Water Resources and Climate Change Adaptation in Hawai‘i:

Adaptive Tools in the Current Law and Policy Framework

2012

CENTER FOR ISLAND CLIMATE ADAPTATION & POLICY

Pacific RISA

Sea Grant University of Hawai‘i

College of Social Sciences

HAWAIʻINUIĀKEA School of Hawaiian Knowledge

SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY UNIVERSITY OF HAWAIʻI AT MĀNOA

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White Paper prepared by:

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A note about the presentation of ʻōlelo Hawaiʻi (Hawaiian language) in this report: In rendering Hawaiian words, the authors have used diacritical marks. Many of the sources quoted and cited do not use diacritical marks and are reproduced in their original form.

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Executive Summary

Climate change adaptation is the process of increasing resilience and reducing vulnerability to risks related to climate change. From a law and policy perspective, adaptation primarily means: (i) ensuring that current policies and procedures account for climate trends, variability, and uncertainty; and (ii) ensuring that, when decision-makers receive new information from climate scientists in the future, they can appropriately act on that information with the existing policies and procedures. One particularly relevant observation of adaptation points out that it is not just about creating new policies, but about routinely considering how the future climate may affect the outcomes of decisions, and using that understanding to make more informed decisions.

The need for adaptive tools is especially sharp in the context of managing vital water resources. Hawai'i water experts have recognized that alterations in rainfall, temperature, wind, or other climate phenomena have the potential to devastate natural resources and human communities.

This paper briefly describes Hawai'i's water resources, and then identifies troubling patterns of climate change that are already evident in Hawai'i, including (a) declining rainfall, (b) reduced stream flow, (c) increasing temperature, and (d) rising sea level. Each poses serious consequences for the replenishment and sustainability of groundwater and surface water resources. These worrisome trends are then further compounded by the prospect of other looming impacts related to climate change, such as potential changes in the trade wind regime, the intensity and frequency of drought and storm events, the El Niño-Southern Oscillation, and the Pacific Decadal Oscillation. And even without such climate-related trends and risks, the forecast for rising population and increasing water demand presents a compelling need to carefully manage water resources.

The picture is clear. Hawai'i must adapt to a future that will be different from the present, especially where water resources are involved. Fortunately, aspects of Hawai'i's existing laws and policies on water management already include adaptive mandates. This paper describes the general principles of climate change adaptation. In broad terms, "adaptive capacity" is defined by laws and policies that require water management to be: (1) forward-looking—focused on crisis avoidance as well as crisis mitigation; (2) flexible—able to adjust to changing needs and conditions; (3) integrated—able to address climate-related impacts that cut across political and geographical boundaries; and (4) iterative—utilizing a continuous loop of monitoring, feedback, and reevaluation.

The picture is clear. Hawai'i is feeling the effects of climate change, and must adapt to a future that will be different from the present

This paper analyzes the structure of Hawai'i's water management scheme, with a special focus on adaptation. Water is the only natural resource addressed in a stand-alone section in the state constitution. That section, along with other constitutional provisions, mandates the long-term protection of natural water resources. These top-level protections are bolstered by (i) the public trust doctrine, which imposes a duty on the state to protect and manage all water resources for the benefit of present and future generations, and (ii) the precautionary principle, which empowers water managers to take precautionary action without first waiting for a crisis to establish absolute certainty of the related risks. The constitution also directs the formation of a

single agency—the Commission on Water Resource Management ("Water Commission")—to establish policies and procedures for water management. This is accomplished primarily through the State Water Code and associated rules.

Numerous aspects of this legal structure exhibit adaptive characteristics. Examples include: forward-looking mandates for long-term water resource protection; the flexibility of the Water Commission to continuously update and refine estimates of the sustainable yield (the amount of water that can be sustainably drawn from each aquifer); the integrated approach in which the Water Commission oversees a four-part Hawai'i Water Plan with input from virtually every corner of the state; and the iterative requirement that salinity and other measures of water sustainability must be vigilantly monitored.

This paper identifies twelve adaptive tools that can make a critical difference in Hawai'i's water future and adaptation to climate change

Springing from this basic framework, Section 4 of this paper identifies twelve potential adaptive tools that are not presently implemented in Hawai'i, or that are implemented only in part. Each tool is consistent with the existing law and policy framework, and each exhibits adaptive characteristics. Many of these tools are derived from existing models, already tested in in Hawai'i or elsewhere. Summarized, the twelve tools are:

Table 1. Adaptive Tools for Water Resource Management in Hawai'i

Planning and Policy Tools	Section
1 - Incorporate climate change planning into the Hawai'i Water Plan.	4.1.1
2 - Enforce five-year updates to the Hawai'i Water Plan.	4.1.2
3 - Expand models of water- and climate-conscious land use plans and policies.	4.1.3
4 - Adopt existing models to integrate watershed conservation with water resource planning.	4.1.4
5 - Finalize and implement mandatory water conservation and recycling plans.	4.1.5

Regulatory Tools	Section
6 - Adopt climate-conscious sustainable yield and instream flow standards.	4.2.1
7 - Enforce and expand statewide water resource monitoring and reporting.	4.2.2
8 - Expand Water Management Areas.	4.2.3
9 - Adopt more adaptive conditions for water use, well construction, and stream diversion permits.	4.2.4

Market-Based Tools	Section
10 - Encourage water-conscious construction and modifications with green-building benefits and credits.	4.3.1
11 - Relate Water Commission fees more closely to the cost of water management and watershed protection.	4.3.2
12 - Adopt a public goods charge for water use.	4.3.3

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Introduction

> "*The impacts of global climate change in the Hawaiian Islands can potentially devastate our considerable natural resources.*"
>
> "*Climate change causes alterations in temperature and precipitation patterns, and Hawaii's water resources are almost exclusively dependent on rainfall.*"
>
> "*Prudent water resource planning should consider the long-term impacts of global climate change and how this could affect Hawaii's water supplies ….*"
>
> —State of Hawai'i Commission on Water Resource Management, 2008.[1]

There is no question that water is a vital resource. It is therefore no surprise that Hawai'i's water experts conclude that climate-driven changes to Hawai'i's water cycle must be taken seriously. Already, scientists are observing climate change phenomena in Hawai'i such as (a) decreasing rainfall, (b) declining stream flow, (c) rising sea level, and (d) increasing temperatures. All of these trends threaten the sustainability of Hawai'i's water resources. Other trends on the horizon may pose even more serious impacts on the water cycle. Section 1 of this paper identifies these climate-related threats, and provides a snapshot of the forecast for rising population and increasing water demand across the state. Together these trends illustrate that Hawai'i must adapt to a future that will be different from the present, especially in the realm of water resource management.

Fortunately, aspects of Hawai'i's existing laws and policies on water management already include adaptive mandates. Section 2 of this paper describes the general principles of climate change adaptation. In broad terms, "adaptive capacity" is defined by laws and policies that require water management to be:

- *Forward-looking*—focused on crisis avoidance over crisis mitigation;
- *Flexible*—able to adjust to changing needs and conditions;
- *Integrated*—able to address climate-related impacts that cut across political and geographical boundaries; and
- *Iterative*—utilizing a continuous loop of monitoring, feedback, and reevaluation.

