge, information, and resources. In 2011, CWRM completed an update of the drought mitigation project listings for each of the County Drought Mitigation Strategies.

K.4 Other Drought Resources

K.4.1 U.S. Drought Monitor and Designation of Drought

The U.S. Drought Monitor (USDM) is a map-based drought assessment displaying levels of drought intensity across the contiguous United States, Alaska, Hawaiʻi and Puerto Rico. Updated weekly, the USDM is a collaborative effort between the National Oceanic and Atmospheric Association, USDA, and the National Drought Mitigation Center. Each state has an expert author(s) who is responsible for weekly updates of the USDM using a combination of hydrologic and on-the-ground drought impact data in various sectors to formulate the weekly assessment of drought. The USDM is used as an index to make policy decisions related to drought. The USDA uses the USDM to make secretarial drought disaster designations and to distribute disaster program assistance.

In Hawaiʻi, the USDM is used to monitor the intensity and duration of drought events and cycles and has become the de facto drought indicator for the State of Hawaiʻi.

K.4.2 Drought Impact Reporter, Hawaiʻi

The Drought Impact Reporter (DIR) is an online geospatial drought database where the public can report drought impacts in their location and impact sector. The DIR, developed by the National Drought Mitigation Center, compiles drought impact data from news outlets, government reports, and individual observers into a comprehensive database of drought impacts across the United States. Users can search the DIR database by location, time period, categories and report types.

A DIR, Hawaiʻi version was later developed by the NDMC to facilitate the reporting of drought impacts from Hawaiʻi.

K.4.3 National Integrated Drought Information System

The National Integrated Drought Information System (NIDIS) was established by Congress in 2006 to provide an effective drought early-warning system, coordinate and integrate federal drought research, and to build upon existing drought forecasting and assessment programs and partnerships. According to the NIDIS website[5]:

[5] National Integrated Drought Information System, U.S. Drought Portal Overview, accessed March 3, 2014, http://www.drought.gov/drought/content/what-nidis

The NIDIS Implementation Plan outlines how to:

- Develop the leadership and networks to implement an integrated drought monitoring and forecasting system at federal, state, and local levels
- Foster and support a research environment focusing on risk assessment, forecasting, and management
- Create an "early warning system" for drought to provide accurate, timely, and integrated information
- Develop interactive systems, such as the Web Portal, as part of the early warning system
- Provide a framework for public awareness and education about droughts

The Road Ahead

As we embark on implementing NIDIS, the initial focus will be on:

- Developing the U.S. Drought Portal
- Integrating and fostering coping strategies through research, preparedness, education and public awareness
- Integrating data and predictions
- Developing pilot programs for design and implementation of early warning systems in selected locations

The U.S. Drought Portal

The U.S. Drought Portal is part of the interactive system to:

- Provide early warning about emerging and anticipated droughts
- Assimilate and quality control data about droughts and models
- Provide information about risk and impact of droughts to different agencies and stakeholders
- Provide information about past droughts for comparison and to understand current conditions
- Explain how to plan for and manage the impacts of droughts
- Provide a forum for different stakeholders to discuss drought-related issues

K.4.4 Hawai‘i Rainfall Atlas

The Rainfall Atlas of Hawai‘i[6] website was developed by the University of Hawai‘i Geography Department in 2013 to provide a comprehensive estimate of monthly and annual mean (average) rainfall in the State of Hawaii. The Rainfall Atlas of Hawai‘i is an online tool with an interactive rainfall map and links to downloadable rainfall data and maps from across the State of Hawai‘i. Data from over 1,000 rainfall stations for the base period 1978-2007 were used along with advanced analytical methods to estimate rainfall at discrete grid units measuring 234 meters x 250 meters. Other features of this website include the history of rainfall collection in Hawai‘i as well as the project methodology and final report. The Rainfall Atlas of Hawai‘i project has initiated other important rainfall research including month-year rainfall maps, which are available on the Rainfall Atlas of Hawai‘i website.

K.5 Recommendations for Drought Planning

The drought program in Hawai‘i has been successful in raising public awareness of drought hazard and in creating an effective planning framework. The HDP establishes a leadership structure to coordinate drought monitoring, mitigation, and response activities, and formalizes a protocol for communication among agencies and stakeholders. The HDP also serves as a guide for government agencies to develop mitigation and response strategies within their areas of jurisdiction and serves as a resource document for private stakeholders to develop appropriate strategies to prepare for and respond to drought.

The HDP delineates several State- and county-level priority implementation actions, which are included below with general drought program recommendations and are incorporated herein as recommendations for statewide drought planning:

- The Hawai‘i Drought Council should continue to refine drought indices for each impact sector by correlating historical drought impact data with past drought events and developing a drought climatology for Hawai‘i.

- Additional monitoring of surface water sources, including stream diversions, ditch systems, and reservoirs should be undertaken. The drought leadership structure should discuss ways in which agencies can achieve better coordination of program activities to facilitate monitoring of these surface water resources.

- The State Drought Coordinator should work with the National Weather Service Climate Prediction Center to determine if additional drought-forecasting products can be developed for Hawai‘i. Similarly, the State Drought Coordinator should continue to correspond and work together with other drought-related agencies such as the National Drought Mitigation Center, National Integrated Drought Information System, Western Regional Climate Center, Western Governors’ Association, University of Hawai‘i,

[6] http://rainfall.geography.hawaii.edu/

National Weather Service–Honolulu Office, State and County Emergency Management Agencies, etc. to coordinate data collection and access to such data in a reasonable time frame and to provide real-time data where possible through the sharing of electronic databases.

- A methodology to conduct statewide drought impact assessments should be developed. The HDC, through its Water Resources Committee, the State Drought Coordinator and CLDCs should work together to develop a uniform system for the assessment of drought impacts. CLDCs should establish and implement a mechanism for conducting impact assessments on a regular basis after each drought event and report such information to the HDC.

- CLDCs should continue their work towards developing county-level drought mitigation and response strategies. CLDCs should also continue to work with State and county emergency management agencies to incorporate additional drought mitigation projects into the County Hazard Mitigation Plans.

- CWRM should continue to implement its Hawai‘i Water Conservation Plan and to develop partnerships with government and private organizations to further water conservation and efficiency throughout the State.

- Further refinement of the Drought Risk and Vulnerability Assessment and GIS Mapping Project (2003), should be conducted. The assessment should be updated to include data from State rain gages and analyses of multi-year drought events, recurrence intervals, drought patterns, and drought severity during El Niño and La Niña years.

- The University of Hawai‘i, Pacific Regional Integrated Sciences and Applications, and Pacific Islands Climate Change Cooperative should continue research on climate change impacts to drought in Hawai‘i and to develop climate change adaptation policies for drought.

- The Hawai‘i Drought Monitor website should be maintained and utilized to promote public education and awareness of drought-related program activities and initiatives.

- The County Drought Committees should maintain and update their respective list of drought mitigation projects and initiatives and continually seek out funding for implementation.

- The State Drought Coordinator with the County Drought Committees should promote individual drought and water conservation plans for agricultural operations, water utilities, and other businesses or organizations impacted by drought.

K.5.1 Recommendations for Future HDP Updates and Revisions

The HDP should undergo timely updates and revisions at least every five years. Plan recommendations and the drought communication protocol should likewise be reevaluated and revised as appropriate.

The plan has been designed as a dynamic “living” document, which should be utilized and updated to reflect changing conditions, new information, and an evolving leadership structure. Additional public and private sector resources should be continually sought, and the participation of all appropriate agencies and stakeholder representatives should be expanded and fortified. The net effect of the HDP implementation will be the effective coordination of people and resources to reduce and minimize drought impacts to the State of Hawaiʻi.

APPENDIX L

Watershed Protection

Water Resource Protection Plan 2019 Update

L Watershed Protection

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Figures

L Watershed Protection

The USGS simply defines a watershed as the divide separating one drainage basin from another.[1] However, the watersheds of Hawaiʻi are an important part of our ecosystem. They function as an integral vehicle whereby water flows from the sky to the land and the ocean. Healthy watersheds provide Hawaiʻi communities with valuable water-related ecosystem services such as flood mitigation, adequate streamflow, healthy nearshore waters, and healthy ground water supplies. Watershed management seeks to maintain and restore the continuing functioning of these and other services.

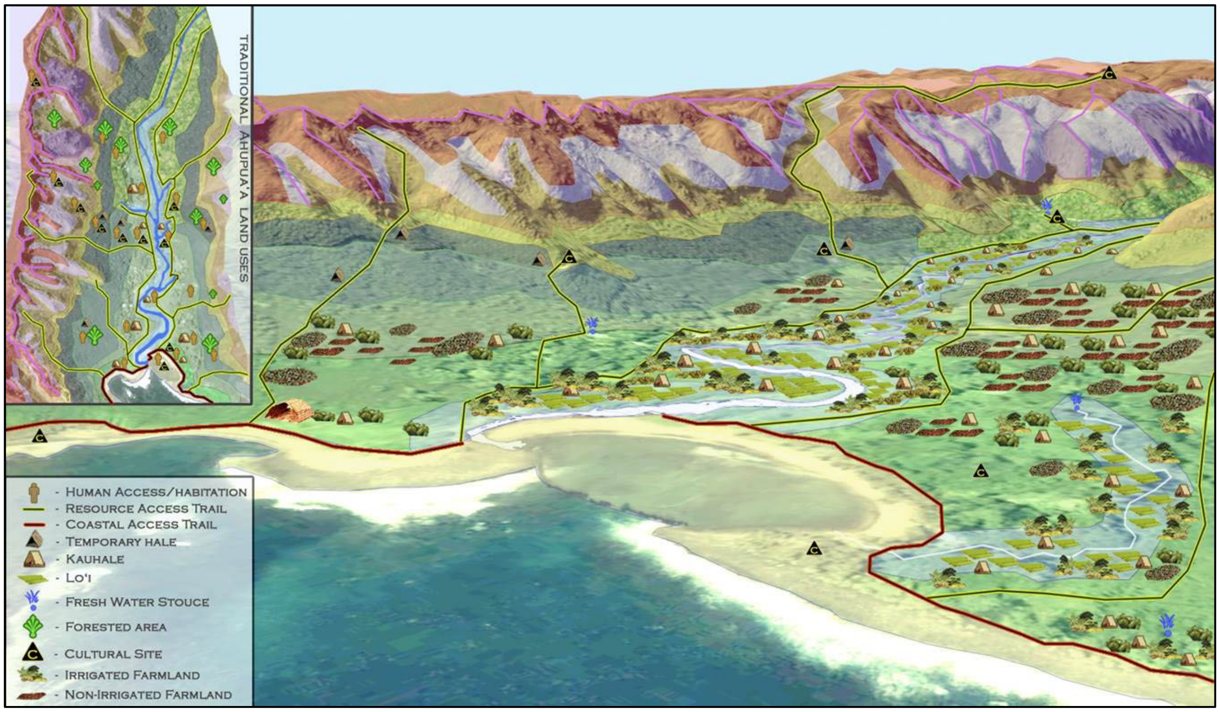
Figure L-1 Diagram of a Watershed

Source: http://fullspectrumbiology.blogspot.com/2013/06/watersheds-preservation-of-important_1180.html

The Hawaiian people recognized the benefit of a holistic land-management system through their establishment of the ahupuaʻa management system. Ahupuaʻa are traditional land divisions organized around water, as it was – and still is – the necessary resource for basic human needs such as drinking, bathing, and food production. According to traditional moʻolelo (stories), fresh water streams and springs were created throughout Hawaiʻi by the gods Kāne and Kanaloa. Therefore, water also has a spiritual meaning to Hawaiians and cannot be physically owned or commoditized.

[1] USGS Water Science Center http://water.usgs.gov/wsc/glossary.html#W

Figure L-2 Diagram of an Ahupuaʻa



Drawing by Dr. Jonathan Ching

Ahupuaʻa provided the necessary resources for survival, with typical ahupuaʻa following watershed boundaries, running from the mountains out to the nearshore waters, with few exceptions. Hawaiians understood that every element within the ahupuaʻa was related to one another and that the consequences of an action could directly affect the state of the environment, the people, and their way of life. Therefore, ahupuaʻa resources were managed holistically to ensure the continued functioning of the system, much like modern watershed management principles prescribe.

The State of Hawaiʻi has a long history of watershed protection and management programs, which were initiated specifically to ensure a sustainable water supply. Additionally, many modern watershed protection and management programs have sprung from the requirements of the Clean Water Act of 1977, subsequent supporting legislation, a resurgence in Hawaiian culture, and a newfound appreciation for traditional land and water management principles. In the face of a changing climate, these programs and principles have become even more critical as a means to ensure the sustainability of clean and plentiful water resources for our island communities.

This section of the WRPP describes CWRM's role to support watershed protection efforts, as well as the identification of other entities that share in the responsibility to protect and manage one of our most valuable resources.

L.1 Background on Watershed Management in Hawai‘i

Article XI, Section 7 of the Hawai‘i State Constitution says that:

> *“The State has an obligation to protect, control and regulate the use of Hawai‘i's water resources for the benefit of its people.*
>
> *The legislature shall provide for a water resources agency which, as provided by law, shall set overall water conservation, quality and use policies; define beneficial and reasonable uses; protect ground and surface water resources, watersheds and natural stream environments; establish criteria for water use priorities while assuring appurtenant rights and existing correlative and riparian uses and establish procedures for regulating all uses of Hawai‘i's water resources.”*

The definition of a “watershed” can be found in the enabling statutes for the Division of Forestry and Wildlife (DOFAW). HRS § 183-31 states:

> *“The department of land and natural resources shall determine, after public hearing held in the same manner as provided in section 91-3, areas which are watersheds.*
>
> *The term "watershed" as used in this part means (1) an area from which the domestic water supply of any city, town or community is or may be obtained, or (2) an area where water infiltrates into artesian or other ground-water areas from which the domestic water supply of any city, town or community is or may be obtained.”*
>
> *HRS §183-1.5(4) also states that DLNR shall “devise ways and means of protecting, extending, increasing, and utilizing the forests and forest reserves, more particularly for protecting and developing the springs, streams, and sources of water supply to increase and make that water supply available for use.”*

DOFAW implements the statutes identified above through programs such as the Natural Area Reserves System (NARS) Program, Natural Area Partnership Program, and the Watershed Partnership Program.

L.2 Goals and Objectives

Watershed protection is not only reliant upon collaboration across all levels of government, but must also include communities, which are a key component of successfully implementing any watershed protection goals. The following are CWRM's goals and objectives to support State efforts to protect and manage Hawaiʻi's watersheds:

- Encourage integrated programs at the watershed level that currently exist between mauka- and makai-area interests, urban issues and conservation priorities, and economic goals and pollution prevention.

- Encourage the research necessary to link management activities in the watershed (e.g. fencing, invasive species removal, non-point source pollution mitigation, etc.) with changes to the hydrologic products from the watershed (e.g. increased water supplies, healthy coral reefs, water quality improvement, etc.).

- Encourage collaboration and coordination amongst agencies, local communities, and other stakeholders in the development and implementation of watershed protection programs.

L.3 Hawaiʻi Watershed Protection Programs

In 1903, the Governor of the Territory of Hawaiʻi approved Act 44, enacted by the territorial legislature, to designate forest reserves and extend the reserve system to protect ground water supplies. Extensive cattle grazing in native forests during the 1800s had resulted in significant deforestation. Public and private concerns about water supply and quality were the impetus for placing the forests into reserves and undertaking massive reforestation projects at the turn of the century. Through Act 44, the Territory of Hawaiʻi established one of the first forestry agencies in the nation, with the authority to establish forest reserves for the protection of springs, streams, and other water supply sources. The State's long-standing policy of watershed protection resulted in dramatic improvements from the degraded conditions due to overgrazing that prevailed at the turn of the century. Management activities such as protective zoning, fencing, removal or control of feral animals, reforestation, and fire protection have laid some groundwork for reducing excessive erosion and loss of vegetative cover.

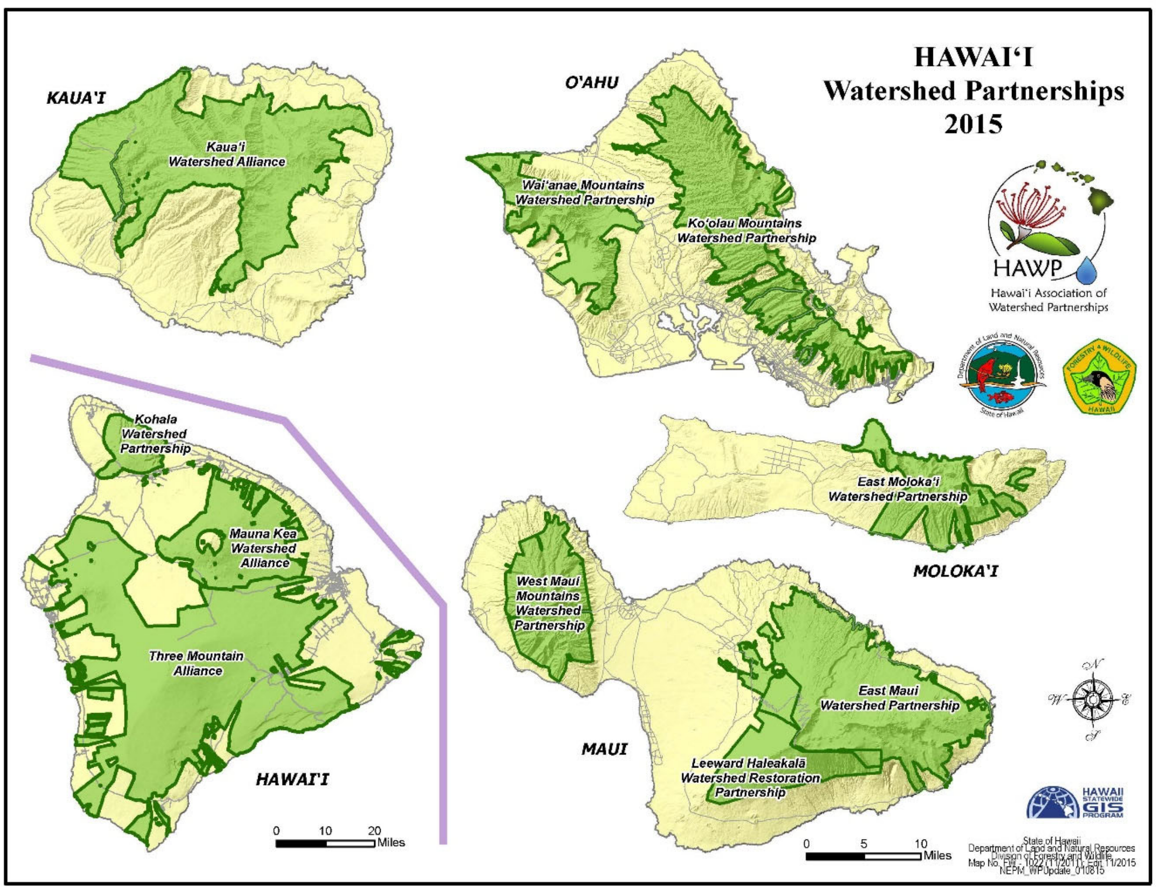
L.3.1 The Hawaiʻi Association of Watershed Partnerships

The modern form of watershed management through public/private partnerships emerged in the early 1990s, with voluntary alliances between landowners committed to the common value of protecting large areas of forested watersheds for water recharge and other shared interests. The first Watershed Partnership was formed in 1991 on East Maui when several public and private landowners realized the benefits of working together to ensure the conservation of a shared watershed that provided billions of gallons of fresh water to the area.

The successful creation of the East Maui Watershed Partnership reinvigorated the historic cooperative partnership of public and private sectors in working together to protect essential, forested watershed recharge areas in Hawai‘i. In the following years, more watershed partnerships formed including Ko‘olau Mountains Watershed Partnership, East Moloka‘i Watershed Partnership, West Maui Mountains Watershed Partnership, The Kaua‘i Watershed Alliance, and Kohala Watershed Partnership. The success of these partnerships highlighted the need to address watershed issues statewide.[2]

In 2003, the Hawai‘i Association of Watershed Partnerships (HAWP) was established through the signing of a Memorandum of Understanding (MOU) between the seven existing watershed partnerships. The State of Hawai‘i also signed the MOU as an individual partner. The parties, through the MOU, established principles and agreed to participate in cooperative fundraising, building public and political support, and capacity building for island-based mauka watershed partnerships.

Figure L-3 Hawai‘i Association of Watershed Partnerships



[2] Hawai‘i Association of Watershed Partnerships Webpage. Accessed 2013. http://hawp.org/about-us/history/

Today there are 10 active watershed partnerships, collaborating with approximately 75 public and private partners representing 2.2 million acres of vital watershed lands across the State (**Figure L-3 Hawai‘i Association of Watershed Partnerships**).

Island of Kaua‘i

- **Kaua‘i Watershed Alliance (144,004 acres)**
  Kamehameha Schools; Princeville Corporation; County of Kaua‘i Department of Water; Kaua‘i Ranch, LLC; Lihue Land Company; McBryde Sugar Company, Ltd.; DLNR; Grove Farm Company, Inc.; Ben A. Dyre Family Limited Partnership

Island of O‘ahu

- **Wai‘anae Mountains Watershed Partnership (46,000 acres)**
  Honolulu BWS; DLNR; Gil-Olson Joint Venture; MA’O Organic Farms; U.S. Army; U.S. Navy; Ka‘ala Farms Inc.

- **Ko‘olau Mountain Watershed Partnership (100,484 acres)**
  Kamehameha Schools; Honolulu BWS; DLNR; Bishop Museum; DHHL; Agribusiness Development Corp.; U.S. Army; Queen Emma Land Company; Manana Valley Farm, LLC; Tiana Partners; Dole Food Co., Inc.; U.S. Fish and Wildlife Service; Hawai‘i Reserves, Inc.; Kualoa Ranch; O‘ahu Country Club; The Nature Conservancy; DOH; EPA; U.S. Forest Service; NRCS; USGS; ‘Ōhulehule Forest Conservancy LLC; Lyon Arboretum; Hi‘ipaka LLC dba Waimea Valley

Island of Moloka‘i

- **East Molokai Watershed Partnership (32,983)**
  Kamehameha Schools; Kapualei Ranch; Ke Aupuni Lokahi Enterprise Community Governance Board; DOH; DLNR; Kalaupapa National Historical Park; Maui County; Maui Board of Water Supply; Moloka‘i-Lāna‘i Soil and Water Conservation District; NRCS; US Fish and Wildlife Service; USGS; EPA; The Nature Conservancy; Kawela Plantation Homeowners Association, Kawela Ahupua‘a;

Island of Maui

- **East Maui Watershed Partnership (100,000 acres)**
  DLNR; The Nature Conservancy; Maui County Board of Water Supply; Haleakala Ranch Co.; East Maui Irrigation Co., Ltd.; Haleakala National Park; Hana Ranch; County of Maui

- **Mālama Kahalawai Watershed Partnership (48,000 acres)**
  Maui County Board of Water Supply; Kamehameha Schools; C. Brewer and Co., Ltd.; Amfac/JMB Hawaiʻi, LLC; The Nature Conservancy; Maui Land and Pineapple Co., Inc.; DLNR; County of Maui

- **Leeward Haleakalā Watershed Restoration Partnership (43,000 acres)**
  Department of Hawaiian Home Lands (DHHL); Estate of James Campbell; Haleakalā National Park; Haleakalā Ranch; Kaʻonoʻulu Ranch; Nuʻu Mauka Ranch; DLNR; ʻUlupalakua Ranch; John Zwaanstra

Island of Hawaiʻi

- **Three Mountain Alliance (1,116,300 acres)**
  Kamehameha Schools; DLNR; Department of Public Safety, Kulani Correctional Facility; U.S. Fish and Wildlife Service; USGS Biological Resources Division; U.S. Forest Service; The Nature Conservancy; National Park Service, Hawaiʻi Volcanoes National Park

- **Mauna Kea Watershed Alliance (484,000 acres)**
  DLNR; DHHL; Kamehameha Schools; Hakalau Forest National Wildlife Refuge; Kūkaʻiau Ranch

- **Kohala Mountain Watershed Partnership (68,000 acres)**
  Parker Ranch, Inc.; Kahua Ranch, Ltd.; Ponoholo Ranch, Ltd.; The Queen Emma Foundation; Kamehameha Schools; Laupāhoehoe Nui, LLC; DLNR; DHHL; Hawaiʻi County Department of Water Supply; The Nature Conservancy

L.3.2 The Division of Forestry and Wildlife's Watershed Protection Initiatives

In addition to being a member of all of the above watershed partnerships, DOFAW supports the implementation of management plans developed by the partnerships through their administration of the Watershed Partnerships Program Grant (WPPG).

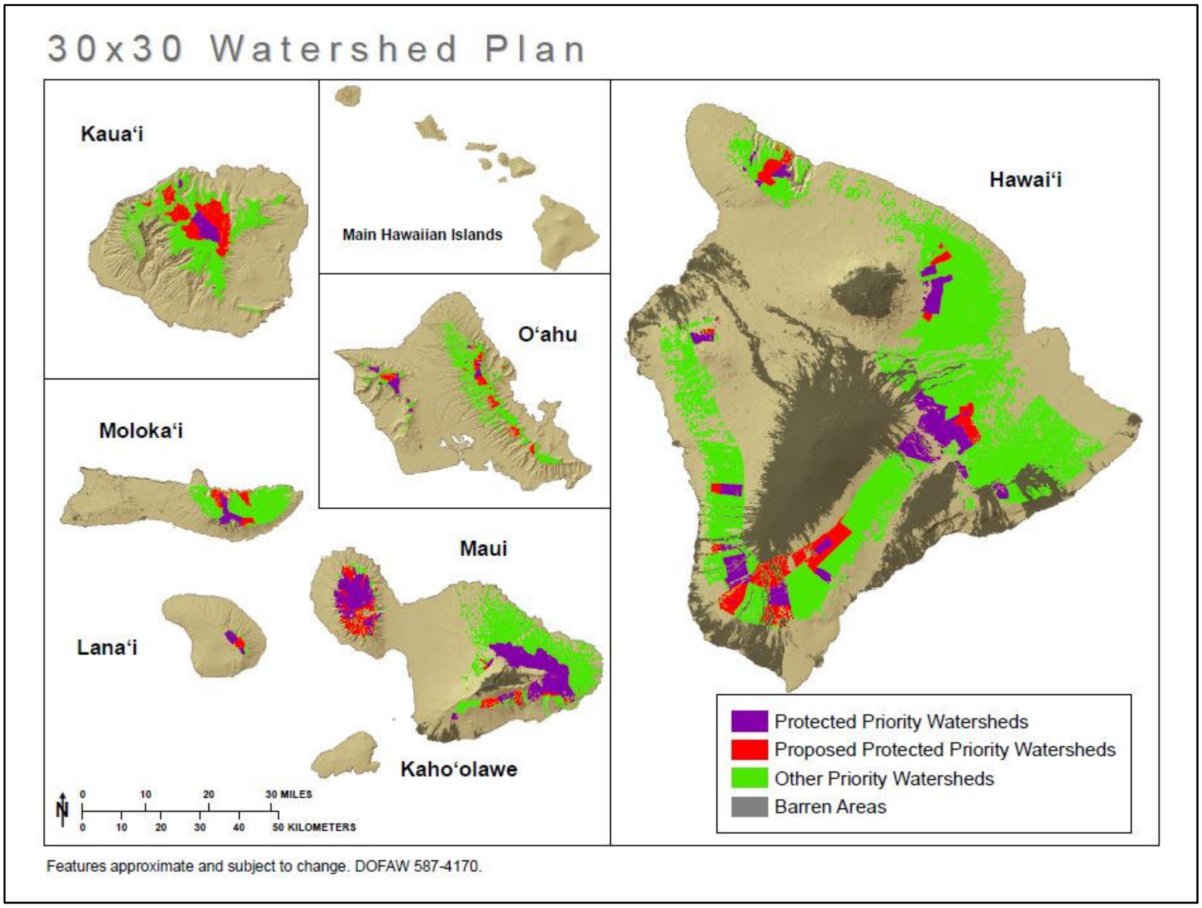
As the watershed partnership program is a means through which DOFAW implements the charge given to them in HRS183-31, they recognized the need to develop a new plan to support this program. The importance of watershed protection was also recognized by Governor Abercrombie through his *New Day in Hawaiʻi* plan when he called on DLNR to "*Ensure that our mauka watersheds are fully functioning so that our fresh water resources can be utilized and enjoyed by the people of Hawai'i in perpetuity.*"

The cost to upkeep our watersheds is difficult to define, but the State's "Watershed Initiative" (Rain Follows the Forest) estimated approximately $11 million per year. At the time (2011), the goal was to double the acres protected (20%). However, in light of the advancing threats facing Hawaii's watersheds, Governor David Ige launched his Sustainable Hawaii Initiative in Sept 2016, which increased the goal to protect 30% (253,000 acres) of Hawaii's highest priority watershed forests by 2030 (30x30 Watershed Plan Figure L-4). Of the 843,000 acres identified as priority watershed across the state, 140,000 (17%) are currently protected. In order to reach the 30% goal, more funding is needed to build protective fences, which will enclose priority areas that are critical to water recharge and safeguarding biodiversity. In FY19, the Legislature allocated over $7 million for fence construction that will protect an additional 18,000 acres of priority watersheds. The status of watershed protection can be tracked via an online dashboard at https://dashboard.hawaii.gov/stat/goals/5xhf-begg/4s33-f5iv/wtjm-96jt

Before (1998) and after (2005) watershed management efforts

Source: Hawaii Alliance of Watershed Partnerships

Figure L-4 30x30 Watershed Plan



L.3.3 Honolulu Board of Water Supply Watershed Prioritization

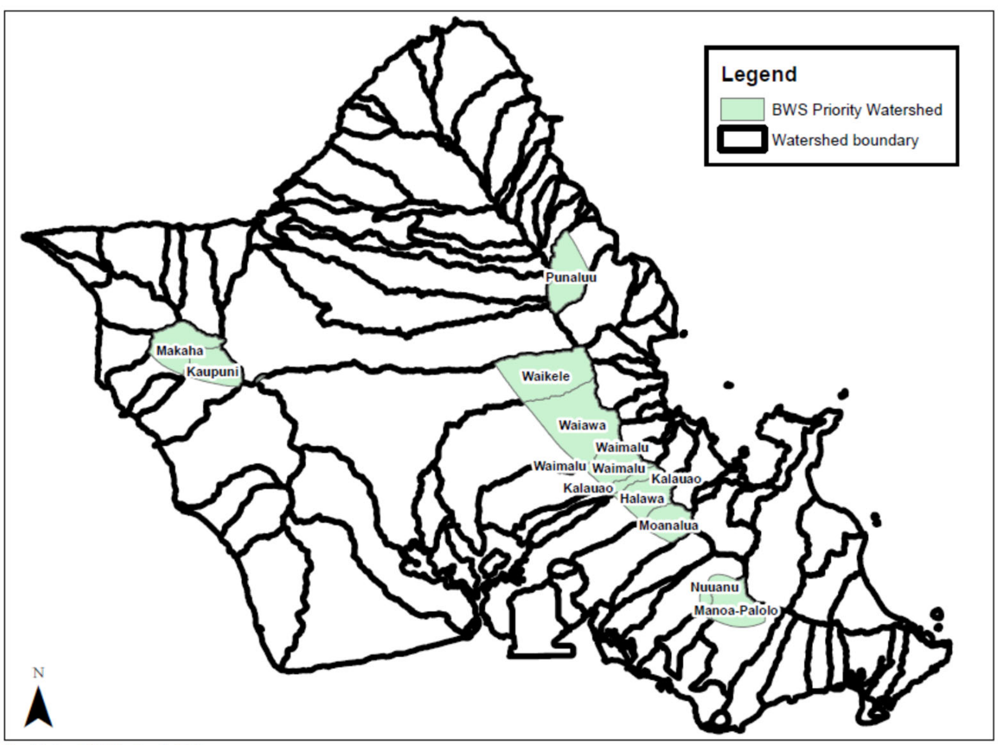
The Honolulu Board of Water Supply (BWS) is the largest municipal water supplier for the island of O'ahu. Officially created in 1929 by the Territorial Legislature, BWS' mission is to provide safe, dependable and affordable water now and into the future. A key component of accomplishing this mission involves proper management of the watersheds, which directly affect ground water supply.

Accordingly, BWS' Water Resources Division is responsible for preparing Watershed Management Plans covering O'ahu, which meets the requirement for a County Water Use and Development Plan per the State Water Code and City and County of Honolulu ordinance. To date, the Wai'anae, Ko'olauloa, Ko'olaupoko, and North Shore Watershed Management Plans have been completed. The Central, 'Ewa, and Primary Urban Center Watershed Management Plans are currently in progress and the East Honolulu Plan has yet to be started.

The BWS Water Resources Division, Hydrology-Geology Branch also plays a primary role in proper management of watersheds on O'ahu. Through its Watershed Program, the Branch has leveraged partnerships with other Federal, State, and local agencies and organizations to help maximize the effectiveness of countless watershed conservation and restoration projects. Examples of such projects include fencing of native forests, ungulate (pig and goat) removal, invasive plant removal, replanting of native species, and establishing vegetative firebreaks.

The Branch also completed a Watershed Prioritization Report, which prioritized watersheds on O'ahu from its water supply perspective, to meet two objectives. First, as a member of both the Ko'olau and Wai'anae Mountains Watershed Partnerships (KMWP and WMWP), BWS prioritization results serve as input for prioritizing watersheds for cooperative conservation and restoration work. Second, BWS prioritization results serve as guidance for its own watershed management projects, to focus funding and implementation efforts. In order to prioritize watersheds from a water supply perspective, basic concepts of water budgeting were considered: ground water recharge and ground water production from the watersheds. Ground water recharge parameters included general soil/rock/vegetation type in each watershed, and relative rainfall amounts across watersheds. Ground water production parameters included production amounts compared to the sustainable yields defined for watershed regions, as well as relative chloride concentrations. In addition to these parameters, the demand from major agricultural irrigation systems was considered and incorporated into the prioritization scheme. The identified priority watersheds for the Wai'anae and Ko'olau mountain ranges (**Figure L-5 BWS Priority Watersheds**) were organized into a tiered strategy, and have since been utilized to focus funding and labor efforts on numerous watershed conservation and restoration projects. More information about the BWS prioritization can be found at http://www.boardofwatersupply.com/bws/media/files/publication-watershedprioritization-poster-2013-07. pdf.

Figure L-5 BWS Priority Watersheds



Honolulu Board Of Water Supply, 2013

L.3.4 The Hawai‘i Coastal Zone Management Program

Coastal Zone Management, or CZM, is about balancing the needs of economic development and conservation of resources in a sustainable manner. The federal Coastal Zone Management Act (CZMA) of 1972 established the voluntary program with a broad framework in order to allow flexibility among the State programs. In 1977, the Hawai‘i State Legislature enacted the State CZM law (codified in HRS Chapter 205A) to provide a common focus for State and County actions dealing with land and water uses and activities. The Hawai‘i CZM Program was officially approved in 1978. The Office of Planning (OP) within the State Department of Business, Economic Development and Tourism is responsible for the overall administration of the Hawai‘i CZM Program.

The Hawai‘i Coastal Zone Management Act recognized this link between terrestrial activities in the watershed and the health of coastal and marine resources. It defines watershed management areas as the uppermost reaches of the mountains out into the sea.[3] The Hawai‘i CZM Program was established through this Act to coordinate land use practices, and the entities that influence those practices, towards a common goal of improving the quality of the coastal zone and nearshore waters.

As the State’s coastal zone resource management policy umbrella, the Hawai‘i CZM Program is the guiding perspective for the design and implementation of allowable uses and activities within the coastal zone. The Hawai‘i State Legislature charged the CZM Program with the responsibility of encouraging agencies to look at resources from a broader ecosystem perspective.

The Hawai‘i CZM Program is undertaking many important initiatives including, but not limited to, the following:

- Coordinate the implementation of the Hawai‘i Ocean Resources Management Plan (ORMP), which was last updated in 2013. The ORMP is a primary means for achieving the objectives of the CZM Act of 1977 across jurisdictions, disciplines, and communities. Eleven management priorities over the next five years are identified to meet the challenges of increasing land use and ocean resource development, competing human uses, the impacts from climate change, and environmental health.