Section 3 of this paper analyzes the structure of Hawai'i's water management scheme, with a special focus on adaptation. The state constitution and Water Code, bolstered by the public trust doctrine and precautionary principle, exhibit numerous adaptive characteristics. Examples include: forward-looking mandates for long-term water resource protection; the flexibility of the statewide Commission on Water Resource Management ("Water Commission") to continuously update and refine estimates of the sustainable yield of water that can be drawn from each aquifer; the integrated approach in which the Water Commission oversees a four-part Hawai'i Water Plan with input from virtually every corner of the state; and the iterative requirement that salinity and other measures of water sustainability be vigilantly monitored.

Springing from this underlying framework, Section 4 of this paper identifies twelve potential adaptive tools that are not presently implemented in Hawai‘i, or that are implemented only in part. Each tool is consistent with the existing law and policy framework, and each exhibits adaptive characteristics. Summarized, the proposed tools are:

Adaptive Planning Tools:

1. Incorporate climate change scenario planning into the Hawai‘i Water Plan.
2. Enforce five-year updates to the Hawai‘i Water Plan.
3. Expand existing models of water- and climate-conscious land use plans and policies.
4. Adopt existing models of integrating watershed conservation with water resource planning.
5. Implement mandatory water conservation and recycling plans.

Adaptive Regulatory Tools:

1. Impose climate-conscious sustainable yield and instream flow standards.
2. Enforce statewide water resource monitoring and reporting.
3. Expand designated Water Management Areas.
4. Adopt more adaptive conditions for all water use, well construction, and stream diversion permits.

Adaptive Market-Based Tools:

1. Encourage water-conscious construction and modifications with green-building tax credits, rebates, and other incentives.
2. Relate Water Commission fees more closely to the cost of water management.
3. Adopt a public goods charge for water use.

1. Climate Change Risks to Hawai‘i's Water Resources

1.1 Understanding Freshwater Resources

In this opening section, we summarize scientific findings on the nature and scope of climate change impacts on Hawai‘i's water resources (Section 1.3). As an aid to understanding those findings, we first briefly describe: (a) the hydrologic processes that control freshwater resources in Hawai‘i, (Section 1.1); and (b) the present and predicted allocation and uses of those water supplies in Hawai‘i (Section 1.2). These initial descriptions are intended as an introductory primer on Hawai‘i's water cycle and water use.

1.1.1 Rainfall

Precipitation, in all its forms, is the natural source of freshwater input to Hawai‘i's water supply. Rainfall provides the overwhelming majority of that input, derived from trade wind driven windward showers and storm rainfall from cold fronts, Kona storms, upper-level lows, and tropical storms.[2] Cloud water—when intercepted by plants and ground surfaces in a process known as "fog drip"—is also a significant source of water in mountain ecosystems.[3]

Figure 1. Orographic Rainfall and the Trade Wind Inversion

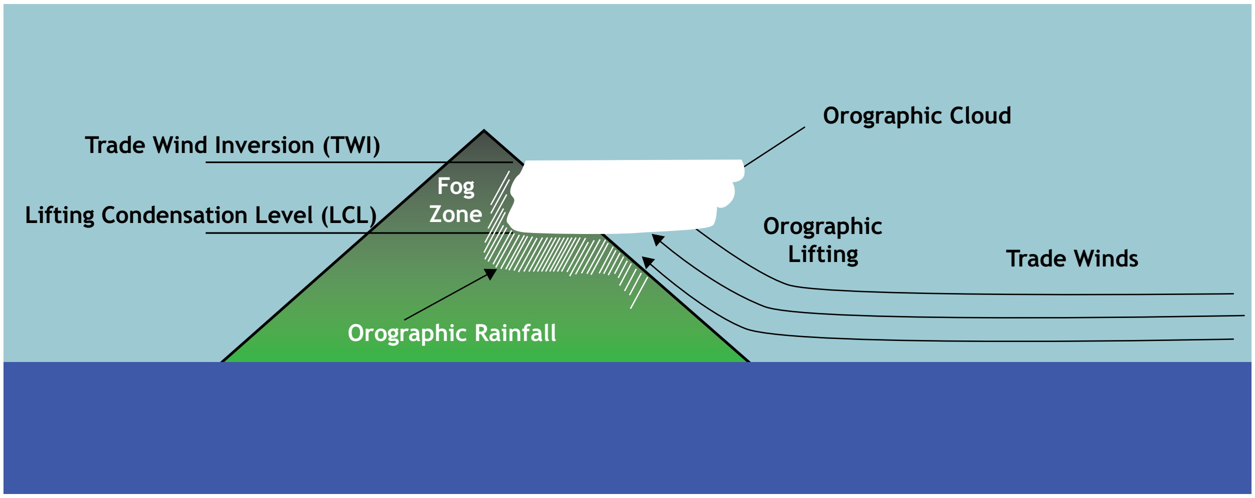


Illustration of trade winds causing "orographic lifting," leading to rainfall at higher elevations. Changes in the trade wind regime, the height of the inversion layer, the lifting condensation level, or other effects, may impact this critical source of groundwater recharge.

Courtesy of T. W. Giambelluca, Q. Chen, A.G. Frazier, J.P. Price, Y-L Chem, P-S Eischeid, and D. Delparte, *The Rainfall Atlas of Hawai'i*, http://rainfall.geography.hawaii.edu.

Photo: Zena Grecni

Orographic clouds, like those pictured here on O'ahu's Ko'olau Mountains, produce rain and fog drip that is critical to groundwater recharge.

Rainfall is controlled by a number of complex interactions, all of which can be impacted by climate change:

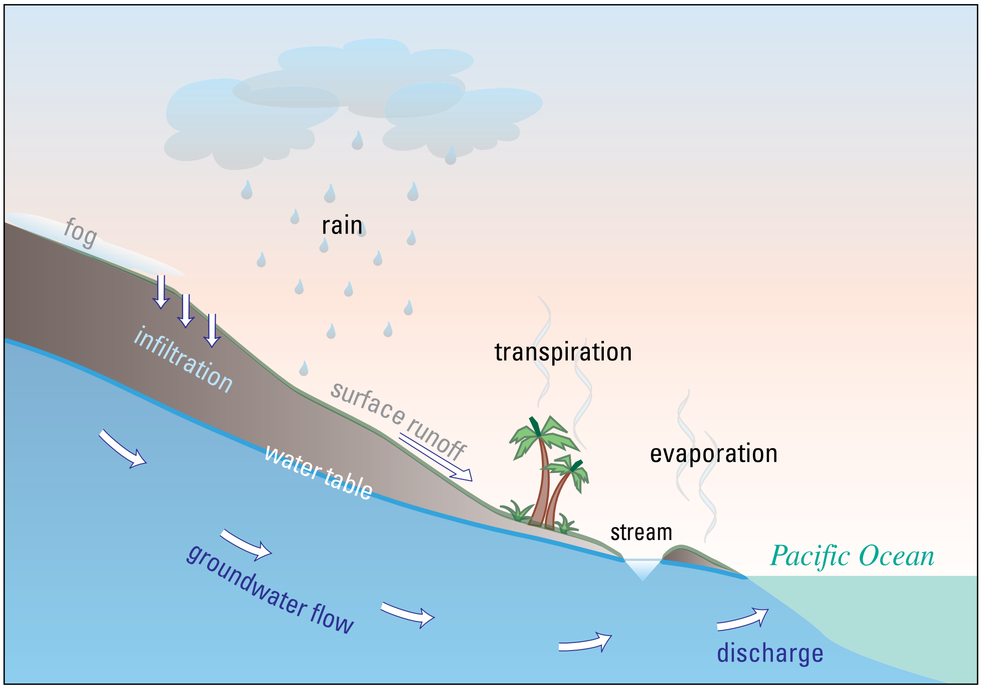
1. *Orographic rainfall.* At the local scale, island topography (e.g. steep slopes) and surface characteristics (e.g. heating) cause moist sea-level air to rise as it blows against the mountainside. This is called orographic lifting. The moist air cools as it rises, leading to cloud formation, condensation, and rainfall. This rainfall is heaviest in windward areas, and at altitudes above 3000 feet. The drier air then descends over leeward areas, where generally drier conditions prevail.[4]
2. *Inversion layer.* Local circulation and weather patterns can also exert control over the distribution of rainfall. In general, air gets colder as elevation increases. However, an upper-level temperature inversion sometimes forms over Hawaiʻi, creating a high-altitude zone where the air instead gets warmer as elevation increases. This effect is caused by a larger circulation pattern in which air from the upper atmosphere warms as it sinks, thus "capping" cooler air rising from below. The persistence and base elevation of this inversion layer have implications for rainfall, because the inversion layer exerts a measure of control on the thickness of the cloud zone. A higher inversion layer allows a thicker cloud layer to form, leading to more rainfall. A lower inversion layer thins the cloud layer, leading to less rainfall.
3. *The trade wind regime and winter storms.* Large-scale circulation patterns lead to the persistent trade winds that drive the majority of orographic rainfall. These near-surface winds blow from northeast to southwest for much of the year—typically more than 90 percent of days during summer months, and 40 to 60 percent during winter months. Changes in the underlying circulation patterns can have effects on trade wind persistence, and on the formation of the upper-level temperature inversion. Not much rainfall in leeward areas is received during trade wind weather. Instead, these areas get their rainfall when winter cold fronts and low-pressure cyclonic storms (Kona storms) occur, often bringing westerly or southerly winds. These storms tend to blanket larger areas than orographic rains, but occur less frequently.
4. *Ocean-atmosphere interactions.* On a regional scale, year-to-year and decade-to-decade variations in climate and rainfall have been linked to important ocean-atmosphere interactions in the Pacific. The El Niño-Southern Oscillation, marked by variations in sea surface temperature in the tropical Pacific, fluctuates on a time scale of two to eight years. The Pacific Decadal Oscillation fluctuates on the interdecadal scale, and is reflected by sea surface temperatures in the North Pacific. Both have been tied to variability in rainfall in Hawaiʻi and elsewhere, via effects such as trade wind intensity and jet stream latitude.[5]

1.1.2 Surface Water and Groundwater Resources

There are numerous visible signs of water flowing through Hawaiʻi's hydrologic cycle, such as clouds, rainbows, waterfalls, and streams. Surface water resources supply approximately 20 percent of the state's water needs, including key agricultural resources.[6] Surface waters also play a critical role in sustaining natural ecosystems, and supporting the constitutionally protected traditional and customary rights of Native Hawaiians. They also provide valued recreational and aesthetic benefits.

Rainfall feeds surface streams in two ways. *Storm flow* runs off the land quickly, causing stream levels to rise during and immediately after a rain event. *Base flow* is supplied more steadily as rain percolates through

Figure 2. The Hydrologic Cycle



U.S. Geological Survey illustration of an island hydrologic cycle, showing connections between elements such as rainfall, fog drip, groundwater recharge, storm flow, and base flow.

Courtesy of U.S. Geological Survey, Pacific Water Science Center. Reproduced from G. W. Tribble, *Ground Water on Tropical Pacific Islands—Understanding a Vital Resource: U.S. Geological Survey Circular 1312 1, 24* (2008), available at http://pubs.usgs.gov/circ/1312/.

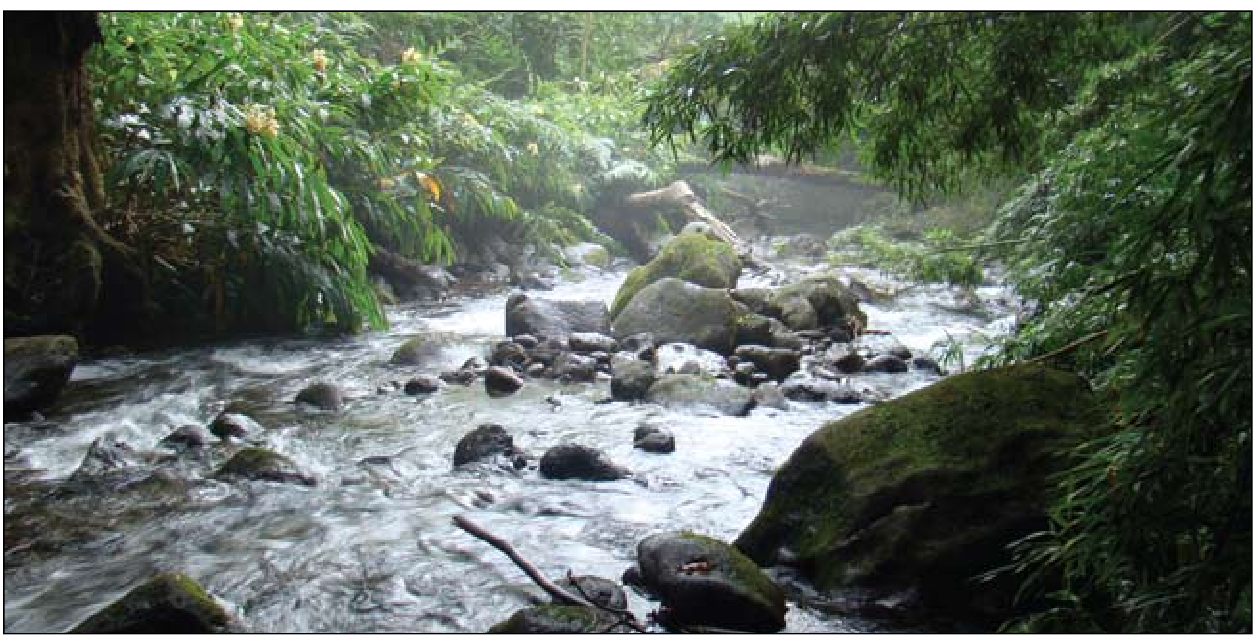


Photo: Zena Grecni

Water flowing in the Waiāhole Stream is fed by ground water from dike-impounded aquifers in the Koʻolau Mountains.

the ground, and is then discharged from groundwater resources (described below). Base flow also responds to changes in rainfall over time, but much more slowly than storm flow.[7]

The fresh water we cannot see—water stored under the ground in aquifers—is also a critical resource. On O'ahu, ground water provides more than 90 percent of drinking water and half the water used in agriculture.[8] On Maui, approximately 50 percent of the municipal water supply comes from a single groundwater source, the 'Iao aquifer.[9] Overall, ground water is estimated to provide approximately 80 percent of the fresh water used statewide.[10]

The *freshwater lens* (see Figure 3a), underlying the surface of each island, is the largest and most exploited type of aquifer in Hawai'i. These aquifers consist of fresh water (also known as basal ground water) floating as a "lens" on underlying denser salt water. As rainfall, fog drip, and other surface waters infiltrate the ground, they recharge the lens and displace salt water. The result is that the water table is elevated relative to sea level, with a height that increases with distance from the coast. Nearer the coast, the lens thins as the elevation of the water table drops toward sea level. In coastal areas, the water level of the lens is impacted by daily tide changes, and is also influenced by seasonal or other variations in sea level.[11]

The freshwater lens, underlying the surface of each island, is the largest and most exploited aquifer type in Hawai'i

To ensure that the freshwater lens provides a reliable source of fresh water, "these aquifers must be carefully managed so that overpumping does not draw up the salty or 'brackish' water that is beneath the freshwater lens."[12] Even under natural conditions, the seaward flowing fresh water mixes with underlying salt water, to form a brackish "transition zone." The thickness of this transition zone is one measure of an aquifer's "health." This thickness depends on the physical properties of the aquifer, the amount of groundwater flow, tides and sea level, the distribution of wells pumping ground water from the aquifer, and the extent to which water mixes within the aquifer.[13]

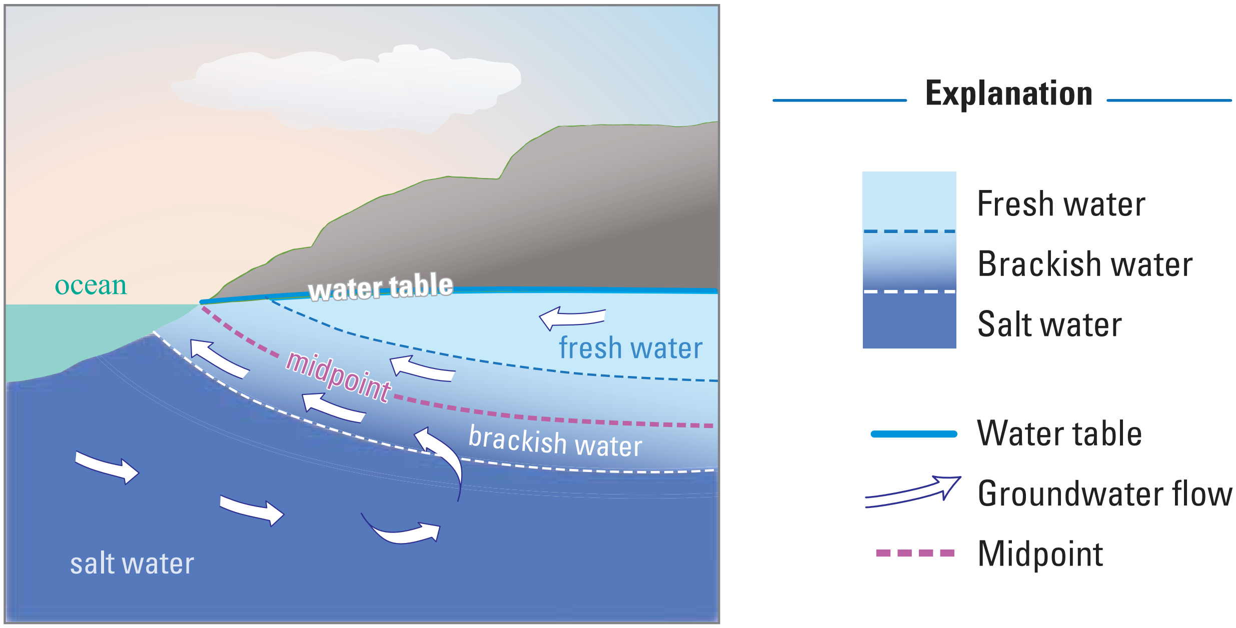
Chloride (i.e. salt) levels are another indicator of aquifer health, and are typically monitored at each production well to flag overpumping and indicate potential changes in the transition zone. Drinking water regulations suggest that 250 milligrams per liter is the upper acceptable limit for chloride levels in potable water.[14] However, lower chloride levels are preferable. For example, the Honolulu Board of Water Supply prefers to distribute water containing less than 160 milligrams per liter.[15] Non-potable water, with higher concentrations of chloride or other solutes, can be used in some contexts, such as irrigation of salt-tolerant species, or as a component to blend with fresh water.

The volcanic geology and geography of each island also forms other types of aquifers, such as *dike-impounded aquifers*[i] and *perched systems*.[ii] For example, much of the water collected from the windward side of O'ahu is through tunnels that penetrate dikes and withdraw the impounded water.[16] Perched systems are generally smaller in size and extent than the other aquifer types. However, they have been an important source

[i] An elevated water table trapped between tabular sheets of volcanic rock that block or slow the flow of ground water to create an elevated water table.

[ii] An elevated water table formed where low-permeability rock slows the downward movement of water.

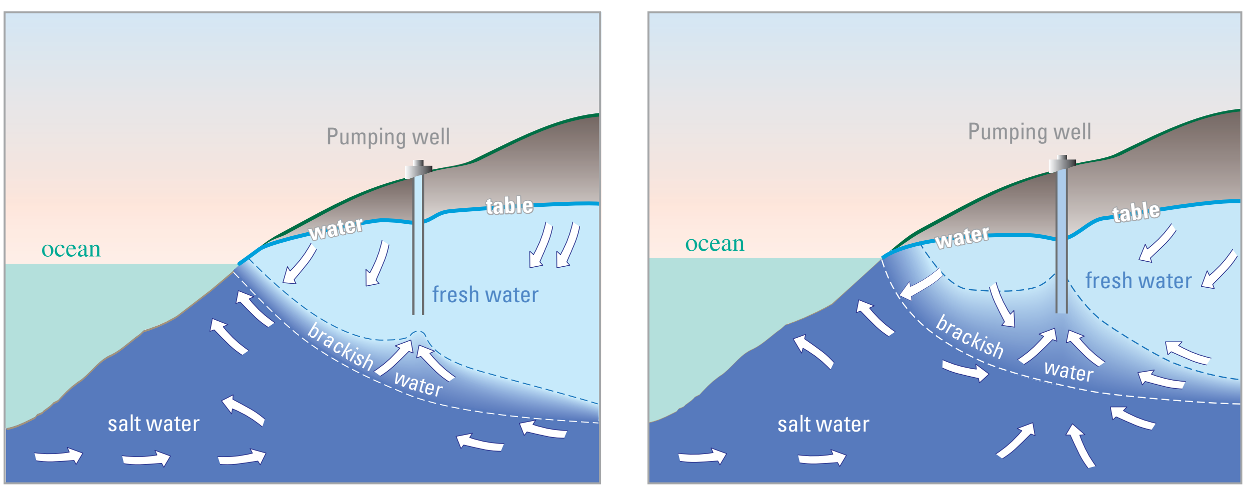
Figure 3a. Typical Freshwater Lens System, Showing a "Transition Zone" of Brackish Water



U.S. Geological Survey illustration of a typical freshwater lens system, showing a transition zone from salty to fresh water.