[3] Hawai‘i Office of Planning Coastal Zone Management Program, “Hawai‘i Watershed Guidance”. Date accessed 01/2013. Available at: http://www.reefresilience.org/pdf/HI_Watershed_Guidance.pdf

- Assess, consider, and control cumulative and secondary impacts of coastal growth and development, including integrated planning that builds on and better supports the stewardship efforts of community groups and organizations. The goal is to move the State towards place-, cultural-, and community-based approaches to natural and cultural resource management.

- Reduce hazards to life and property from coastal hazards, including tsunami, storm waves, stream-flooding erosion, and subsidence.

- Implement CZM Program compliance through Special Management Area (SMA) and Shoreline Setback Areas (SSA), which are designated for more intensive management by the Counties.

The Hawaiʻi CZM Program focuses on complex multi-functional resource management problems, issues, concerns, and opportunities. HRS Section 205A-2, enumerates the CZM objectives and policies which address recreational resources, historic resources, scenic and open space resources, coastal ecosystems, economic uses, coastal hazards, managing development, public participation, beach protection, and marine resources. Compliance with HRS Chapter 205A, CZM objectives and policies ensure that appropriately designed developments along coastal areas respect economic, biological, environmental, and cultural values.

Within a network of State and County agencies, the program employs a wide variety of regulatory and non-regulatory techniques to address coastal issues and uphold environmental law. Much of CZM's work is characterized by stewardship, planning, permit administration, education and outreach, multi-functional coordination, policy development and implementation, identification of emerging issues and exploration of solutions, technical assistance to local governments and permit applicants, and assuring State and County compliance with the statutory requirements.

L.3.5 Department of Health Water Quality Programs

The goals and objectives of the national Clean Water Act and Safe Drinking Water Act, among other federal laws, are embodied in the EPA's management, regulatory, and permitting programs that are carried out in Hawai‘i by the State DOH.

The DOH Clean Water Branch (CWB) administers National Pollutant Discharge Elimination System (NPDES) permits to minimize discharge of pollutants to State waters. The CWB also administers the Surface Water Quality Management Program, which includes the Total Maximum Daily Load (TMDL) and Polluted Runoff Control programs. The DOH Safe Drinking Water Branch (SWDB) is responsible for protecting drinking water sources (surface water and ground water) from contamination and regulates owners and operators of public water systems. The DOH Wastewater Branch administers water pollution control programs and regulates municipal and private wastewater treatment works, as well as individual wastewater systems. More information on the DOH and water quality management is provided in the WRPP **Appendix M Water Quality**.

Most of the DOH's programs are federally funded. These programs must meet federal Clean Water Act requirements, obtain EPA approval, and employ a watershed-based approach to water quality management.

Section 6217 of the Coastal Zone Act Reauthorization Amendments (CZARA) of 1990 requires each federally-approved CZM program to develop and implement a Coastal Nonpoint Pollution Control Program. The Hawai‘i Watershed Guidance[4] was developed by the CZM Program and DOH in a joint effort to coordinate the protection of the resources that are impacted by the quality of water from Hawai‘i's watersheds (e.g., healthy and productive marine ecosystems). The guidance is meant to help managers and others working in the watershed to develop effective watershed plans to achieve water quality goals. This document is a component of the Ocean Resources Management Plan.

Through the ORMP, the CZM Program and DOH are the primary State agencies responsible for coordinating watershed management activities with the goal of protecting the <u>quality</u> of our water resources. Through the Rain Follows the Forest Plan, DOFAW is leading the effort to coordinate watershed activities to protect the <u>quantity</u> of our water resources. Holistic watershed management requires that CWRM support both of the above endeavors.

[4] Hawai‘i Office of Planning Coastal Zone Management Program, “Hawai‘i Watershed Guidance.” Date accessed 01/2013. Available at: http://www.reefresilience.org/pdf/HI_Watershed_Guidance.pdf

L.3.6 Other State Watershed Protection Programs

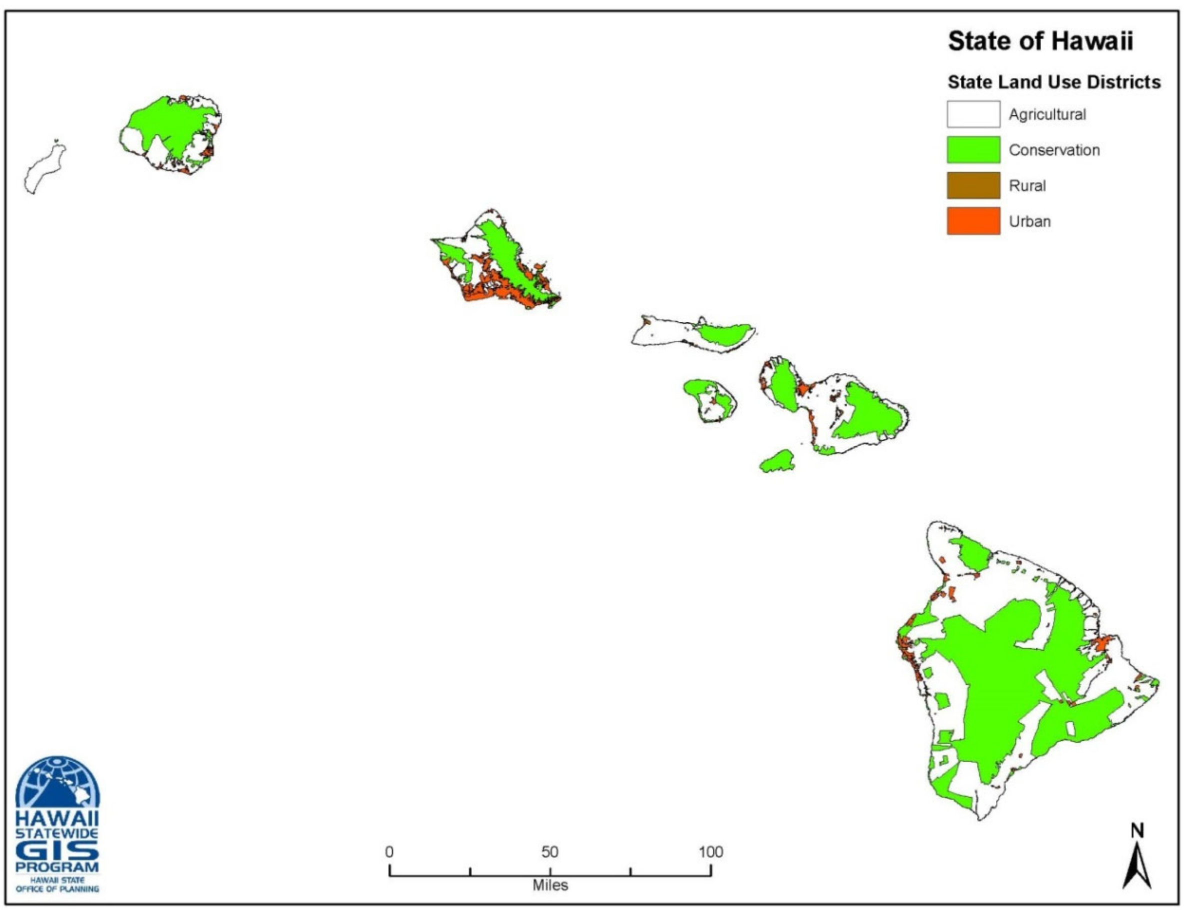
In addition to the State programs that involve active management activities, the DLNR Office of Conservation and Coastal Lands (OCCL) and the DBEDT Land Use Commission (LUC) prevent degradation of the watershed through land use designations and regulation of land use activities. Similarly, the Hawai‘i Soil and Water Conservation District Program assists agricultural producers in the watershed in reducing erosion and sediments that may result from on-farm activities.

L.3.6.1 DBEDT Land Use Commission

The LUC's primary role is to ensure that areas of state concern are addressed and considered in the land use decision-making process. The LUC is administratively attached to DBEDT and has established four land use districts: Urban District, Rural District, Agricultural District, and Conservation District.

The LUC acts on petitions for land use district boundary changes submitted by private landowners, developers and State and county agencies. Decisions on boundary change petitions are guided by a specific set of criteria, which includes preservation or maintenance of important natural systems or habitats. Such values are generally associated with Conservation District lands.

Figure L-6 State Land Use Districts



Act 187 defined Conservation as meaning the protection of watersheds and water supplies; preserving scenic areas; providing park lands, wilderness and beach reserves; conserving endemic plants, fish, and wildlife; preventing floods and soil erosion; forestry; and other related activities. The Conservation District is comprised primarily of lands in existing forest and water reserve zones and includes areas necessary for protecting watersheds and water sources; scenic and historic areas; parks; wilderness; open space; recreational areas; habitats of endemic plants, fish and wildlife; and all submerged lands seaward of the shoreline. The Conservation District also includes some lands that are subject to flooding and soil erosion. Since 1964, the Board of Land and Natural Resources has adopted and administered land use regulations for the Conservation District pursuant to the State Land Use Law (Act 187) of 1961.

L.3.6.2 DLNR Office of Conservation and Coastal Lands

The Office of Conservation and Coastal Lands (OCCL) is responsible for overseeing approximately two million acres of private and public lands that lie within the State Land Use Conservation District. In addition to privately and publicly owned Conservation District lands, OCCL is responsible for overseeing beach and marine lands to the seaward extent of the State's jurisdiction.

The OCCL has multiple functions in addition to overseeing activities in the mauka to makai Conservation District These include permit processing, prosecution of land use violations, resolution of shoreline encroachments, enactment of beach restoration projects, administration of contested cases involving Conservation District Use Permits and shoreline certifications. The OCCL provides direction and guidance to coastal landowners, concerned citizens and resource agencies on current best practices for shoreline use and management through the development, implementation, and monitoring of Coastal Management Policy and Procedures. It is a goal of OCCL to balance the conservation of our State's unique and fragile natural resources from Mauka to Makai with development of these resources for the good of the State.

L.3.6.3 State Soil and Water Conservation Districts

Separate and distinct from the State land use Conservation District are “Soil and Water Conservation Districts” or “Resource Conservation Districts,” which originated during the Dust Bowl era of the 1930s, after President Roosevelt urged state governors to recommend legislation that would allow the establishment of local soil Conservation Districts. There are approximately 3,000 Conservation Districts nationwide. Their mission is to coordinate assistance from public and private local, state, and federal sources to develop locally driven solutions to natural resource concerns.

According to the National Association of Conservation Districts, the nonprofit organization that represents the 3,000 local Conservation Districts, local residents should make conservation decisions, with technical and funding assistance from federal, state, and local governments and the private sector. Conservation Districts help accomplish the following actions:

- Implement farm conservation practices to keep soil in the fields and out of waterways;
- Conserve and restore wetlands, which purify water and provide habitat for birds, fish and numerous other animals;
- Protect ground water resources;
- Plant trees and other land cover to hold soil in place, clean the air, provide cover for wildlife, and beautify neighborhoods;
- Help developers and homeowners manage the land in an environmentally sensitive manner; and
- Reach out to communities and schools to teach the value of natural resources and encourage conservation efforts.

In Hawai‘i there are 16 Conservation Districts. They strive to assist partners and government agencies with identifying and implementing culturally sensitive projects and practices, to assure the protection of Hawai‘i’s environment.

Current challenges facing Conservation Districts include managing manure and fertilizer to prevent water pollution, restoring wetlands, improving irrigation efficiency and flood protection measures, and addressing urban expansion issues, including the protection of plant and animal habitats and water quality. These challenges are not unique to farmers and ranchers. Although specifics may vary, municipal, state, and federal agencies and conservation groups also deal with the same issues, albeit the specific aspects of the issues vary.

L.3.7 Current CWRM Support of Watershed Protection and Management

Although CWRM does not have a formal watershed protection and management program, there are several ongoing initiatives that support the missions of watershed management organizations. The first is the cooperative hydrologic monitoring program between CWRM and the USGS. This is a long-term monitoring program that collects rainfall, ground water, and surface water data from monitoring stations throughout the State. The data from this program allows managers to observe trends in Hawai‘i’s water resources that are associated with land use change, seasonal climate variability, and climate change. This program currently funds monitoring stations in several watersheds on O‘ahu as a means to observe hydrologic responses to watershed management activities. For more information on the cooperative monitoring program please refer to WRPP **Appendix G Monitoring of Water Resources**.

CWRM also funds research that is vital to understanding the impacts of watershed management on water supplies. These include the regular updates of ground water recharge estimates by the USGS, a recent update of the Rainfall Atlas of Hawaiʻi (2013) by the University of Hawaiʻi, a statewide estimate of evapotranspiration rates by the University of Hawaiʻi, and numerical ground water models by the USGS.

CWRM has recently partnered with the USGS and the Maui Department of Water Supply to study the impacts of native and nonnative vegetation on the hydrology of selected watersheds on Maui. The findings of the first phase of this study is scheduled to be published sometime in 2018 and will help water resource managers begin to understand how freshwater availability is affected by watershed restoration activities.
Despite these ongoing efforts, gaps in the understanding of the hydrologic processes that occur in the watershed still exist. The high cost of protecting mauka watershed areas[5] underscores the importance of the need to support research that helps water resource managers determine how watershed protection efforts impact the sustainability of fresh water supplies. Research recommendations for CWRM to support watershed management are identified later in this section.

L.4 Federal Watershed Protection and Management Programs

At the national level there exists Federal watershed protection and management programs to support and compliment State watershed protection efforts. However, a key difference to note is that the focus of these Federal programs is water quality.

Federal protection and management activities are primarily executed through certain programs administered by the EPA, the USACE, and the USDA. These programs are described below.

L.4.1 Environmental Protection Agency (EPA) Programs

Over the past 20 years, the EPA has found that the discharge of pollutants into the nation's lakes, streams, rivers, wetlands, estuaries, coastal waters, and ground water has been substantially reduced. This was achieved primarily by controlling point sources of pollution and, in the case of ground water, preventing contamination from hazardous-waste sites under the provisions of the Clean Water Act and the Safe Drinking Water Act. Environmental threats to water resources still exist, and the potential causes of pollution vary with human activities in the watershed. In addition to discharges from industrial or municipal sources, water resources may be threatened by urban, agricultural, or other forms of polluted runoff; landscape modification; depleted or contaminated ground water; changes in flow; over-harvesting of fish and other organisms; introduction of exotic species; bioaccumulation of toxics; and deposition or recycling of pollutants between air, land, and water.

[5] http://www.civilbeat.org/2017/01/money-sought-to-protect-watersheds-and-grow-more-food/

Through program evaluation, the EPA has found that the federal laws addressing water resource problems have tended to focus on particular sources, pollutants, or water uses. Such laws have not enabled an integrated environmental management approach. Consequently, significant gaps exist in efforts to protect watersheds from the cumulative impacts resulting from the combination of all human activities in the watershed. However, the existing water pollution prevention and control programs, waste- and pesticide-management programs, and other related natural resource programs are excellent foundations on which to build an integrated watershed management approach.

The U.S. Environmental Protection Agency Office of Water (Office of Water) is responsible for preventing pollution wherever possible and reducing risk to people and ecosystems through implementation of the Clean Water Act and Safe Drinking Water Act; portions of the Coastal Zone Act Reauthorization Amendments of 1990; Resource Conservation and Recovery Act; Ocean Dumping Ban Act; Marine Protection, Research and Sanctuaries Act; Shore Protection Act; Marine Plastics Pollution Research and Control Act; London Dumping Convention; International Convention for the Prevention of Pollution from Ships; and several other statutes. Several organizations make up the Office of Water: Office of Wetlands, Oceans and Watersheds; Office of Science and Technology; Office of Wastewater Management; and the Office of Ground Water and Drinking Water. In addition, Water Divisions in all ten regional offices work with stakeholders to implement all programs.

Other federal agencies, state and local governments, Indian tribes, the regulated community, organized professional and interest groups, landowners and managers, and the public-at-large assist in program implementation. The Office of Water provides guidance, specifies scientific methods and data collection requirements, performs oversight, and facilitates communication among involved parties.

Through experience gained over the past several decades, the Office of Water has gained valuable insight to resource regulation and management. The Office of Water notes on its website a central theme that summarizes the difficulties faced by government agencies involved in resource management:

> *"…[W]e are still working with laws and regulations that treat land, air, water and living resources as separate entities instead of as interrelated systems. This regulatory pattern makes comprehensive solutions and their implementation problematic, and complicates protection of ecosystems and habitat. The traditional command and control approach, combined with single media laws, precludes flexibility and deflects attention from developing and applying alternative solutions that include market mechanisms, economic incentives, voluntary approaches, alternative enforcement penalties, prevention, negotiation, education and land use planning."*
>
> U.S. EPA Office of Water[6]

[6] U. S. EPA. 2006. *Overview of the National Water Program.* Internet, Available at: http://www.epa.gov/water/programs/owintro.html.

To remedy the existing jurisdictional and regulatory issues intrinsic in the structure of government, the Office of Water advocates supplementing the “command and control approach” with alternative techniques to allow program implementation on an integrated watershed basis, including air, land, and ecosystem relationships and related regulatory tools in water initiatives. The Office of Water seeks to apply a broad and balanced approach, utilizing regulatory enforcement, education outreach, voluntary compliance, and volunteer initiatives, particularly initiatives that prevent rather than remedy pollution. Thus, the Office of Water developed a Watershed Protection Strategy to protect water resources and public health at the overreaching watershed scale. The following sections provide information on the strategy development and the framework for implementation.

EPA’s Watershed Protection Approach

The Office of Water describes its Watershed Protection Approach as “a strategy for effectively protecting and restoring aquatic ecosystems and protecting human health.” The approach is based on the premise that many water quality and ecosystem problems are best solved at the watershed level, rather than at the individual body of water or discharger level.

The Watershed Protection Approach includes the following actions:

- Targeting priority problems;
- Promoting a high level of stakeholder involvement;
- Using integrated solutions that employ the expertise and authority of multiple agencies; and
- Measuring success through monitoring and other data gathering.

In 1996, the EPA published its *Watershed Approach Framework*[7] to build upon the Office of Water’s Watershed Protection Approach, which was endorsed by senior EPA managers in 1991. The *Watershed Approach Framework* emphasizes the role EPA envisions for states and tribes. According to the Office of Water, the Watershed Protection Approach Framework also reflects the high priority that individual Office of Water programs have put on developing and supporting comprehensive state and tribal watershed approach strategies that actively involve public and private interests at all levels to achieve environmental protection.