Courtesy of U.S. Geological Survey, Pacific Water Science Center. Reproduced from G. W. Tribble, *Ground Water on Tropical Pacific Islands—Understanding a Vital Resource: U.S. Geological Survey Circular 1312* 1, 24 (2008), available at http://pubs.usgs.gov/circ/1312/.

Figure 3b. The Effects of Overpumping Ground Water



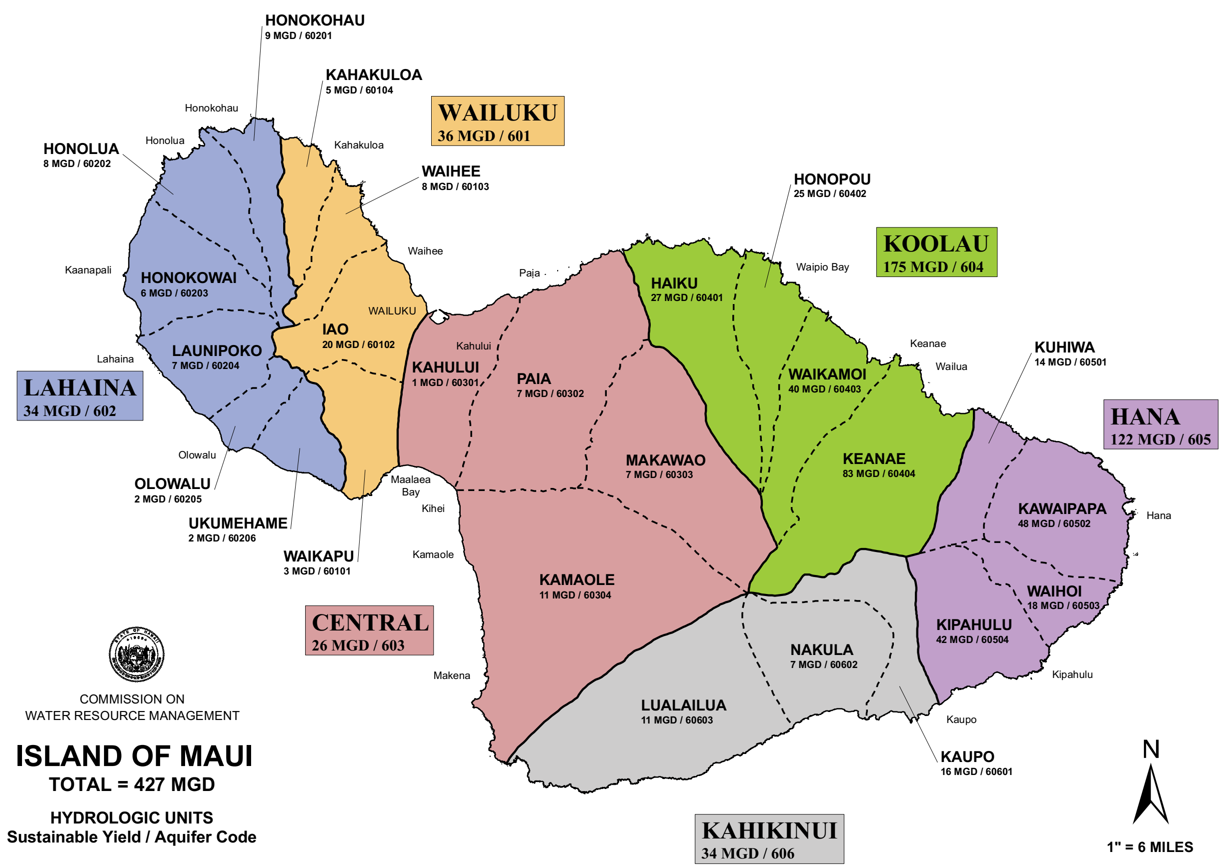
U.S. Geological Survey illustration of overpumping causing a rising transition zone and increasing salinity near the pump.

Courtesy of U.S. Geological Survey, Pacific Water Science Center. Reproduced from G. W. Tribble, *Ground Water on Tropical Pacific Islands—Understanding a Vital Resource: U.S. Geological Survey Circular 1312* 1, 24 (2008), available at http://pubs.usgs.gov/circ/1312/.

of water supply to rural communities, and they were utilized by early Hawaiians to store surface runoff for brief periods.[17] Other various types of low-permeability geologic structures may also slow the flow of ground water, and create high-level ground water. These include, for example, the central plateau of O'ahu, and the Waimea area on the Island of Hawai'i.[18] Dike-impounded and perched systems are typical sources of perennial base flow for high elevation streams.[19] The remaining water (if not removed) eventually infiltrates past the low-permeability layer, and contributes to the lower freshwater lens system (part of the "recharge" process described below).[20]

The composite structure of each island's geologic features results in intricate systems, combining different aquifers in various states of interconnectedness. These groundwater systems are similarly connected to each island's surface water system. For the purpose of water management, each island is divided into several "hydrologic units," which roughly correspond to the distribution of these surface watersheds or groundwater basins.

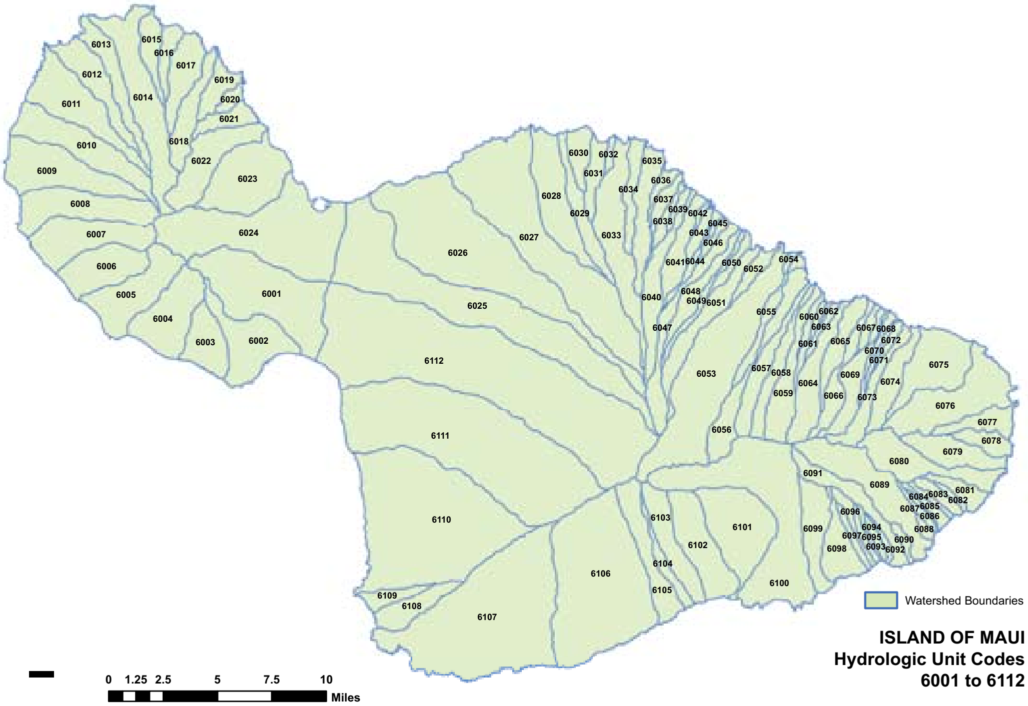
Figure 4a. Groundwater Hydrologic Units, Maui



For water management purposes, Maui's groundwater resources are divided into the illustrated hydrologic units, roughly corresponding to groundwater basins.