Increased public awareness and concern over environmental issues has invigorated community-volunteer initiatives for watershed protection nationwide. The creation of multidisciplinary and multi-jurisdictional partnerships between public and private organizations facilitates community actions to address local problems within their watershed. The Office of

[7] U. S. EPA.. 1996. ***Watershed Approach Framework***. EPA 840-S-96-001, Office of Water (4501T), U.S. EPA, Washington, DC. Available online at: http://www.epa.gov/owow/watershed/framework.html.

Water supports and encourages such partnerships for watershed restoration, maintenance, and protection. The Watershed Protection Approach Framework provides a coordinating structure for environmental management that focuses public- and private-sector efforts on the highest-priority problems within hydrologically defined geographic areas, or watersheds. The hydrologic boundaries consider both ground and surface water flow.

Guiding Principles and Benefits

The Watershed Protection Approach focuses on achieving pollution prevention, sustainable environmental improvements, and meeting community goals. The Watershed Protection Approach is flexible and its application may vary in terms of specific project objectives, priorities, elements, timing, and resources. However, the EPA recommends that projects apply the following guiding principles:

- **Partnerships:** The people most affected by management decisions are involved throughout and shape key decisions. This ensures that environmental objectives are well integrated with those for economic stability and other social and cultural goals. It also provides that the people who depend upon the natural resources within the watersheds are well informed of, and participate in, planning and implementation activities.

- **Geographic Focus:** Activities are directed within specific geographic areas, typically areas that drain to surface water bodies, or that recharge or overlay ground water, or a combination of both.

- **Sound Management Techniques based on Strong Science and Data:** Collectively, watershed stakeholders employ sound scientific data, tools, and techniques in an iterative decision-making process. This includes:

    - Assessing and characterizing natural resources and the communities that depend upon them;

    - Goal setting and identifying of environmental objectives, based on the condition or vulnerability of resources, and the needs of the aquatic ecosystem and the people within the community;

    - Identifying priority problems;

    - Developing specific management options and action plans;

    - Implementing plans; and

    - Evaluating effectiveness and revising plans, as needed.

All stakeholders and involved parties provide input on the roles, priorities, and responsibilities. Collective actions are based upon shared information and a common understanding. The Office of Water notes that the iterative nature of the Watershed Protection Approach encourages partners to set goals and targets and to make maximum progress based on available information, while continuing analysis and verification in areas where information is incomplete. This is of particular importance in Hawaiʻi, where data is lacking in many areas. The Watershed Protection Approach also accommodates concerns about environmental justice and promotes the adoption of pollution prevention techniques.

There are numerous benefits that are derived from utilizing the EPA's Watershed Protection Approach. Active and broad involvement of citizens, agencies, and private interests fosters a sense of community, reduces conflicts, increases individual and group commitment to follow through with action items, and improves the likelihood of sustaining long-term environmental improvements. Other specific benefits include:

- Operating and coordinating programs on a watershed basis makes good sense for environmental, financial, social, and administrative reasons.

- Joint review of environmental studies and assessments (for drinking water protection, pollution control, fish and wildlife habitat protection, and other aquatic resource protection programs) allows managers from all levels of government to understand the cumulative impacts of various human activities and determine the most critical problems within each watershed.

- Shared use of environmental studies and assessments allows public and private managers to allocate limited financial and human resources to set priorities for action and address the most critical needs.

- Establishing and monitoring environmental indicators helps guide activities toward solving high-priority problems and measuring success in real-world improvements, rather than simply fulfilling programmatic requirements.

- The emphasis on broad community involvement provides those people who depend on the aquatic resources for their health, livelihood, or quality of life a meaningful role in the management of resources.

- A cooperative approach can result in cost savings by leveraging and building upon financial resources and the willingness of individuals and concerned parties to take action.

- Improved communication and coordination reduce costly duplication of efforts and conflicting actions.

- Regarding actions that require permits, specific actions taken within a watershed context (for example, establishing of pollutant-trading schemes or wetlands mitigation banks and related streamlined permit review) enhance predictability that future actions will be permitted, and reduces costs for the private sector.

- Through resource leveraging and cost savings, the Watershed Protection Approach can help enhance local and regional economic viability in ways that are environmentally sound and consistent with watershed objectives.

- The Watershed Protection Approach strengthens teamwork between the public and private sectors at the federal, state, tribal, and local levels to achieve the greatest environmental improvements with the available resources.

Implementation through State and Local Watershed Approaches

> *"The [EPA] has both a national interest in and responsibility for supporting watershed approaches. The interest stems from the belief that the diverse sources of aquatic ecosystem impacts will best be brought under control through a combination of cooperative and mandatory measures tailored to the needs in specific watersheds with wholehearted support from watershed stakeholders. EPA's responsibility includes definition and ensured compliance with basic water programs; development of national standards and tools; funding; and national assessment of status and progress."*

– EPA Office of Water, Watershed Protection Approach Framework, 1996[8]

State and local government agencies implement existing water and natural resource protection programs and are well situated to coordinate among other levels of government (e.g., local, regional, and federal). Therefore, the EPA places special emphasis on supporting state and tribal partners in developing and implementing comprehensive watershed approaches. However, this emphasis should not be construed as a lack of support for other parties who may want to be involved in watershed management, especially local stakeholders.

The EPA recognizes that each state or tribe may approach watershed management differently. The EPA supports watershed approaches that are specifically tailored to the needs of the jurisdictions, and therefore, the agency will not prescribe implementation actions. EPA envisions locally driven, watershed-based activities embedded in comprehensive state and tribal watershed approaches all over the United States.

[8] U. S. EPA.. 1996. ***Watershed Approach Framework***. EPA 840-S-96-001, Office of Water (4501T), U.S. EPA, Washington, DC. Available online at: http://www.epa.gov/owow/watershed/framework.html.

The Office of Water provides assistance to public and private water quality managers and staff in the development and implementation of watershed approaches. In 2008 the EPA published the Handbook for Developing Watershed Plans to Restore and Protect our Waters.[9] This handbook provides guidance on how to incorporate the minimum elements of the Clean Water Act to meet water quality standards and protect water resources. The Hawaiʻi Watershed Guidance developed by the CZM Program and DOH complements the EPA guidance and links Federal recommendations to local level actions.

L.4.2 U.S. Army Corps of Engineers (USACE) Permitting Programs

The Water Resources Development Act of 1986 (§729) authorizes the USACE to assess the water resource needs of river basins and watersheds, including needs related to watershed protection and ecosystem protection and restoration. The West Maui Ridge to Reef Initiative is an example of a watershed project undertaken in Hawaiʻi pursuant to this authority.

Upon receipt of a request for assistance and formal assurance of local cooperation by a non-federal sponsoring agency, and subject to the availability of federal funds, an initial watershed assessment is conducted. This reconnaissance phase is 100% federally funded and limited to $100,000 per project. After approval of the watershed assessment, the project enters a watershed study phase which will lead to the development of a watershed plan that recommends tools and strategies for achieving the desired conditions in the watershed. The cost of this phase is shared 75% Federal and 25% non-Federal.

The USACE also has jurisdiction over activities in waters of the United States and administers a regulatory program to protect aquatic resources. Waters of the United States consist of, essentially, all surface waters including all navigable waters and their tributaries, all interstate waters and their tributaries, all wetlands adjacent to these waters, and all impoundments of these waters. The USACE permit review process is intended to prevent adverse impacts to surface water resources and wetland environments, through the evaluation of proposed actions with respect to applicable laws, regulations, and policies.

The USACE derives its regulatory authority over waters of the United States from two Federal laws: Section 10 of the Rivers and Harbors Act of 1899 applies to all navigable waters of the United States and Section 404 of the Clean Water Act applies to all waters, including wetlands that have sufficient nexus to interstate commerce.

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[9] U. S. EPA.. 2008. ***Handbook for Developing Watershed Plans to Restore and Protect our Waters***. EPA 841-B-08-002, Office of Water (4501T), U.S. EPA, Washington, DC. Available online at: http://water.epa.gov/polwaste/nps/upload/2008_04_18_NPS_watershed_handbook_handbook.pdf

L.4.3 USDA Natural Resource Conservation Service

In 1935, the USDA created the Natural Resource Conservation Service (NRCS), a federal-private partnership program with landowners and managers, to conserve soil, water, and other natural resources. The objectives of NRCS's natural resources conservation programs include the reduction of soil erosion, enhancement of water supplies, improvement of water quality, increase of wildlife habitat, and reduction of damages caused by floods and other natural disasters. Enhanced natural resources contribute to agricultural productivity and environmental quality, while supporting continued economic development, recreation, and scenic beauty.

The NRCS has six mission goals:

- High quality, productive soils;
- Clean and abundant water;
- Healthy plant and animal communities;
- Clean air;
- Adequate energy supply; and
- Working farms and ranchlands.

To achieve these goals, NRCS implements three strategies:

- **Cooperative conservation:** seeking and promoting cooperative efforts to achieve conservation goals.
- **Watershed approach:** providing information and assistance to encourage and enable locally led, watershed-scale conservation.
- **Market-based approach:** facilitating the growth of market-based opportunities that encourage the private sector to invest in conservation on private lands.

NRCS conservation activities include farmland protection, upstream flood prevention, emergency watershed protection, urban conservation, and local community projects designed to improve social, economic, and environmental conditions. Soil surveys, conservation needs assessments, and National Resources Inventory assessments provide the basis for resource conservation planning activities and an accurate evaluation of the condition of private lands. Local NRCS offices provide technical and financial conservation assistance to farmers and ranchers to develop conservation plans and to advise on design, layout, construction, management, operation, maintenance, and evaluation of the recommended, voluntary conservation practices.

The NRCS also provides conservation assistance through a nationwide network of conservation districts. The agency implements its “watershed approach strategy” through relationships with conservation districts and with local farmers and landowners.

L.4.4 The West Maui Ridge to Reef Initiative

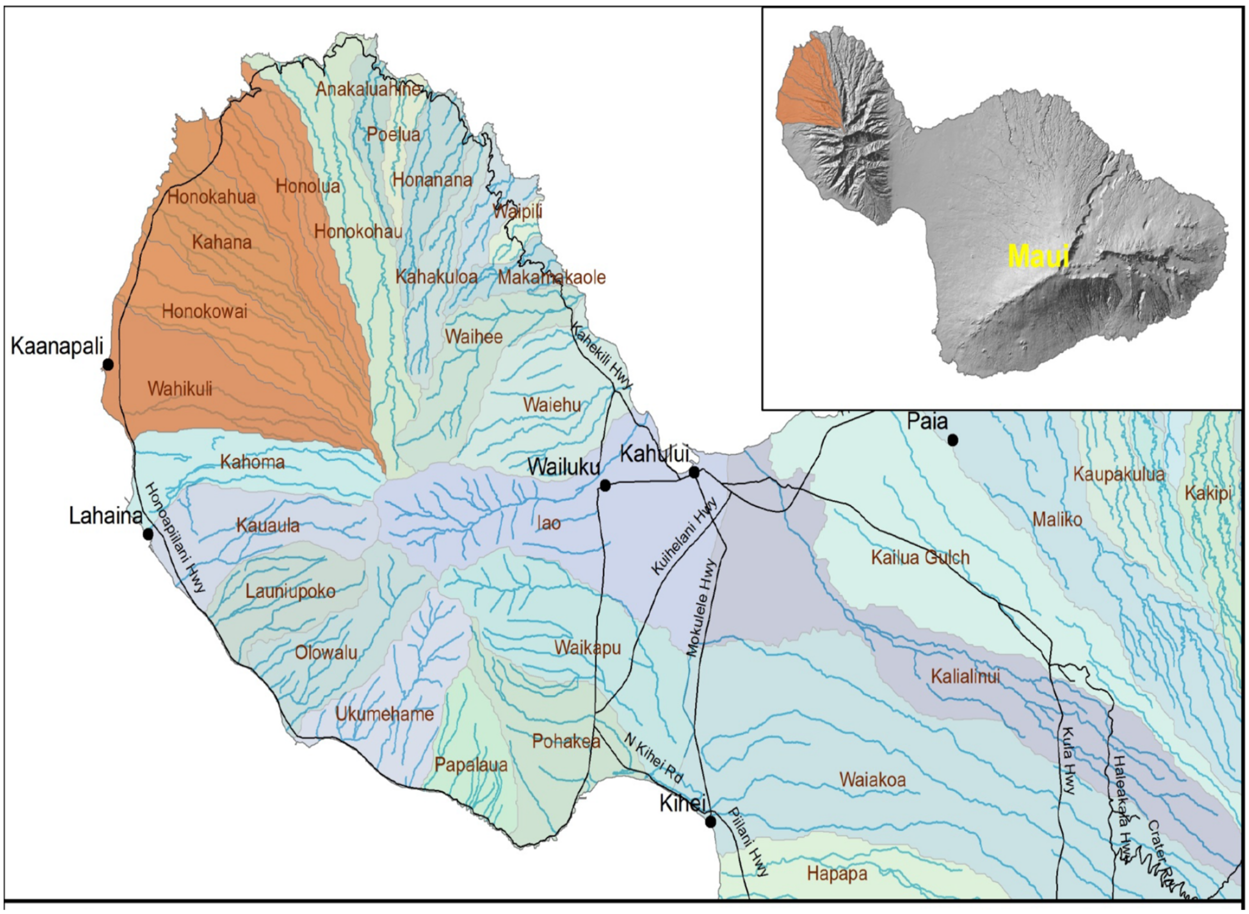
In 2011, the U.S. Coral Reef Task Force identified the Wahikuli and Honokōwai watersheds as priority management areas to protect the coral reef ecosystem along the West Maui coast. A Watershed Management Plan funded by the National Oceanic and Atmospheric Administration (NOAA) for these watersheds, which qualified under the EPA’s Clean Water Act (CWA) §319 funds were previously developed. The priority area was expanded to also include the watersheds of Kahana, Honokahua, and Honolua to the north (**Figure L-7 Watershed covered by the West Maui Ridge to Reef Initiative**).[10] The goal of the initiative is to “restore and enhance the health and resiliency of West Maui coral reefs and nearshore waters through the reduction of land-based pollution threats from the summit of Puʻu Kukui to the outer reef.”

Federal partners include EPA, USACE, NOAA, USGS, USFW, and NRCS. State partners include DAR, DOFAW, CWRM, and DOH. Non-profits and community-based organizations are also contributing to the effort. The planning process will initiate a watershed planning process focusing on the Kahana, Honokahua, and Honolua watersheds in the short-term and complete the USACE’s Water Resources Development Act of 1986 §729 watershed assessment process for all five watersheds over the longer-term. It is hoped that the short-term watershed planning process will also qualify the northern three watersheds for additional EPA’s CWA §319 funds for implementation.

[10] West Maui Ridge to Reef Initiative. Date accessed 4/1/13. Available online at: http://www.westmauir2r.com/

The steps in the planning process include identify problems and opportunities, inventory and forecast resources, formulate measures and strategies, evaluate alternative strategies, compare alternative strategies, and identify a recommended strategy. Throughout the three-year planning process, implementation of measures previously identified through the watershed planning process for the Wahikuli and Honokōwai watersheds will proceed and inform the larger planning effort. Identified data gaps will also be filled through additional studies and data collection to the extent possible.

Figure L-7 Watershed covered by the West Maui Ridge to Reef Initiative



L.5 Gaps in Watershed Protection

Although current watershed management efforts favor a comprehensive approach, watershed management in Hawaiʻi tends to have either a water quality or water quantity improvement focus. CWRM, BWS, the Watershed Partnerships, and DOFAW's *Healthy Forest, Healthy People* Plan are focused primarily on water quantity improvements, while DOH, EPA, and the CZM Program are responsible for coordinating watershed protection efforts to improve water quality and protect coastal resources. NRCS and the Soil and Water Conservation Districts address both water quality and quantity, and entities such as OCCL, LUC, and USACE address water as part of a system, but do not have water resource protection as a main focus.

CWRM supports DOFAW's role as the lead entity coordinating watershed management activities to improve ground water resources. As briefly described earlier, CWRM regularly collaborates with researchers to study precipitation changes, ground water recharge rates, and water resource impacts from climate change. CWRM efforts are focused on the following two fundamental issues to support the Division's goals:

1. Determination of the magnitude and timing of the change to water resources that result from watershed protection actions; and

2. Identification of priority areas to focus watershed management in response to current and projected increased competition for water resources.

L.5.1 Understanding the Magnitude and Timing of Changes to Water Resources from Watershed Management Actions

In order to understand the benefit of watershed management, we must measure the magnitude and timing of changes that result from watershed management actions. The basic premise of the watershed management referred to HRS §183-31 and *The Rain Follows the Forest* Plan is that protecting native flora and fauna from nonnative species will result in increased drinking water supplies. However, the change in ground water supplies as a result of these native forest protections is not well understood. This makes it difficult to justify funding for watershed management, as there is no data that demonstrates this link to drinking water supplies or the magnitude of the benefit.

Work by Giambellucca[11] and Kagawa[12] have shown that stands of native forest on the Island of Hawai‘i use water more efficiently than those dominated by studied non-native species. When the USGS recently estimated the recharge to the island's ground water, they incorporated this data into their analysis and observed a 10 to 12 percent increase in recharge.[13] However, recent work by Rosa on Moloka‘i found that recharge decreased along with runoff in a watershed reforested by native species.[14] Brauman also found evidence to support this in her analysis of land cover effects on ground water recharge in the tropics. She suggests that in a precipitation scenario consistent with climate change predictions, differences in vegetation will have little effect on water quantity, instead impacting changes in water quality and runoff.[15] The differing information from these studies has made it difficult for CWRM to understand the impact of watershed management efforts on water resources and to connect them to resource sustainability estimates. More research is needed to synthesize information on individual hydrologic components in a variety of vegetative regimes to provide a better understanding of how water resources are affected by watershed management actions.

L.5.2 Identification of Priority Areas for Watershed Management

The approach pioneered by the Honolulu BWS watershed prioritization program should be applied throughout the State. This will allow watershed managers and funding partners to better prioritize and focus actions, allowing for management to respond to areas where water resources may be under threat from natural or anthropogenic pressures.