Courtesy of State of Hawai'i Commission on Water Resource Management. Reproduced from *Water Resource Protection Plan* (2008), available at http://hawaii.gov/dlnr/cwrm/planning_wrpp.htm.

Figure 4b. Surface Water Hydrologic Units, Maui



Maui's surface water resources are also divided into hydrologic units, roughly corresponding to surface watersheds.

Courtesy of State of Hawai'i Commission on Water Resource Management. Reproduced from *Water Resource Protection Plan* (2008), available at http://hawaii.gov/dlnr/cwrm/planning_wrpp.htm.

1.1.3 Recharge

The delivery of water from the earth's surface to groundwater aquifers is termed recharge, often expressed as the rate of delivery (millions of gallons per day) in a given area. Overall, recharge is tied to top-level inputs from rainfall and fog drip. However, a number of other factors also affect recharge in a particular area. These include local climate, soils, vegetation, surface runoff patterns, and the interconnected geologic formations that make up the recharge and aquifer system. Generally, the inland mountain regions from 2000 to 6000 feet, where rainfall is highest, are critical recharge areas.

Human intervention in the hydrologic cycle adds an additional layer of complexity to recharge rates. For example, agricultural irrigation can be a significant contributor to recharge. This is especially important in current-day Hawai'i, where irrigation in many areas has decreased over the past forty years, due to a shift away from sugarcane production, and a move toward more efficient drip irrigation systems.[21] From a combination of declining agricultural land use, more efficient irrigation methods, and low rainfall, estimated groundwater recharge decreased 44 percent from 1979 to 2004 in central and west Maui.[22]

The overall impact of these types of land use changes is even more complex. For example, if water formerly used for agriculture is reinvested to restore natural stream flow, areas of reduced agriculture may see *lower* recharge rates, while seepage through streambeds may contribute to *higher* recharge rates in the restored areas.[23] Other human activities, such as wastewater reuse, storm water reclamation, and direct re-injection into wells, can also contribute to recharge, although important concerns about groundwater contamination can be an obstacle to these types of groundwater augmentation.[24]

All ground water and surface water eventually flows back into the ocean, or escapes back into the atmosphere as water vapor; necessary steps in completing the hydrologic cycle.[25]

1.2 A Snapshot of Present and Future Freshwater Use in Hawai‘i

Relatively abundant groundwater and surface water resources are a major factor in the Hawaiian Islands' ability to sustain a relatively large population. However, it is obvious that these resources are finite. To better understand the constraints on water resource management, we briefly review the present and future use of fresh water.

Because of challenges associated with collecting accurate water use data from all users, it is difficult to accurately assess, in the aggregate, freshwater demand. Groundwater pumpage reporting on Kaua‘i and Moloka‘i appears particularly ill-suited to this task, and the other islands presently suffer gaps in reporting and data.[26] Assessing future demand is also made difficult because it is impossible to perfectly predict population growth. But, these challenges aside, available projections indicate that the population, and its demand for fresh water, are increasing:

Table 2. Projected Growth in Freshwater Demand and Population, by Island (million gallons per day, "mgd")

	2010	2015	2020	2025	2030	% Increase, 2010 to 2030
Kaua‘i						
Water demand	16.16	17.00	17.79	18.74	19.70	22%
Population	67,091				78,880	18%
O‘ahu						
Water demand	164.28	176.84	185.21	195.68	206.15	25%
Population	953,207				1,017,600	7%
Maui						
Water demand	35.61	39.05	42.39	45.99	49.70	40%
Population	144,444				176,597	22%
Moloka‘i						
Water demand	0.86	0.89	0.92	0.95	0.99	15%
Population	7,345				9,090	24%
Lāna‘i						
Water demand	1.67	1.86	2.05	2.24	2.42	45%
Population	3,193				3,832	20%
Hawai‘i						
Water demand	97.79	108.89	121.57	135.98	148.71	52%
Population	185,079				261,800	41%
TOTAL						
Water demand	316.4				427.7	35%
Population	1,360,359				1,547,799	14%

Adapted from Table 6-16, 2008 State of Hawai‘i Water Resource Protection Plan, using population data from the 2010 U.S. Census, and projected population from the State of Hawai‘i.[27]

For every island except Moloka‘i, water demand is expected to grow faster than population. This projected demand increase is significant, ranging from 15 percent to more than 50 percent, over 20 years. And it is not clear that these projections account for potentially huge increases in water demand—such as for bioenergy production from water-thirsty crops. Indeed, flat or falling water demand in various areas over the last 30 years is widely attributed to the decline of large plantation industries (such as sugar), and to more efficient agricultural irrigation.

Some Hawai‘i aquifers are already being drawn at, or above, their estimated sustainable yield

Moreover, this aggregated picture does not tell the complete story. Because of spatial variability in rainfall, surface water, and aquifer systems, the *sustainable yield*[iii] is specific to a particular water source. Some individual aquifers are already being drawn at, or above, their estimated sustainable yield. For more detail, we examine several individual areas of concern on the islands of Maui, O‘ahu, and Moloka‘i. Unsurprisingly, these three islands are also home to several particularly difficult disputes regarding water allocation.

Maui

The ‘Iao and Waihe‘e aquifer systems provide most of the public water supply for Maui County. The Mokuhau Well field, drawing from the ‘Iao aquifer, has experienced a problematic history. Historically, chloride levels ranged from about 20 to 90 milligrams per liter, but from 1977 onward, chloride levels generally rose.[iv] From 1988 onward, chloride levels monitored at Well Number 2 routinely exceeded the maximum recommended potable level of 250 milligrams per liter, and rose to over 400 milligrams per liter by 1995.[28] A similarly worrisome trend was observed in water levels. Between the 1950s (when pumping started) and late 1990s, the water levels in the Mokuhau Well field fell substantially.[29] Pumping at Well Number 2 was discontinued in 1996. In addition to pumpage, studies have shown that the water levels in ‘Iao wells also correlated to mean rainfall over the preceding twelve months.[30] This is particularly noteworthy, in light of observed declining rainfall in Hawai‘i.

Another well, Waiehu Heights Number 1, has also recently experienced problems, with chloride levels reaching approximately twice the recommended potable limit around 2006. After a dramatic decrease in

[iii] As discussed in more detail in Section 4.2.1, *sustainable yield* is defined as “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.” Haw. Rev. Stat. § 174C-3. The Commission on Water Resource Management estimates a sustainable yield for each hydrologic system using a mathematical model tied to salinity profiles measured at wells around the state. *See 2008 Water Resource Protection Plan*, *supra* note 1, at 3-43 to -56.