CWRM currently uses the Hawai‘i Water Plan process, hydrologic studies, and stakeholder input to identify areas of the State where there are or will be increased competition for water resources. CWRM should delineate these areas in a format that can easily integrate with DoFAW's watershed priority areas, thereby providing additional data to prioritize watershed management activities.

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[11] Giambelluca, T.W., Delay, J.K., Asner, G.P., Martin, R.E., Nullet, M.A., Huang, M., Mudd, R.G., Takashi, M. 2008. *Stand Structural Controls on Evapotranspiration IN Native and Invaded Tropical Montane Cloud Forest in Hawai‘i*. American Geophysical Union, Fall Meeting 2008, abstract #B43A-0422.

[12] Kagawa, A., Sack, L, Duarte, K, and James, Shelley, 2009*, Hawai‘ian native forest conserves water relative to timber plantation; species and stand traits influence water use*: Ecological Applications, v. 19, no. 6, p. 1429–1443.

[13] Engott, J.A., 2011, *A water-budget model and assessment of groundwater recharge for the Island of Hawai‘i*: U.S. Geological Survey Scientific Investigations Report 2011 5078, 53 p.

[14] Rosa S.N. 2013. *Evaluating Land-Cover Change Effects on Runoff and Recharge in Kawela, Molokai, Hawai‘i*. M.S. Thesis, University of Hawai‘i at Mānoa, 102p

[15] Brauman, K.A., D.L. Freyber, G.C. Daily. 2011. *Land Cover Effects on Groundwater Recharge in the Tropics: Ecohydrologic Mechanisms*. DOI:10.1002/eco.236

To complement prioritization efforts that focus on the recharge potential of upper forested lands, impacts from makai land uses and activities need to be taken into account. High water use activities may elevate the importance of a watershed area because we rely heavily on it for potable water. Additionally, threats to water sources from potential contamination may also influence a watershed's prioritization.

Only a few tools currently exist to account for competition for water and threats to recharge and water quality, particularly as they relate to makai areas. The first are the County Water Use and Development Plans (WUDPs) that set forth the allocation of water to land use in each county. The WUDPs inventory existing water uses as well as future land uses, and related water needs for each county. Strategies for meeting water demands over a minimum twenty-year planning horizon must consider alternative water sources, including conservation, in addition to ground and surface water resources, and may also incorporate land use controls, such as downzoning. The statutory requirement to utilize the ground and surface water hydrologic units designated by CWRM for the presentation of data and analysis allows CWRM to identify the hydrologic units that may experience increased competition for water in the future and focus management efforts accordingly. Please refer to the WRPP **Appendix H Existing and Future Demands** for a more detailed discussion of the WUDPs.

The second tool available to refine the priority area maps are the ground water Capture Zone Delineation (CZD) maps[16] that were developed by the DOH for their source water assessment program. These maps were developed to identify areas that would directly impact drinking water sources should any type of ground water contamination occur in that area. The zones created by this analysis can be interpreted as areas where recharge directly feeds a particular drinking water source. However, as CZD maps were created to protect individual wells from contamination and not to enhance ground water recharge to the larger aquifer, some of the capture zones identified through the program may be too small to address watershed management concerns for the benefit of water supply. To increase the usefulness of this product for *The Rain Follows the Forest Plan*, GIS analysis could be refined to extend ground water capture zones into the mauka forested areas where much of the recharge to ground water aquifers occur.

A third tool available to refine the priority area maps are the USGS ground water recharge estimations for the Hawaiian Islands. These studies provide a primary input for CWRM to determine the sustainability of Hawai'i's ground water resources. They would also allow for the identification of high recharge areas that may be negatively impacted by changes in vegetation and/or land use. Unfortunately, some of the limitations in using this data results from the lack of detailed vegetation and land cover maps. More data on plant water usage in various ecosystems is also needed to quantify the changes in recharge rates. CWRM should engage the research community to identify the studies and data needed to overcome these limitations.

[16] Hawaii DOH Source Water Protection Program: http://health.hawaii.gov/sdwb/swap/

L.6 Recommendations

The State Water Code states that CWRM, through the WRPP, shall coordinate programs to conserve, augment, and protect the resource and cooperate with other agencies and entities.[17] In the face of a changing climate, CWRM has an important role to play in supporting the watershed management efforts of DOFAW, DOH, and the CZM Program. Therefore, CWRM should directly pursue, or support and cooperate in the implementation of the following recommendations:

- Continue to provide the hydrologic data needed to support DOFAW's watershed management activities and the division's leadership role in watershed management.
- Improve the facilitation of data sharing amongst agencies on hydrologic and biological resources.
- Continue to support the CZM Program and DOH's role to coordinate watershed management activities to protect coastal resources.
- Support efforts to synthesize and summarize current watershed research efforts in the context of eco-hydrologic services.
- Continue to attend and support watershed partnership group meetings.
- Support research on the effects of climate change on water resources in Hawaiʻi and products from the watershed.
- Support research that improves the understanding of how landscape changes in the watershed affect ground and surface water resources, such as paired catchment studies.
- Work with partners and support research to identify and refine priority watershed areas meant to enhance ground and surface water quantity.
- Study existing government and community efforts in watershed management and protection and encourage sharing of information and experiences.
- Encourage stakeholders to support long-term hydrologic monitoring programs to understand changes in watershed hydrology that results from watershed management activities.

[17] HRS §174C-31(d)(4) and §174C-5(12).

APPENDIX M

Water Quality

Water Resource Protection Plan 2019 Update

M Water Quality

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M Water Quality

The State Water Code provides that the Department of Health (DOH) shall have primary jurisdiction and responsibility for administration of the state's water quality control programs[1]. The Hawaiʻi Administrative Rules, Title 11, Chapter 20, Rules Relating to Public Water Systems, identifies the maximum contaminant levels for various chemicals, as well as other parameters for drinking water quality. While CWRM defers to DOH on most water quality related matters, CWRM management principles utilize operational water quality definitions based on chloride concentration as follows:

- **Fresh Water:** Chloride concentrations from 0 to 250 milligrams per liter (mg/L)
- **Brackish Water:** Chloride concentrations from 251 to 16,999 mg/L
- **Seawater:** Chloride concentrations of 17,000 mg/L and higher[2]

M.1 DOH Strategic Plan: The Five Foundations for Healthy Generations

The strategic plan examines DOH's core environmental protection programs and discusses their history, organization, mission, goals, objectives, strategies, and performance measures; the plan also sets forth targets to measure the effectiveness of programs in meeting community needs. Specifically, the plan calls for the State to improve its capability to solve serious environmental problems through risk assessment, streamlining the permitting process, and developing a priority-setting system.

In 2011, the DOH developed its FY 2011-2014 Strategic Plan, "The Five Foundations for Healthy Generations," (http://health.hawaii.gov/opppd/files/2013/04/Five_Foundations.pdf).

[1] See HRS §174C-66.

[2] Please note that CWRM's water quality definitions differ from surface water definitions found in HAR §11-54-1.

M.2 Water Quality Plan

The DOH's responsibilities include the formulation and regular update of a State Water Quality Plan (WQP) for all existing and potential sources of drinking water.[3] The WQP, together with the WRRP, SWPP, AWUDP, and the County WUDPs, provide the overall guidance and direction for managing Hawai'i's precious water resources.

The major objective of the WQP is to protect public health and ecological systems by preserving, protecting, restoring, and enhancing the quality of ground and surface waters throughout the State of Hawaii. The following sections provide information on the purpose and function of the WQP, the status of efforts to update the WQP, and descriptions of current DOH programs that contribute to the plan update.

M.2.1 Statutory Requirements for the Water Quality Plan

HRS §174C-31(a)(4) requires the DOH to develop a WQP for the State and identifies the plan as a component of the Hawai'i Water Plan (HWP). The WQP should encompass all existing and potential sources of drinking water, with the requirements for the plan governed by HRS §340E and HRS §342.The Hawai'i Water Code, in HRS §174C-68(a) also requires the DOH to include in the WQP, criteria for CWRM to use in the designation of ground water and surface water management areas. HRS §174C-68(b) stipulates that the WQP will be reviewed and revised periodically by the DOH as needed. In formulating or revising the WQP, the DOH is also required to consult with and carefully evaluate the recommendations of concerned federal, State, and local agencies, especially county water supply agencies.

M.2.2 Integration of the Water Quality Plan with Other Hawai'i Water Plan Components

Although different State and county agencies prepare the various components of the HWP, CWRM oversees their preparation to ensure that they will be coordinated and cohesive. The WQP and the WRPP are the two plans that outline the regulations, standards, and resource management and protection policies that define the availability of ground and surface water resources, the quality that must be maintained in those resources, and the quantity that may be sustainably withdrawn. Since the WQP and WRPP are critical to determining both water usage and strategies for developing water resources, they provide critical input to the remaining components of the HWP. Therefore, the SWPP, AWUDP, and County WUDPs must be consistent with the most recently adopted WQP and WRPP until subsequent updates are developed. However, new statutory, rule, and policy amendments to water quality regulations may supersede information contained in the current versions of the WQP and WRPP.

[3] HRS §174C-68 and HAR §13-170-50.

M.2.3 Water Quality Plan Recommended Plan Updates

The Statewide Framework for Updating the Hawaiʻi Water Plan (Framework) was adopted by CWRM in 2000 to assist State and county agencies as they update various HWP components. The Framework recommended that the DOH include the following elements in the WQP:

Determination of whether or not a drinking water source might be susceptible to contamination.

The first step to making such a determination is completion of the Hawaiʻi Source Water Assessment Program (SWAP), which is locating drinking water sources, identifying potentially contaminating activities, determining the susceptibility of drinking water sources to contamination, and assessing new drinking water sources as they are developed. Once the Hawaiʻi SWAP has been developed, comprehensive prevention and protection programs may be developed for drinking water sources. The Hawaiʻi SWAP is an active DOH program is further described in **Section M.3.2**.

Development of Effective Linkages Among Inter-Agency Programs

The DOH has several inter- and intra-agency water quality programs (such as the SWAP, Source Water Protection Strategy, UIC, and wastewater programs). Such collaborative efforts should be fostered to identify program linkages and integrate related programs, resulting in comprehensive assessments of problems, identification of available mitigation measures, and development of improved management strategies. The WQP should identify such program linkages and establish procedures and program measures for coordinating and streamlining agency activities and permitting requirements of similar programs. The major goals and objectives of this effort should include, but not be limited to:

- *Maximizing efficient use of agency time, staff and program resources;*
- *Identification of overlapping and/or duplicative program/statutory responsibilities;*
- *Establishment of more effective inter-agency coordination and communication;*
- *Consolidation (wherever possible) of agency review and permitting requirements; and*
- *Resolving conflicting permit approvals or other agency requirements (if any), including procedural disagreements between agencies.*

M.3 Department of Health Programs Related to the Water Quality Plan

The DOH administers several programs that provide input and guidance to the WQP. The Clean Water Branch, the Safe Drinking Water Branch, and the Wastewater Branch are the main organizational units within the DOH that administer water quality protection programs. The Solid Hazardous Waste Branch, Hazard Evaluation and Emergency Response Office, Environmental Planning Office and Compliance Assistance Office also address water quality issues in their respective offices and for their respective responsibilities.

The Clean Water Branch protects the public health and restores inland and coastal waters for marine life and wildlife through implementation of the Surface Water Quality Management Program, which includes administration of permitting, enforcement, Water Quality Standards, beach monitoring, TMDLs, polluted runoff control projects, and public education. The Safe Drinking Water Branch is responsible for safeguarding public health by protecting Hawai‘i’s drinking water sources (surface water and ground water) from contamination and assures that owners and operators of public water systems provide safe drinking water to the community. The Wastewater Branch administers the statewide engineering and financial functions relating to water pollution control, municipal and private wastewater treatment works, wastewater recycling, individual wastewater systems, and the water pollution control revolving fund.

The DOH program areas that will contribute to future updates to the WQP are described in the subsequent sections of this chapter. The summaries of program goals, status, and recommendations for future actions provided herein reflect information provided by the DOH.

DOH Programs Contributing to the Water Quality Plan:

- Surface Water Quality Management Program
- Source Water Assessment and Protection Program
- Comprehensive State Groundwater Protection Program Strategy/Plan
- Underground Injection Control Program
- Groundwater Contamination Maps
- Wastewater Recycling Program
- Underground Storage Tank Program
- Emergency Response
- Land Use Review
- Compliance with Environmental Laws and Regulations

M.3.1 Surface Water Quality Management Program

The Surface Water Quality Management Program is implemented by the DOH Clean Water Branch. This program sets the State's Water Quality Standards, monitors and assesses surface water quality for recreational and environmental health, plans for long-range surface water quality improvement (TMDL Process and Polluted Runoff Control Program), controls discharges that may impact surface waters through implementation of the National Pollutant Discharge Elimination System (NPDES) program, and enforces applicable water quality regulations. Most of this work is federally-funded and must meet federal Clean Water Act requirements. Many program efforts must also obtain U.S. Environmental Protection Agency (EPA) approval and employ a watershed-based approach to water quality management.

M.3.1.1 Water Quality Standards (WQS)

Federal law requires the State to complete a WQS review process and make necessary revisions every three (3) years.

Program Goals:
The goal of the WQS Program is to develop scientifically based WQS that (a) meet federal requirements, (b) specify the uses to be protected in State waters, and (c) provide appropriate criteria and methods for evaluating the attainment of these protected uses.

Recommended Actions:
To achieve the program goals, the DOH is implementing the following actions:

- Adopt formal guidance for using WQS to assess water quality conditions and make regulatory decisions.

- Clarify the overall framework of waterbody types, waterbody classes, protected uses, and evaluative criteria to improve the linkage between specific uses and specific criteria and to improve the basis for specific, use-based assessment methodologies.
- Develop/adopt biological criteria for recreational and environmental uses in streams.
- Develop/adopt biotoxicity and sediment toxicity criteria for recreational and environmental uses in all waterbody types.

Current Program Status:
The last WQS rule amendments were adopted on December 6, 2013.

M.3.1.2 Beach Monitoring Program

The Beach Monitoring Program ensures that Hawai‘i’s coastal waters are safe and healthy for people, plants, and animals. Under the DOH Beach Monitoring Program, beaches are divided into three tiers. Tier 1 beaches are Hawai‘i’s most important and threatened beaches and therefore are monitored three times a week. Tier 1 represents our core beaches and will be monitored continually until they are re-classified as Tier 2 beach.

Tier 2 beaches are beaches represented by moderate use and are sampled once or twice a week for six month periods. After six months a new set of Tier 2 beaches are monitored for another six months. If a Tier 2 beach shows periodic elevated counts for no obvious reason, it will be re-sampled another six months or be elevated to a Tier 1 status.

If a beach shows that it is not impaired or threatened and has consistently low indicator bacteria counts, then it will be changed to a Tier 3 status. Tier 3 beaches are, for the most part, hard to access, with no houses nearby, and very little anthropogenic influences. Tier 3 beaches are sampled at least once during a six month period.

Program Goals:
The goal of the Beach Monitoring Program is to maintain coastal waters for the health and safety of people, plants, and animals.

Current Program Status:
In 2012, 183 beaches were monitored compared to 302 beaches in 2008. Statewide reduction-in-force action in 2010 reduced the Monitoring and Analysis Section of the Clean Water Branch by 40%. Monitoring 183 beaches per year is the upper limit under the current workload and manpower resources available to the Monitoring and Analysis Section.

M.3.1.3 Total Maximum Daily Load (TMDL)

Federal law requires the State to, every two years, identify and prepare a list of waters that do not or are not expected to meet WQS after applying existing required controls (e.g., minimum sewage treatment technology). For each listed waterbody/pollutant combination, the State must (a) establish the waterbody's loading capacity (the maximum loading rate at which WQS can still be met, also known as Total Maximum Daily Loads), and (b) allocate this loading capacity among contributing point and nonpoint sources. After these TMDLs are approved by the EPA, the State implements pollutant load reductions through permits and by funding watershed based plans that are designed to reduce nonpoint source pollution.

Program Goals:
The goals of the TMDL Program are as follows:

- Quantitatively assess watershed-scale water quality problems, contributing sources, and pollutant load reductions.
- Provide an analytical basis for planning and implementing pollution controls.
- Provide assistance with identifying restoration projects that will improve water quality and protect public and environmental health.

Recommended Actions:
To achieve the program goals, the DOH is implementing the following actions:

- Incorporate CWB program elements (beach and surface water monitoring, polluted runoff control, NPDES permits, etc.) into the TMDL process to develop effective, implementable TMDLs.
- Collaborate with the counties and other state agencies to prioritize watersheds for restoration efforts and support stakeholder stewardship of watershed resources through coordinated efforts.

Current Program Status:
The points listed below summarize the status of the TMDL Program:

- 2008-2012 Integrated Report approved (includes the CWA §303(d) List of Impaired Waters)
- Existing TMDLs are being implemented through NPDES permits and watershed based plans, while planning for future TMDLs is ongoing.

M.3.1.4 Polluted Runoff Control Program

The Polluted Runoff Control Program is implemented by the DOH Clean Water Branch to prevent environmental degradation due to nonpoint source pollution. Unlike pollution from permitted facilities and sites, nonpoint source pollution comes from many diffuse sources. Nonpoint source pollution develops when rainfall moving over and through the ground picks up natural and manmade pollutants that are eventually deposited in streams, wetlands, coastal waters, and underground sources of drinking water. Examples of such pollutants are:

- Excess fertilizers and pesticides from fields and gardens;
- Oil, grease, and toxic chemicals from urban and industrial areas;
- Sediment from construction sites, crop and forest lands, and eroding stream banks; and
- Bacteria and nutrients from livestock, pet wastes, and faulty septic systems and cesspools.

Program Goals:
The Polluted Runoff Control Program's goal is as follows:

- To protect and improve the quality of Hawai‘i's water resources by preventing and reducing nonpoint source pollution.

Recommended Actions:
To achieve the program goal and to implement an integrated watershed approach, the State must increase the amount of resources devoted to watershed planning and implementing polluted runoff control projects and promote collaborative agency efforts to more effectively utilize the limited resources that are currently devoted to controlling polluted runoff. The State's Coastal Nonpoint Pollution Control Program (CNPCP) Management Plan identifies management measures that must be implemented by relevant government agencies and the public to control polluted runoff.

Current Program Status:
The Polluted Runoff Control Program administers grant money it receives from the EPA through Section 319(h) of the Federal Clean Water Act. The program solicits projects that implement best management practices arising from watershed plans that meet the EPA's nine elements of effective watershed management plans. Effective watershed management plans identify what and where polluted runoff issues are in the watershed, how the issues can be addressed and by whom, and how to evaluate the implementation of best management practices to determine success.

Specific activities considered for funding may include: implementation of measures to minimize excessive nutrients, sediment and other pollutants delivered to surface and/or coastal waters, restoration of native vegetation in critical watershed areas such as stream banks/riparian corridors, ungulate control and invasive species removal, support for watershed coordinators, water quality monitoring and evaluation efforts, educational efforts, and refinement of watershed plans to include nonpoint source pollution elements. The program focuses its efforts in specific priority watersheds where effective watershed-based plans exist and the branch can leverage its resources for a comprehensive approach to addressing water pollution.

These activities are consistent with Hawai‘i's Nonpoint Source Management Plan (2015 to 2020), which is a plan for implementation of activities to be undertaken by State and County agencies, federal agencies, and Hawaii's citizens to reduce nonpoint source pollution in the state.

M.3.1.5 NPDES Program

The NPDES Program is administered by the DOH Clean Water Branch to prevent environmental degradation due to point source pollution. Pollution from traditional point sources such as industrial sewage treatment plants, refineries, electricity generating stations, as well as stormwater discharges from municipalities, military installations, and other industrial complexes, are strictly regulated through NPDES permits and enforcement. Traditional NPDES permits regulate the discharge of pollutants such as temperature, solids, toxics, nutrients, pesticides, and bacteria/pathogens.

M.3.2 Source Water Assessment and Protection Program

The 1996 reauthorization of the Federal Safe Drinking Water Act included an amendment requiring states to develop a program to assess sources of drinking water, and encouraging states to establish protection programs. The drinking water source assessment is the first step in the development of a comprehensive drinking water source protection program.

Program Goals:
The goals of the SWAP Program are as follows:

- Assess the susceptibility of public drinking water sources to contamination;
- Protect public drinking water sources from contamination; and
- Use source water assessment information to meet drinking water requirements.

Recommended Actions:
To achieve the program goals, the DOH is implementing the following actions:

- Assess all existing drinking water sources;
- Assess new and proposed drinking water sources;
- Periodically review and update these assessments;
- Create and implement state and local source water protection workgroups;
- Work with public water systems in developing and implementing protection strategies and plans for protecting drinking water sources;
- Work with government agencies and stakeholder organizations to integrate protection strategies and plans;
- Work with county water and planning departments to integrate protection strategies and plans;
- Develop and implement the Wellhead Protection Financial Assistance Program;
- Work with public water systems in using assessment information as a starting point for meeting various drinking water requirements; and
- Determine the susceptibility of drinking water sources to PCAs located within source water assessment and protection capture zones (SWAP-CZ).

Current Program Status:
The points listed below summarize the status of the SWAP Program:

- Assessments have been conducted on over 475 existing drinking water sources throughout the state. In 2006, DOH completed the *Hawaiʻi Source Water Assessment Program Report, Volume I, Approach Used for the Hawaiʻi Source Water Assessments*.[4] Assessments will continue for all new and proposed drinking water sources.

- The current EPA-approved Wellhead Protection Financial Assistance Program has resulted in the funding of protection projects by various public water systems (including the County Water Departments for Hawaiʻi, Kauai, and Maui, plus several privately owned public water systems). The Wellhead Protection Financial Assistance Program is currently being updated for review and approval by EPA to allow utilization of 15% DWSRF WHP funds for protection projects beginning in Federal Fiscal Year 2016.

- DOH is developing the framework for a source water protection monitoring program based on PCAs located within the SWAP Capture Zone. This includes the development and acquisition of laboratory capabilities and resources.

- DOH is working with county water departments and other agencies to create workgroups.

- DOH Safe Drinking Water Branch will utilize source water assessment data/information (as applicable) in meeting drinking water requirements.

M.3.3 Comprehensive State Groundwater Protection Program Strategy/Plan

The overall goal of the Comprehensive State Groundwater Protection Program Strategy/Plan is to protect human health and sensitive ecosystems through the protection and enhancement of ground water quality throughout the State of Hawaiʻi. The development and implementation of the program has the following general goals:

- Provide the State with greater flexibility in directing its ground water protection activities relative to various sources of contamination across the federal, State, and local programs, and geographic areas, to achieve comprehensive resource-based ground water protection.

[4] Whittier, R.B., K. Rotzoll, S. Dhal, A.I. El-Kadi, C. Ray, G. Chen, and D. Chang. 2006. *Hawaii Source Water Assessment Program Report, Volume I, Approach Used For the Hawaii Source Water Assessments*. Hawaii Department of Health, Honolulu, Hawaii.

- Increase coordination between related programs to improve effectiveness and reduce duplicate efforts that cause ineffective expenditures of resources by the various ground water protection programs.

- Demonstrate the State's proactive approach to ground water protection, thus justifying increased funding for program development and additional flexibility from the EPA and other federal agencies.

- Clearly delineate the appropriate roles of federal, State, and local governments as partners in ground water protection and define processes for coordinating efforts between programs.

- Establish a mechanism for better recognition and understanding of the relationships between ground water quantity and ground water quality concerns.

- Improve public understanding of ground water protection concerns within the State and provide a broader context for public participation.

- Build a consensus across all levels of government regarding the need for comprehensive ground water protection and the basic structure of comprehensive protection programs.

Recommended Actions:
The DOH is working to complete the development and implementation of a Comprehensive State Groundwater Protection Program Strategy/Plan. The CSGPPS/P has six strategic activities to foster more efficient and effective protection of ground water. The strategic activities are:

1. Establish specific ground water protection goals to guide the relevant federal, State, and local programs operating within the State;

2. Establish priorities, based on a characterization of the resource, identification of sources of contamination, and delineation of the program's needs, to guide relevant federal, State, and local programs and activities;

3. Define authorities, roles, responsibilities, and resources, and coordinate mechanisms between relevant federal, State, and local programs for addressing identified ground water protection priorities;

4. Define the necessary efforts consistent with the established priorities, detail the responsibilities of each program, and identify the coordination mechanisms between programs needed to implement these efforts;

5. Evaluate the effectiveness of the ground water protection efforts by coordinating information collection to measure progress toward the specific GWP goals, then re-evaluate priorities and methods and revise as needed to increase the effectiveness of all ground water related programs; and

6. Improve public education and participation in all aspects of ground water protection.

Once the Comprehensive State Groundwater Protection Program Strategy/Plan has been developed, it should be implemented as part of the SDWB Groundwater Protection Program.

Current Program Status:
An initial draft of the Comprehensive State Groundwater Protection Program Strategy/Plan was submitted to EPA, Region 9, on December 6, 2000 (the document is dated November 30, 2000). The strategy/plan represents the guiding document for the future of ground water protection in Hawaiʻi. Additional draft documents relating to resource assessment and ground water quality monitoring were also prepared.

The Safe Drinking Water Branch, under the Groundwater Protection Program, is currently reviewing and updating the Comprehensive State Groundwater Protection Program Strategy/Plan.

M.3.4 Underground Injection Control (UIC) Program

The Underground Injection Control (UIC) Program was established to monitor and control injection well activity, in order to prevent ground water pollution. Ground water pollution can directly affect the quality of drinking water sources, as well as indirectly affect the quality of water in streams and near-shore waters.

Injection wells are used to dispose of wastewater from various activities (e.g., sewage treatment, industrial processes, aquaculture, and surface runoff). Each of these activities, and more, has the potential to cause ground water pollution. Additionally, injection well activity is specifically targeted for monitoring and control because injection wells are direct, open conduits into the subsurface and are often in contact with ground water.

Injection well activities are monitored or controlled through UIC permits issued by the DOH. The operator of an injection well must obtain the UIC permit before the injection well can be put into service. The UIC permit stipulates discharge standards, operating conditions, and water quality testing and reporting requirements to prevent or minimize ground water pollution. Violators of UIC permits, or of the regulations for injection wells under Hawaiʻi Administrative Rules, Title 11, Chapter 23, can be fined and ordered to perform corrective action.

Notwithstanding the risks to Hawai'i's ground water resources, injection wells provide an important alternative method for wastewater disposal for facilities that cannot access the municipal sewer system or cannot discharge through an outfall.

Program Goals:
The function of the UIC Program is to protect the quality of Hawai'i's sources of drinking water from chemical, physical, radiological, and biological contamination from injection well activity through the specific actions listed below:

- Permit processing and project reviews for new permits and renewals, modifications, and abandonment of injection wells;
- Evaluating geologic logs of soil and rock, injectivity tests, geologic maps, and ground water quality profiles to determine the viability of subsurface injection;
- Maintaining an inventory and database of all injection well files;
- Organizing and conducting site inspections to verify the locations and performance of injection wells, and to verify compliance with all testing or well-closure plans;
- Conducting site investigations to identify problems, such as unpermitted facilities and uncorrected deficiencies;
- Enforcing underground injection control rules and permit conditions; and
- Serving the public by providing information and technical assistance.

Recommended Actions:
To achieve the program goals, the DOH is implementing the following actions:

- Implement and sustain an effective and efficient regulatory permitting program. Seek compliance first through voluntary and self-responsible motivations, but be ready to acquire compliance through enforcement measures.
- Constantly seek methods, techniques, and approaches that advance effectiveness and efficiency in permitting, as well as in monitoring and enforcement.
- Through our permits, processing, decision-making, and handling/servicing of applicants, agencies, consultants, and the general public, constantly aim to build a good, fair, trustworthy, and honorable reputation.

Current Program Status:
The UIC Program currently manages the UIC line, or boundary, which identifies areas where injection wells are permitted (see http://health.hawaii.gov/sdwb/uicprogram/ for the online maps). The program also enforces HAR, Title 11, Chapter 23, Underground Injection Control (which differs from the UIC Program of the EPA), and performs the other activities identified above.

The UIC program has significantly reduced its backlog due to certain interim processing and reviewing measures being implemented and through the reprioritization of work assignments. Additionally, the UIC program has begun the use of an online permit application system known as the e-permitting Portal to facilitate the submission, review, and data management for most UIC applications. The e-permitting Portal reduces the program’s application reviewing effort by making sure that applications are complete and accurate before they are submitted. Data from E-permitting applications can be directly placed into the program’s database without re-entry. These e-permitting Portal benefits should produce a positive overall effect to UIC program goals. The UIC System Implementation project is underway to develop and implement an online database for the program.

M.3.5 Groundwater Contamination Maps

Hawai‘i’s Groundwater Contamination Maps are an integral part of Hawai‘i’s Groundwater Protection Program (GWPP). The GWPP’s goal is to protect human health and sensitive ecosystems by fostering protection of ground water resources and emphasizing water quality assessment, pollution prevention and protection measures.

The Groundwater Contamination Maps illustrate the DOH’s assessment of ground water quality and trends in ground water contamination. The Contamination Maps identify the location and amount of organic and other contaminants detected and confirmed present in public drinking water wells and select non-potable wells between January 1 and December 31 of a calendar year. The detected levels are currently below Federal and State drinking water standards established to protect public health. Appropriate public health protection measures are implemented before contaminant levels reach these standards.

The Contamination Maps show that ground water contamination is largely the result of human activities, and that once a ground water source becomes contaminated, it remains so for many years. In addition, wells adjacent to contaminated wells have been found to contain the chemicals known to be present in nearby contaminated wells.

Another purpose of the Contamination Maps is to educate the public about ground water contamination and the importance of protecting Hawaii’s ground water resources.

Program Goals:

DOH prepared the Groundwater Contamination Maps in pursuit of the following goals:

- To provide maps identifying locations where certain ground water contaminants have been detected and confirmed; and
- To provide information on the basic health effects related to the contaminants detected in ground water wells.

Recommended Actions:

So that the maps are as useful as possible, and to ensure that those concerned with the issue of ground water contamination have access to the maps, the DOH recommends implementation of the following actions:

- Continue to monitor ground water quality and ground water contamination trends.
- Periodically update the Groundwater Contamination Maps for the State of Hawaiʻi. Ideally, at a minimum, the maps and basic health-effects information should be updated annually.
- Make maps available to water systems, government agencies, landowners, stakeholders, the public and community, and others.

Current Program Status:

Since August 1989, ten editions of the Groundwater Contamination Maps have been published. The most current set of maps was published July 28, 2006, which represents data collected and updated between January and December 2005.

The DOH Safe Drinking Water Branch developed the Groundwater Contamination Viewer (Viewer), which is accessible through the EHA Portal. In the future, users will be required to login to access some of the applications on the EHA Portal. The login will not only determine which systems are accessible to the user, but will eventually also determine what capabilities are available to the user within a system. For example, a Honolulu Board of Water Supply sampler or scheduler may ultimately be able to zoom in to see their system's wells, but not the Kauaʻi Department of Water's wells. For the SDWIS Viewer, approved users will see their own system's information and not others.

Users will be able to decide which cumulative years (e.g., 2013 and prior years; 2010 and prior years) to view on the map and in the data table. Positive results are considered confirmed when verified by a follow-up test or by comparison with historical data. Historical data is included until new information confirms that concentrations have decreased to non-detectable levels. The user may also export the data. To protect the locations of the wells, the map zoom extent has been limited to 1-inch approximately equal to 5 miles. Well coordinate data is not accessible from this system.

M.3.6 Wastewater Recycling Program

The DOH's Wastewater Recycling Program is managed and implemented by the Wastewater Branch. The Wastewater Branch administers the statewide engineering and financial functions relating to water pollution control, the municipal and private wastewater treatment works program, the individual wastewater systems program, and the water pollution control revolving fund program.

Program Goals:
The Wastewater Recycling Program seeks to promote reuse, specifically to increase wastewater reuse to about 30 million gallons per day by 2015 (which is approximately 20 percent of wastewater produced).

Recommended Actions:
To achieve the program goals, the DOH plans to implement the following actions:

- Continue to encourage the use of recycled water by working with counties and private landowners to develop water reuse plans that allow for the most efficient use of recycled water, where available.

- Continue to implement the Wastewater Branch's program for short-duration recycled water use projects, including dust control for construction sites and temporary irrigation.

Current Status:
Since 1993, recycled water usage has been within the range of 19.6 MGD to 23.5 MGD. There have not been any significant increases to recycled water usage since the last report in 2007. There are hopes that with the recent improvement in the economy, there will be more wastewater reuse projects that will be constructed which will result in an increase in the usage of recycled water. More information on recycled water programs and application in Hawaii can be found in **Appendix J Resource Conservation and Augmentation**.

M.3.7 Solid and Hazardous Waste Branch

The Solid and Hazardous Waste Branch oversees management of all solid waste generated within the state through the promotion of pollution prevention and waste minimization. They work to prevent releases, or threat of releases, of petroleum, hazardous substances, pollutants or contaminants into the environment through enforcement of environmental laws and regulations.

M.3.8 Hazard Evaluation and Emergency Response Office

The HEER Office prevents, plans for, responds to, and enforces environmental laws related to releases, or threats of releases, of hazardous substances.

M.3.9 Environmental Planning Office

The EPO assists with collecting, evaluating, and disseminating land use documents.

M.3.10 Compliance Assistance Office

The CAO was established in 1998 to assist small businesses with understanding and complying with the environmental laws and regulations administered by DOH. The free and confidential services help support the CAO mission.

APPENDIX N

1989 Declared Surface Water Use

Water Resource Protection Plan 2019 Update

Note: Declared uses are a “snapshot in time” of existing uses at the time of the adoption of the State Water Code. Many of the declared uses have not yet been verified

N 1989 Declared Surface Water Use

Tables

Note: Declared uses are a "snapshot in time" of existing uses at the time of the adoption of the State Water Code. Many of the declared uses have not yet been verified.

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N 1989 Declared Surface Water Use

Table N-1 1989 Declared Surface Water Use – Island of Kaua'i

Unit Code	Unit Name	Demand (mgd)	Unit Code	Unit Name	Demand (mgd)
Island of Kauai					
2001	Awaawapuhi	0.000	2038	Moikeha	0.053
2002	Honopu	0.000	2039	Waikaea	0.100
2003	Nakeikionaiwi	0.000	2040	Wailua	7.564
2004	Kalalau	0.000	2041	Kawailoa	0.000
2005	Pohakuao	0.000	2042	Hanamaulu	0.004
2006	Waiolaa	0.000	2043	Lihue Airport	0.000
2007	Hanakoa	0.000	2044	Nawiliwili	0.004
2008	Waiahuakua	0.000	2045	Puali	1.637
2009	Hoolulu	0.000	2046	Huleia	5.228
2010	Hanakapiai	0.000	2047	Kipu Kai	0.018
2011	Maunapuluo	0.000	2048	Mahaulepu	0.000
2012	Limahuli	0.649	2049	Waikomo	1.000
2013	Manoa	0.000	2050	Aepo	0.000
2014	Wainiha	0.000	2051	Lawai	1.739
2015	Lumahai	0.000	2052	Kalaheo	0.000
2016	Waikoko	0.000	2053	Wahiawa	7.175
2017	Waipa	0.000	2054	Hanapepe	19.820
2018	Waioli	0.000	2055	Kukamahu	0.000
2019	Hanalei	0.026	2056	Kaumakani	0.000
2020	Waileia	0.000	2057	Mahinauli	0.000
2021	Anini	0.092	2058	Aakukui	0.216
2022	Kalihikai West	0.000	2059	Waipao	0.000
2023	Kalihikai Center	0.000	2060	Waimea	17.693
2024	Kalihikai East	0.000	2061	Kapilimao	32.847
2025	Kalihiwai	0.000	2062	Paua	0.000
2026	Puukumu	0.002	2063	Hoea	0.000
2027	Kauapea	0.000	2064	Niu	0.000
2028	Kilauea	0.000	2065	Kaawaloa	0.000
2029	Kulihaili	0.000	2066	Nahomalu	0.000

Note: Declared uses are a "snapshot in time" of existing uses at the time of the adoption of the State Water Code. Many of the declared uses have not yet been verified.