For surface waters, regulators utilize an analogous concept: the *instream flow standard* is “a quantity or flow 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.” Haw. Rev. Stat. § 174C-3.

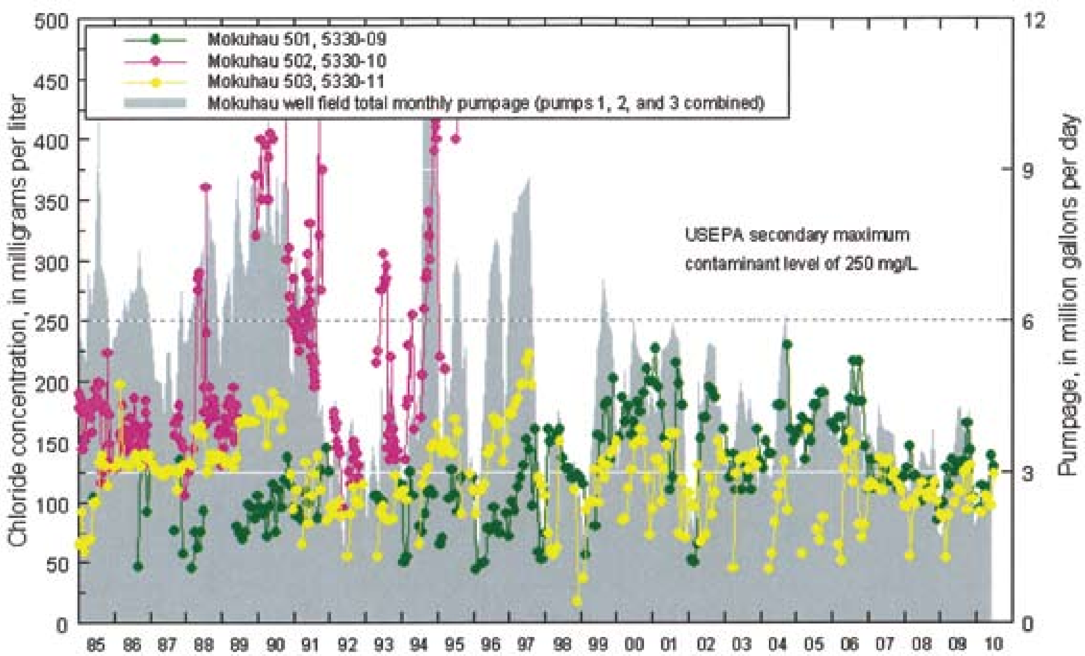
[iv] “Causes for changes in chloride concentration of the pumped water over time can be a function of pumping rate of the particular well, pumping at nearby wells, depth of the well, and overall aquifer trends. Therefore, the evaluation of aquifer conditions based on chloride concentration trends from the pumping wells has limitations. If pumpage is held constant, however, changes in chloride concentration of water from a production well can be valuable for interpreting chloride concentration trends at that location.” *See* W. Meyer & T. K. Presley, *The Response of the Iao Aquifer to Ground Water Development, Rainfall, and Land-Use Practices Between 1940 and 1998, Island of Maui, Hawaii, U.S. Geological Survey Water-Resources Investigations Report 00-4223* 50 (2001), *available at* http://pubs.usgs.gov/wri/wri00-4223.

pumping, chloride levels initially fell. However, recent years have seen the chloride levels increasing again, and exceeding 250 milligrams per liter.[31] Several other well fields on Maui also are exhibiting steadily rising chloride levels, although not yet to the recommended potable limit (e.g. Waiheʻe, Kānoa, Shaft 33).[v]

Maui is experiencing pitched controversies over surface water diversions and stream flow standards

In addition to these groundwater issues, Maui is experiencing pitched controversies over surface water diversions and stream flow standards, and the State of Hawaiʻi Commission on Water Resource Management ("Water Commission") is presently addressing far more Maui-related petitions and contested hearings than for any other island. After climate change impacts and projected demand increase (40 percent over the next 20 years) are added to this mix, it is clear that careful water planning, stewardship, and climate adaptation are required.

Figure 5a. Chloride Concentrations at Mokuhau Well Field, Maui

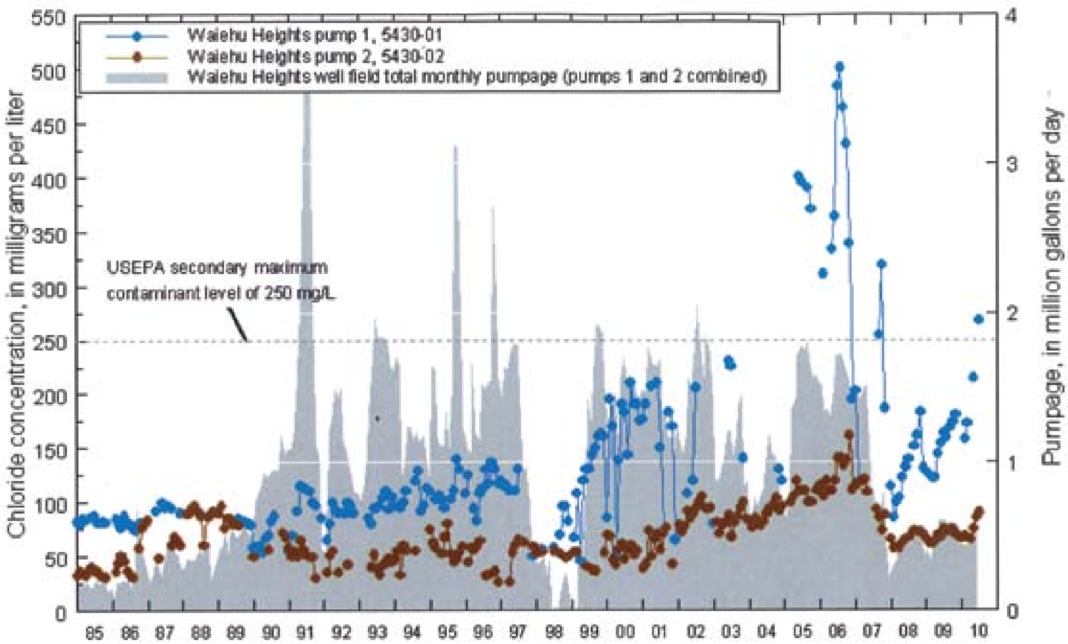


Chloride concentration at the Mokuhau Well field, showing chloride levels at pump No. 502 above 250 milligrams per liter, before pumping was stopped.

Courtesy of U.S. Geological Survey, Pacific Water Science Center. Reproduced from http://hi.water.usgs.gov/recent/iao/chloride.html.

[v] The depth and location of a particular well can contribute to the well's vulnerability to effects associated with overpumping and seawater intrusion. For example, "[t]he Waiehu Heights wells are more vulnerable to increased salinities because they penetrate deeper below sea level than other withdrawal wells…" and "[t]he Kanoa wells are more vulnerable to increased salinities because they are near the northern limit of the sedimentary caprock where the freshwater lens is thinner and less isolated from the ocean." *See* S. B. Gingerich, *Ground-Water Availability in the Wailuku Area, Maui, Hawaiʻi, U.S. Geological Survey Scientific Investigations Report 2008–5236* 53, 61 (2008), *available at* http://pubs.usgs.gov/sir/2008/5236/.