Table N-1 1989 Declared Surface Water Use – Island of Kaua'I (continued)

Unit Code	Unit Name	Demand (mgd)	Unit Code	Unit Name	Demand (mgd)
Island of Kauai					
2030	Pilaa	0.159	2067	Kaulaula	0.000
2031	Waipake	0.164	2068	Haeleele	0.000
2032	Moloaa	0.001	2069	Hikimoe	0.000
2033	Papaa	0.013	2070	Kaaweiki	0.000
2034	Aliomanu	0.000	2071	Kauhao	19.010
2035	Anahola	0.001	2072	Makaha	0.000
2036	Kumukumu	0.000	2073	Milolii	0.000
2037	Kapaa	2.793	2074	Nualolo	0.000
				Kauai Total Declared Surface Water Use	**118.007**

Table N-2 1989 Declared Surface Water Use – Island of O'ahu

Unit Code	Unit Name	Demand (mgd)	Unit Code	Unit Name	Demand (mgd)
Island of Oahu					
3001	Kalunawaikaala	0.000	3010	Kaipapau	0.000
3002	Pakulena	0.000	3011	Maakua	0.000
3003	Paumalu	0.022	3012	Waipuhi	0.006
3004	Kawela	0.000	3013	Kaluanui	0.000
3005	Oio	0.000	3014	Papaakoko	0.000
3006	Malaekahana	0.000	3015	Halehaa	0.000
3007	Kahawainui	0.000	3016	Punaluu	14.242
3008	Wailele	0.000	3017	Kahana	0.000
3009	Koloa	0.000	3018	Makaua	0.000
3019	Kaaawa	0.064	3054	Keehi	0.000
3020	Kualoa	0.000	3055	Manuwai	0.000
3021	Hakipuu	0.000	3056	Salt Lake	0.000
3022	Waikane	0.001	3057	Halawa	0.000
3023	Waianu	0.000	3058	Aiea	0.000
3024	Waiahole	0.000	3059	Kalauao	0.000
3025	Kaalaea	0.000	3060	Waimalu	0.000
3026	Haiamoa	0.000	3061	Waiawa	0.020
3027	Kahaluu	0.008	3062	Waipio	0.000
3028	Heeia	33.532	3063	Kapakahi	0.292

Note: Declared uses are a "snapshot in time" of existing uses at the time of the adoption of the State Water Code. Many of the declared uses have not yet been verified.

Table N-2 1989 Declared Surface Water Use – Island of O‘ahu (continued)

Unit Code	Unit Name	Demand (mgd)	Unit Code	Unit Name	Demand (mgd)
Island of Oahu (continued)					
3029	Keaahala	0.000	3064	Waikele	4.701
3030	Kaneohe	0.000	3065	Honouliuli	0.000
3031	Kawa	0.000	3066	Kaloi	0.000
3032	Puu Hawaiiloa	0.000	3067	Makaiwa	0.000
3033	Kawainui	0.936	3068	Nanakuli	0.000
3034	Kaelepulu	0.000	3069	Ulehawa	0.000
3035	Waimanalo	0.006	3070	Mailiili	0.000
3036	Kahawai	0.000	3071	Kaupuni	0.144
3037	Makapuu	0.000	3072	Kamaileunu	0.000
3038	Koko Crater	0.000	3073	Makaha	0.000
3039	Hanauma	0.000	3074	Keaau	0.000
3040	Portlock	0.000	3075	Makua	0.000
3041	Kamiloiki	0.000	3076	Kaluakauila	0.000
3042	Kamilonui	0.000	3077	Manini	0.000
3043	Hahaione	0.000	3078	Kawaihapai	0.000
3044	Kuliouou	0.000	3079	Pahole	0.000
3045	Niu	0.000	3080	Makaleha	0.006
3046	Wailupe	0.000	3081	Waialua	0.000
3047	Waialaenui	0.000	3082	Kiikii	25.543
3048	Diamond Head	0.000	3083	Paukauila	0.000
3049	Ala Wai	2.801	3084	Anahulu	0.530
3050	Nuuanu	0.156	3085	Loko Ea	0.000
3051	Kapalama	0.200	3086	Keamanea	0.000
3052	Kalihi	0.002	3087	Waimea	0.000
3053	Moanalua	0.000			
				Oahu Total Declared Surface Water Use	**83.211**

Note: Declared uses are a “snapshot in time” of existing uses at the time of the adoption of the State Water Code. Many of the declared uses have not yet been verified.

Table N-3 1989 Declared Surface Water Use – Island of Moloka'i

Unit Code	Unit Name	Demand (mgd)	Unit Code	Unit Name	Demand (mgd)
Island of Moloka'i					
4001	Waihanau	0.274	4012	Oloupena	0.000
4002	Waialeia	0.000	4013	Puukaoku	0.000
4003	Waikolu	0.130	4014	Wailele	0.000
4004	Wainene	0.000	4015	Wailau	0.004
4005	Anapuhi	0.000	4016	Kalaemilo	0.000
4006	Waiohookalo	0.000	4017	Waiahookalo	0.000
4007	Keawanui	0.000	4018	Kahiwa	0.000
4008	Kailiili	0.000	4019	Kawainui	0.000
4009	Pelekunu	0.000	4020	Pipiwai	0.000
4010	Waipu	0.000	4021	Halawa	0.002
4011	Haloku	0.000	4022	Papio	0.007
4023	Honowewe	0.000	4037	Kawela	0.716
4024	Pohakupili	0.000	4038	Kamiloloa	0.000
4025	Honoulimaloo	0.139	4039	Kaunakakai	0.000
4026	Honouliwai	0.250	4040	Kalamaula	0.000
4027	Waialua	0.000	4041	Manawainui	0.071
4028	Kainalu	0.000	4042	Kaluapeelua	0.000
4029	Honomuni	0.018	4043	Waiahewahewa	0.000
4030	Ahaino	0.000	4044	Kolo	0.000
4031	Mapulehu	0.000	4045	Hakina	0.000
4032	Kaluaaha	0.000	4046	Kaunala	0.000
4033	Kahananui	0.000	4047	Papohaku	0.000
4034	Ohia	0.000	4048	Kaa	0.000
4035	Wawaia	0.000	4049	Moomomi	0.000
4036	Kamalo	0.000	4050	Maneopapa	0.000
				Moloka'i Total Declared Surface Water Use	**1.610**

Note: Declared uses are a "snapshot in time" of existing uses at the time of the adoption of the State Water Code. Many of the declared uses have not yet been verified.

Table N-4 1989 Declared Surface Water Use – Island of Maui

Unit Code	Unit Name	Demand (mgd)	Unit Code	Unit Name	Demand (mgd)
Island of Maui					
6001	Waikapu	2.507	6033	Kakipi	0.155
6002	Pohakea	0.000	6034	Honopou	1.327
6003	Papalaua	0.000	6035	Hoolawa	0.133
6004	Ukumehame	4.888	6036	Waipio	0.050
6005	Olowalu	4.556	6037	Hanehoi	0.007
6006	Launiupoko	0.728	6038	Hoalua	0.000
6007	Kauaula	6.008	6039	Hanawana	0.000
6008	Kahoma	5.626	6040	Kailua	0.000
6009	Wahikuli	0.000	6041	Nailiilihaele	0.000
6010	Honokowai	0.000	6042	Puehu	0.000
6011	Kahana	1.099	6043	Oopuola	0.000
6012	Honokahua	0.000	6044	Kaaiea	0.000
6013	Honolua	0.000	6045	Punaluu	0.000
6014	Honokohau	0.011	6046	Kolea	0.000
6015	Anakaluahine	0.000	6047	Waikamoi	0.000
6016	Poelua	0.000	6048	Puohokamoa	0.000
6017	Honanana	0.006	6049	Haipuaena	0.000
6018	Kahakuloa	0.004	6050	Punalau	0.000
6019	Waipili	0.027	6051	Honomanu	0.017
6020	Waiolai	0.000	6052	Nuaailua	0.000
6021	Makamakaole	0.007	6053	Piinaau	0.378
6022	Waihee	9.727	6054	Ohia	0.000
6023	Waiehu	0.105	6055	Waiokamilo	0.023
6024	Iao	22.833	6056	Wailuanui	0.002
6025	Kalialinui	0.000	6057	W. Wailuaiki	0.000
6026	Kailua Gulch	0.000	6058	E. Wailuaiki	0.000
6027	Maliko	0.014	6059	Kopiliula	0.000
6028	Kuiaha	0.002	6060	Waiohue	0.000
6029	Kaupakulua	0.012	6061	Paakea	0.000
6030	Manawaiiao	0.000	6062	Waiaaka	0.000
6031	Uaoa	0.000	6063	Kapaula	0.000
6032	Kealii	0.001	6064	Hanawi	0.303

Note: Declared uses are a “snapshot in time” of existing uses at the time of the adoption of the State Water Code. Many of the declared uses have not yet been verified.

Table N-4 1989 Declared Surface Water Use – Island of Maui (continued)

Unit Code	Unit Name	Demand (mgd)	Unit Code	Unit Name	Demand (mgd)
Island of Maui (continued)					
6065	Makapipi	0.000	6089	Oheo	0.000
6066	Kuhiwa	0.000	6090	Kalena	0.000
6067	Waihole	0.001	6091	Koukouai	0.000
6068	Manawaikeae	0.000	6092	Opelu	0.000
6069	Kahawaihapapa	0.000	6093	Kukuiula	0.000
6070	Keaaiki	0.000	6094	Kaapahu	0.000
6071	Waioni	0.000	6095	Lelekea	0.000
6072	Lanikele	0.000	6096	Alelele	0.000
6073	Heleleikeoha	0.001	6097	Kalepa	0.018
6074	Kawakoe	0.002	6098	Nuanuaaloa	0.000
6075	Honomaele	0.000	6099	Manawainui	0.004
6076	Kawaipapa	0.000	6100	Kaupo	0.000
6077	Moomoonui	0.000	6101	Nuu	0.000
6078	Haneoo	0.000	6102	Pahihi	0.000
6079	Kapia	0.002	6103	Waiopai	0.000
6080	Waiohonu	0.000	6104	Poopoo	0.000
6081	Papahawahawa	0.000	6105	Manawainui Gulch	0.000
6082	Alaalaula	0.007	6106	Kipapa	0.000
6083	Wailua	0.101	6107	Kanaio	0.000
6084	Honolewa	0.000	6108	Ahihi Kinau	0.000
6085	Waieli	0.000	6109	Mooloa	0.000
6086	Kakiweka	0.000	6110	Wailea	0.000
6087	Hahalawe	0.000	6111	Hapapa	0.000
6088	Puaaluu	0.112	6112	Waiakoa	0.000
				Maui Total Declared Surface Water Use	**60.803**

Note: Declared uses are a “snapshot in time” of existing uses at the time of the adoption of the State Water Code. Many of the declared uses have not yet been verified.

Table N-5 1989 Declared Surface Water Use – Island of Hawai‘i

Unit Code	Unit Name	Demand (mgd)	Unit Code	Unit Name	Demand (mgd)
Island of Hawai‘i					
8001	Kealahewa	0.000	8022	Honopue	0.000
8002	Hualua	0.000	8023	Kolealiilii	0.000
8003	Kumakua	0.000	8024	Ohiahuea	0.000
8004	Kapua	0.000	8025	Nakooko	0.000
8005	Ohanaula	0.000	8026	Waiapuka	0.000
8006	Hanaula	0.000	8027	Waikaloa	0.000
8007	Hapahapai	0.000	8028	Waimaile	0.000
8008	Pali Akamoa	0.000	8029	Kukui	0.000
8009	Wainaia	2.259	8030	Paopao	0.000
8010	Halelua	0.000	8031	Waiaalala	0.000
8011	Halawa	0.000	8032	Punalulu	0.000
8012	Aamakao	0.100	8033	Kaimu	0.000
8013	Niulii	9.199	8034	Pae	0.000
8014	Waikama	0.002	8035	Waimanu	0.000
8015	Pololu	2.001	8036	Pukoa	0.000
8016	Honokane Nui	3.502	8037	Manuwaikaalio	0.000
8017	Honokane Iki	0.000	8038	Naluea	0.000
8018	Kalele	0.000	8039	Kahoopuu	0.000
8019	Waipahi	0.000	8040	Waipahoehoe	0.000
8020	Honokea	0.000	8041	Wailoa/Waipio	0.776
8021	Kailikaula	0.000	8042	Kaluahine Falls	0.000
8043	Waiulili	0.000	8089	Kihalani	0.000
8044	Waikoekoe	0.000	8090	Kaiwilahilahi	0.000
8045	Waipunahoe	0.000	8091	Haakoa	0.000
8046	Waialeale	0.000	8092	Pahale	0.000
8047	Waikoloa	0.000	8093	Kapehu Camp	0.000
8048	Kapulena	0.000	8094	Paeohe	0.000
8049	Kawaikalia	0.000	8095	Maulua	0.000
8050	Malanahae	0.000	8096	Pohakupuka	0.000
8051	Honokaia	0.000	8097	Kulanakii	0.000
8052	Kawela	0.000	8098	Ahole	0.000
8053	Keaakaukau	0.000	8099	Poupou	0.000
8054	Kainapahoa	0.000	8100	Manoloa	0.000
8055	Nienie	0.000	8101	Ninole	0.000
8056	Papuaa	0.000	8102	Kaaheiki	0.000

Note: Declared uses are a “snapshot in time” of existing uses at the time of the adoption of the State Water Code. Many of the declared uses have not yet been verified.

Table N-5 1989 Declared Surface Water Use – Island of Hawai‘i (continued)

Unit Code	Unit Name	Demand (mgd)	Unit Code	Unit Name	Demand (mgd)
Island of Hawai‘i (continued)					
8057	Ouhi	0.000	8103	Waikolu	0.020
8058	Kahaupu	0.000	8104	Waikaumalo	0.000
8059	Kahawailiili	0.000	8105	Waiehu	0.000
8060	Keahua	0.000	8106	Nanue	0.000
8061	Kalopa	0.000	8107	Opea	0.000
8062	Waikaalulu	0.000	8108	Peleau	0.012
8063	Kukuilamalamahii	0.000	8109	Umauma	0.000
8064	Alilipali	0.000	8110	Hakalau	0.000
8065	Kaumoali	0.000	8111	Kolekole	0.096
8066	Pohakuhaku	0.000	8112	Paheehee	0.000
8067	Waipunahina	0.000	8113	Honomu	0.000
8068	Waipunalau	0.000	8114	Laimi	0.000
8069	Paauilo	0.000	8115	Kapehu	0.000
8070	Aamanu	0.000	8116	Makea	7.422
8071	Koholalele	0.000	8117	Alia	3.014
8072	Kalapahapuu	0.000	8118	Makahanaloa	0.000
8073	Kukaiau	0.000	8119	Waimaauou	1.808
8074	Puumaile	0.000	8120	Waiaama	2.835
8075	Kekualele	0.000	8121	Kawainui	3.014
8076	Kaala	0.000	8122	Onomea	0.025
8077	Kealakaha	0.000	8123	Alakahi	0.000
8078	Keehia	0.000	8124	Hanawi	0.000
8079	Kupapaulua	0.000	8125	Kalaoa	0.001
8080	Kaiwiki	0.000	8126	Aleamai	0.000
8081	Kaula	0.000	8127	Kaieie	0.000
8082	Kaohaoha	0.000	8128	Puuokalepa	0.030
8083	Kaawalii	0.000	8129	Kaapoko	0.000
8084	Waipunalei	0.000	8130	Papaikou	0.000
8085	Laupahoehoe	0.000	8131	Kapue	0.000
8086	Kilau	0.000	8132	Pahoehoe	0.000
8087	Manowaiopae	0.194	8133	Paukaa	0.000
8088	Kuwaikahi	0.010	8134	Honolii	0.000

Note: Declared uses are a “snapshot in time” of existing uses at the time of the adoption of the State Water Code. Many of the declared uses have not yet been verified.

Table N-5 1989 Declared Surface Water Use – Island of Hawai‘i (continued)

Unit Code	Unit Name	Demand (mgd)	Unit Code	Unit Name	Demand (mgd)
Island of Hawai‘i (continued)					
8135	Maili	0.145	8151	Kiilae	0.001
8136	Wainaku	0.000	8152	Kealakekua	0.000
8137	Pukihae	0.000	8153	Waiaha	0.014
8138	Wailuku	47.343	8154	Honokohau	0.000
8139	Wailoa	0.000	8155	Keahole	0.000
8140	Kaahakini	0.000	8156	Kiholo	0.000
8141	Kilauea	0.000	8157	Pohakuloa	0.000
8142	Keauhou Point	0.000	8158	Kamakoa	0.000
8143	Kilauea Crater	0.000	8159	Haloa	0.000
8144	Kapapala	0.000	8160	Lamimaumau	0.000
8145	Pahala	0.000	8161	Waikoloa	37.155
8146	Hilea	0.001	8162	Kawaihae	0.000
8147	Naalehu	0.001	8163	Honokoa	5.184
8148	Kiolakaa	0.000	8164	Keawanui	0.350
8149	South Point	0.000	8165	Lapakahi	0.000
8150	Kauna	0.000	8166	Mahukona	0.000
				Hawaii Total Declared Surface Water Use	**126.515**

Note: Declared uses are a “snapshot in time” of existing uses at the time of the adoption of the State Water Code. Many of the declared uses have not yet been verified.

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APPENDIX O

Long-Term Tasks

Water Resource Protection Plan 2019 Update

O Long-Term Actions

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O Long-Term Tasks

Section 3 of the WRPP Update outlines the process for developing CWRM's priority recommendations and action plan. The tasks identified in that section are meant to guide CWRM over the next five years to meet its mission and vision.

In addition to the tasks identified in **Section 3**, many more tasks were developed as part of the update process. All of the projects and associated tasks that were identified are considered important to managing the use and protection of water resources. Longer-term tasks are captured in this appendix as tasks that should be revisited in future planning and updates to the WRPP. These tasks may also be implemented within the next five years if opportunities and/or funding emerge or if conditions change to increase the urgency for their implementation. As with any plan, the Water Resource Protection Plan should be regarded as a guide for action and should not be so rigid as to not be adaptable to future conditions, new information, or opportunities.

Tasks listed in the tables below are presented as they correspond to the three goals of CWRM and not necessarily how they ranked during the prioritization process. The tasks are further grouped under their corresponding project, which allows for consistency with **Section 3** of the Action Plan.

Figure O-1 Process for developing projects and tasks for CWRM Action Plan

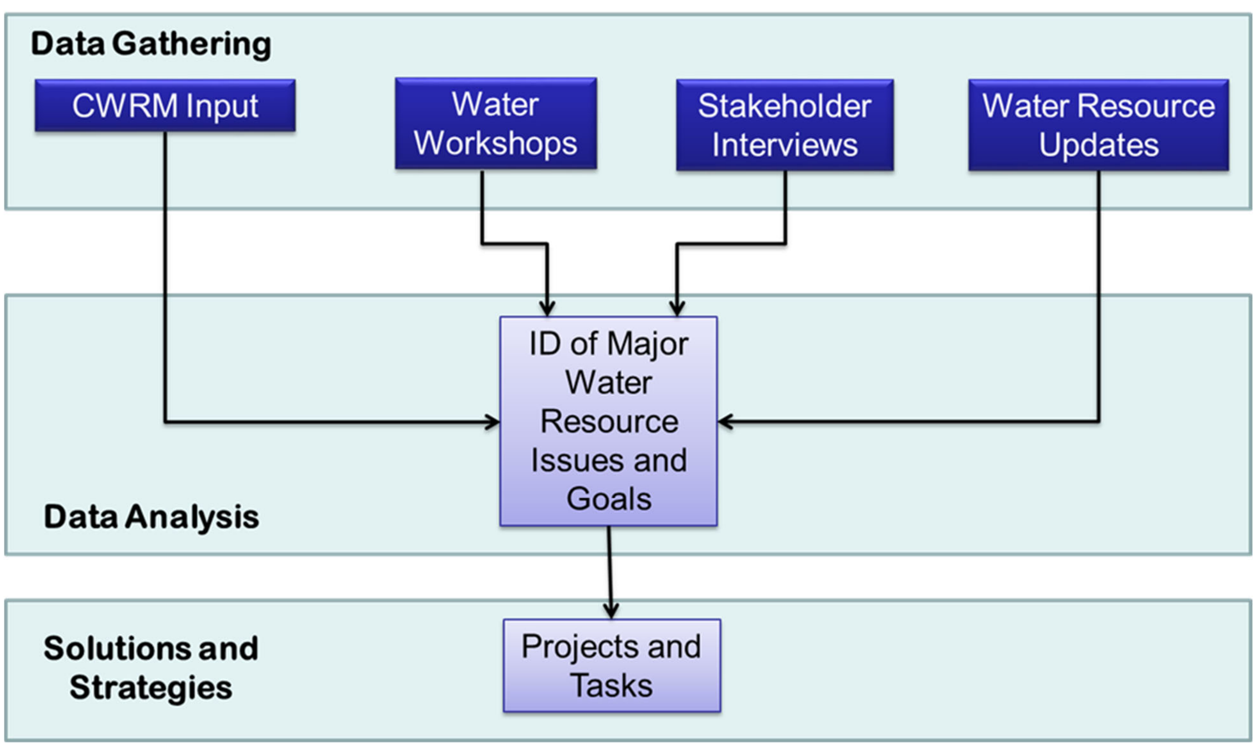

Table O-1 Long-Term Actions and Tasks by Goal

GOAL 1:	**A solid and up-to-date foundation of data on Hawai'i water resources, water use, and water dynamics is used to make water resource management decisions**
Project 1.1	**Collect and analyze climatic data to determine trends in water resource health and anticipate future issues and problems.**
Task 1.1.a	Study new technologies and tools for rainfall estimation.
Task 1.1.b	Increase cloud water interception data collection.
Task 1.1.c	Establish evapotranspiration monitoring stations.
Task 1.1.d	Investigate the probable impacts of long-term climate trends, which includes impacts to Hawaiian hydrology
Project 1.2	**Improve the reporting and analysis of ground and surface water use.**
Task 1.2.a	Monitor for compliance with water use permits.
Task 1.2.b	Expand education and outreach to landowners and surface water system operators.
Task 1.2.c	Enforce the water use reporting program in water management areas.
Task 1.2.d	Expand water use reporting and outreach in non-designated areas.
Task 1.2.e	Enforce penalties for non-reporting of water use in non-designated areas.
Task 1.2.f	Design and implement quality assurance/quality control protocols.
Task 1.2.g	Obtain historical water data for entry into water use databases.
Task 1.2.h	Compare reported surface water use with regulatory thresholds.
Task 1.2.i	Explore the use of different statistics, methods, and measures to assess water uses over time.
Project 1.3	**Update estimates of aquifer sustainable yields with new and best information available using the 2008 precautionary approach.**
Task 1.3.a	Conduct seepage runs.
Task 1.3.b	Apply information on ground water/surface water interaction to reassess sustainable yield.
Task 1.3.c	Apply revised recharge estimates to assess sustainable yield.
Task 1.3.d	Seek the optimization of infrastructure to minimize local stress on aquifers and increase confidence in ground water modeling of sustainable yields. Identify where such optimization is needed and/or possible.
Task 1.3.e	Develop an inventory of natural inland springs to improve the understanding of GW/SW interactions.
Task 1.3.f	Support spring flow monitoring
Task 1.3.g	Utilize numerical models where necessary to refine the conceptual ground water models.

Table O-1 Long-Term Actions and Tasks by Goal (continued)

Goal 1	**A solid and up-to-date foundation of data on Hawai‘i water resources, water use, and water dynamics is used to make water resource management decisions**
Project 1.4	**Develop and implement a strategic surface water monitoring plan.**
Task 1.4.a	Increase federal and state funding for surface water monitoring
Task 1.4.b	Develop a policy that identifies who is responsible for stream and diversion monitoring.
Task 1.4.c	Collect baseline stream data.
Task 1.4.d	Develop a cost analysis for different providers of surface water data.
Project 1.5	**Understand how climate change will impact water resources.**
Task 1.5.a	Incorporate quantified climate change predictions into recharge calculations.
Task 1.5.b	Incorporate quantified climate change predictions into IFS calculations.
Task 1.5.c	Support continued research on climate change including drought and watershed health impacts
Project 1.6	**Understand the impacts of land use on hydrology, ecosystem function, and water resources needed for human consumption.**
Task 1.6.a	Identify the most important areas to protect and manage in order to restore and sustain ground water aquifers.
Project 1.7	**Develop and implement a comprehensive statewide ground water monitoring plan.**
Task 1.7.a	Conduct additional synoptic water level surveys.
Task 1.7.b	Increase monitoring of water levels in West Hawaii high-level wells.
Task 1.7.c	Conduct regular analyses of aquifer health in aquifers of concern.
Task 1.7.d	Incorporate new technologies for deep monitor well data collection and dissemination to improve hydrologic monitoring capabilities.
Task 1.7.e	Reinstate water level measurement in discontinued observation wells.
Task 1.7.f	Drill new water level observation wells.
Task 1.7.g	Conduct geospatial mapping of top of transition zone, mid-point of the transition zone, and water-level elevations.
Task 1.7.h	Evaluate the impact of brine injection wells on the underlying ground water.
Task 1.7.i	Further study the recently discovered fresh ground water found on Hawaii Island.
Task 1.7.j	Conduct additional analyses, monitoring, inventory, and integration of spring data.
Task 1.7.k	Analyze existing data collected from the Waiahole system.

Table O-1 Long-Term Actions and Tasks by Goal (continued)

GOAL 2:	**Protect water resources and balance public trust uses, water rights, and reasonable beneficial uses.**
Project 2.1	**Manage instream and offstream uses to provide for reasonable beneficial use while protecting public trust uses.**
Task 2.1.a	Identify cost-effective ways for obtaining the data necessary for developing IFS.
Task 2.1.b	Develop an action plan to identify and address abandoned diversions.
Project 2.2	**Protect water quality from land use impacts.**
Task 2.2.a	Require conversion of small capacity cesspools to individual wastewater systems.
Task 2.2.b	Study the potential impacts of pharmaceuticals and personal care products in recycled wastewater.
Task 2.2.c	Account for the short and long-term impacts of injection wells on ground water quality.
Task 2.2.d	Evaluate the impacts of Aquifer Storage and Recovery on ground water quality.
Project 2.3	**Provide clear guidance on criteria used to make water resource management decisions, including, but not limited to, the precautionary principle, the protection of public trust purposes, traditional and customary practices, and economic considerations.**
Task 2.3.a	Create rules for establishing appurtenant rights and clarify permitting regulations.
Task 2.3.b	Create rules for 174C-101 Native Hawaiian Water Rights.
Project 2.4	**Update CWRM's policies on enforcement and penalties and modernize and streamline the regulatory process.**
Task 2.4.a	Assist with outreach to landowners to educate them on their responsibilities for stream maintenance.
Task 2.4.b	Continue to modernize internal processing of permits.
Task 2.4.c	Evaluate unused water allocations and revoke unneeded water use permits.

Table O-1 Long-Term Actions and Tasks by Goal (continued)

GOAL 2	**Protect water resources and balance public trust uses, water rights, and reasonable beneficial uses.**
Project 2.5	**Develop, update, and implement water conservation tools, techniques, and plans.**
Task 2.5.a	Convene the Water Conservation Advisory Group annually.
Task 2.5.b	Support the adoption of higher water efficiency standards.
Task 2.5.c	Identify funding sources to support conservation activities.
Task 2.5.d	Require individual water conservation plans as a condition of water use permits.
Task 2.5.e	Incorporate conservation plans and measures as a strategy to meet State agency demands in the State Water Projects Plan.
Task 2.5.f	Work with irrigation system operators to improve the efficiency of agricultural ditch systems.
Project 2.6	**Plan for and provide guidance on the use of alternative water sources.**
Task 2.6.a	Collaborate with DOH to revise/update Graywater Guidelines to streamline implementation.
Task 2.6.b	Study the economic, environmental, social etc. impacts of the various alternative water sources.
Task 2.6.c	Develop standards for dual-water lines in coordination with the Boards of Water Supply and Department of Health per 174C-51.5(b).
Task 2.6.d	Establish a resource augmentation planning program and framework in collaboration with Counties and affected government agencies.
Project 2.7	**Protect ground water sources by updating well standards and sealing abandoned wells.**
Task 2.7.a	Establish continuing education programs for well construction and pump installation contractors.
Project 2.8	**Establish water fees/registration fees.**
Task 2.8.a	Study the establishment of sustainable funding mechanisms needed to support CWRM's data collection and management programs.

Table O-1 Long-Term Actions and Tasks by Goal (continued)

GOAL 2	**Protect water resources and balance public trust uses, water rights, and reasonable beneficial uses.**
Project 2.9	**Prepare for water shortages and drought.**
Task 2.9.a	Complete regular updates of county and local drought mitigation and response strategies
Task 2.9.b	Maintain the Hawaii Drought Monitor website.
Task 2.9.c	Draft guidelines for developing individual water shortage plans for water use permitees.
Task 2.9.d	Develop and adopt water shortage plans in all water management areas.
Task 2.9.e	Seek resources and partnership toward implementing drought plans.
Task 2.9.f	Refine and update the drought risk and vulnerability assessment and GIS mapping project.
GOAL 3:	**Partnerships, education, and awareness increase collaborative water resource management among government, private, and community entities and the citizens of Hawaiʻi.**
Project 3.1	**Update the Hawaiʻi Water Plan.**
Task 3.1.a	Develop a Hawaii Water Plan summary document.
Project 3.2	**Increase CWRM community involvement, participation, outreach, and education.**
Task 3.2.a	Develop more efficient means to share water data maintained by CWRM with the public
Task 3.2.b	Develop presentation formats and methods that are easy for the lay public to understand and are easily updated.
Task 3.2.c	Further elaborate definition of sustainable yield in a lay public format.
Task 3.2.d	Describe and define different types of aquifers and how they are regulated differently.
Task 3.2.e	Hire a CWRM outreach coordinator
Task 3.2.f	Develop user manuals or FAQs, i.e. How to get a SCAP or a stream diversion works permit? How are IFS determined? When do you need a permit? How to file a complaint?
Task 3.2.g	Utilize social media and other online resources to disseminate information
Task 3.2.h	Issue a monthly or quarterly on-line newsletter to provide water resource information.
Task 3.2.i	Develop a program for community based hydrologic data collection and reporting
Task 3.2.j	Partner with community organizations to implement community projects.

APPENDIX P

Administrative and Civil Penalty Guideline

Water Resource Protection Plan 2019 Update

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ADMINISTRATIVE AND CIVIL PENALTY GUIDELINE (G14-01)
COMMISSION ON WATER RESOURCE MANAGEMENT
DEPARTMENT OF LAND AND NATURAL RESOURCES
STATE OF HAWAII

I. GOALS

This penalty guideline seeks to provide a logical and consistent means to assess penalties and guide the settlement of Commission on Water Resource Management (Commission) enforcement cases. The Commission and staff should use this system to:

A. Deter violations;

B. Remove the economic benefit of violations;

C. Provide fair treatment of the regulated community; and

D. Offer the violator a chance to undertake a beneficial alternative, under proper conditions, in a partial or total replacement of a cash penalty.

II. LEGAL AUTHORITY

Hawaii Revised Statutes (HRS) § 174C-15 provided for fines of up to $1,000 for any violation of any provision of HRS § 174C. For a continuing offense, each day during which the offense is committed is a separate violation.

Administrative Rule § 13-167-10 provided for fines of up to $1,000 for any violation of any provision of Title 13, any permit condition or limitation established pursuant to Title 13, or for negligent or willful failure to comply with any final order of the Commission. For a continuing offense, each day during which the offense is committed is a separate violation.

Act 142, approved on June 6, 2004, updated the maximum fine limit from $1,000 to $5,000 in 174C HRS.

III. APPLICABILITY

A. This guideline applies to the Commission programs, which include but are not limited to:

1. Measuring and reporting of water data;
2. Well Construction and Pump Installation Permits;
3. Stream Diversion Works Permits;
4. Stream Channel Alteration Permits;
5. Instream Use Protection Program;
6. Instream Flow Standards;
7. Water Use Permits;
8. Violations of any permit issued by the Commission;
9. Violations for failure to comply with final orders issued by the Commission; and
10. Violations of Hawaii Administrative Rules Title 13.

B. This guideline is only for use by Commission personnel. The guideline is not intended and cannot be relied upon to create rights, substantive or procedural, enforceable by any party in litigation with the Commission on Water Resource Management, Department of Land and Natural Resources or the State of Hawaii. The Commission's staff reserves the right to act at variance with this guideline and to change it at any time without notice. The Commission's staff expects to change this guideline as it gains experience with the guideline's implementation.

IV. INITIAL STAFF ADMINISTRATIVE FEE

An administrative fee of $500 shall be assessed with the issuance of a written notice of violation.

V. PENALTY CALCULATION METHOD

A. The Commission's staff shall calculate an initial minimum penalty figure for daily fines for settlement purposes based on the following:

1. Finding of violation = $250 per day/incident

2. Occurring in Water Management Area = $250 per day/incident

3. Repeat Violation = $250 per day/incident

   (A repeat violation is deemed to occur when the party has previously been found to be a violator by the Commission. A repeat violation is tied to the party involved and is irrespective of the nature of the violation.)

B. Adjustments to Initial Minimum Penalty Figure in Section A: Mitigative and Gravity Factors.

Reduction or enhancement of any recommended fine will be made based on:(1) the degree of risk or actual harm to water resources or the environment and (2) specific factors listed below. Where the risk or actual harm is slight, reduction of the recommended fine should be considered and where the risk or actual harm is great, enhancement of the recommended fine should be imposed.

1. Mitigation Component

Mitigative factors can be considered in the recommendation of any fine or alternative penalty. Presence of one or more mitigative factors can reduce or eliminate the fine or alternative penalty recommendation. Mitigative factors include but are not limited to: insignificant impact on the resource, attempt to remedy the violation without notice, good faith effort to remedy violation once noticed, self reporting in a timely manner, and diligent and speedy effort to remedy the violation once noticed.

2. Gravity Component

Gravity factors can be considered in the recommendation of any fine or alternative penalty. Presence of one or more gravity factors can enhance the fine or alternative penalty recommendation. Gravity factors include but are not limited to: significant risk of or actual damage or harm to the water resources or the environment, multiple or repeat violations of the code or regulations, evidence that the violator should have known about the violation, refusal to correct the violation once noticed, failure to meet deadlines as set by the Commission or its staff.

C. Calculation of the Number of Days for the Recommended Fine.

1. If one or more of the gravity components are met, a daily fine may be imposed. Those fines shall accrue on the following basis:

    1. Violation where no permit is issued and no prior permits have been issued or no permit is required.

       The date the violation has occurred.

    2. Violation where no permit is issued but prior permits have been issued

       The date the violation has occurred.

    3. Violation where permit has been issued

       Either:
       a. The date the violation has occurred
       b. The date of permit approval
       c. The date permit issued
       d. The date of Commission meeting for conditions or deadlines imposed by the Commission not contained in a permit

    4. Tolling. In calculating a recommendation for the imposition of a daily fine, the time may be tolled for upon the filing of a permit application, satisfactory progress in addressing the violation, or for good cause.

    5. End. In calculating a recommendation for the imposition of a daily fine, the period of the violation ends upon: (1) satisfactory

resolution of the violation, or (2) removal or remedy of the violation.

D. No staff recommendation shall exceed the maximum amount allowable in Section 174C-15, HRS.

VI. ALTERNATIVE SETTLEMENT

The following considerations will guide the Commission's staff recommendation in deciding whether to allow a project to substitute for or be credited against a cash penalty. However, any finding of a violation by the Commission shall result in a minimum one-time $500 cash fine in addition to an alternative settlement. Failure to successfully meet the alternative will result in re-institution of the fines as calculated in IV.

1. The project must be something that the violator was not required to do anyway, either because of legal or other obligation. Projects committed to, or started before a settlement is finally agreed upon may be eligible for credit, but such projects must be carefully examined to determine the extent to which they resulted from the enforcement case or were due to other factors, or prior plans or commitments. In some cases, partial credit may be appropriate.

2. The project must result in new water resources (including aquatic biota) information, provide water resources education, or benefit the water resources of the state.

3. The project may consist of corrective action to be completed within a timeframe established by the Commission. Failure to abide by the timeframe will result in re-institution of the fines as calculated in IV.

VII. FUTURE APPLICATIONS

Future applications from an applicant who has not paid fines or met alternative settlements or for a project with outstanding violations may be considered incomplete until sanctions are fulfilled and/or violations are corrected.