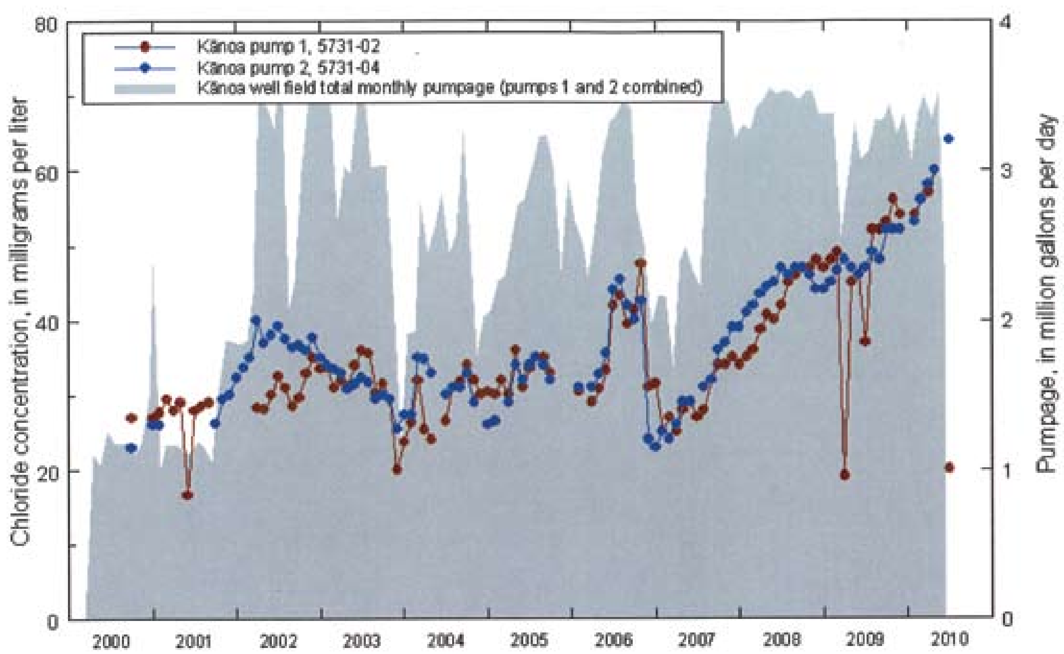
Figure 5b. Chloride Concentrations at Waiehu Heights Well Field, Maui



Chloride concentration at the Waiehu Heights Well field, showing chloride levels at pump No. 1 above 250 milligrams per liter, even after pumpage was reduced in 2007.

Courtesy of U.S. Geological Survey, Pacific Water Science Center. Reproduced from http://hi.water.usgs.gov/recent/iao/chloride.html.

Figure 5c. Chloride Concentrations at Kānoa Well Field, Maui



Chloride concentration at the Kānoa Well field, with an apparent upward trend since 2006.

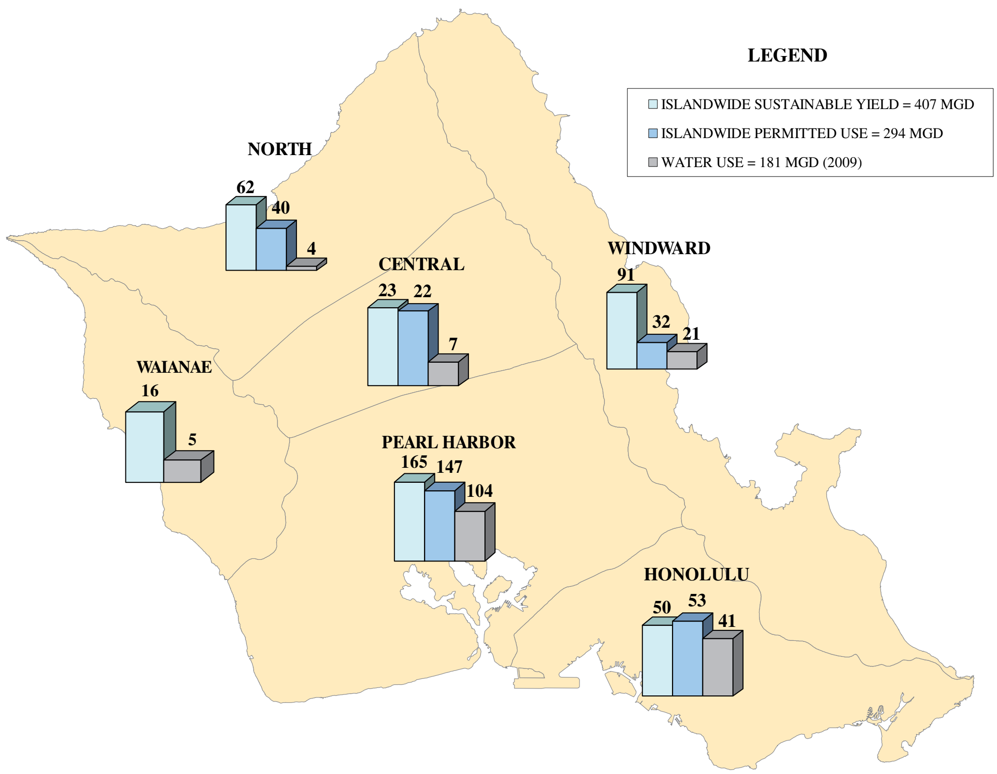
Courtesy of U.S. Geological Survey, Pacific Water Science Center. Reproduced from http://hi.water.usgs.gov/recent/iao/chloride.html.

O'ahu

There are eighteen freshwater aquifer systems in O'ahu's groundwater management areas. Among the ten systems in the Honolulu, Pearl Harbor, and Wahiawa regions—which together account for over 80 percent of the island's fresh ground water—existing water use permit allocations already account for approximately 90 percent of the estimated sustainable yield.[vi] In three of the remaining systems, water allocated to existing permits already accounts for more than 50 percent of sustainable yield.

The projected increase in demand (approximately 25 percent over the next 20 years) has important implications, and illustrates an immediate need to adapt to future conditions with water conservation and other measures. The Water Commission concluded, in 2008, that "[o]n Oahu, it is anticipated that groundwater resources will be committed within 20 or 30 years, requiring the use of more expensive alternatives like reusing

Figure 6. Sustainable Yield and Permitted Use, O'ahu



Honolulu Board of Water Supply figure showing permitted use approaching or exceeding the sustainable yield for several aquifer regions on O'ahu.

Courtesy of Honolulu Board of Water Supply.

[vi] Presently, permitted water allocation may slightly overestimate actual water usage because not all allocated water is withdrawn, and non-utilized permits may not have been revoked. *See, e.g., Ko'olau Loa WMP, supra* note 24, *at* table 3.1 (showing that for aquifer systems in the Ko'olau Loa watershed, permitted use exceeded actual use by approximately 20 percent in 2000). However, permitted allocations are compared to sustainable yield here because (i) the gap between permitted allocation and actual water use is likely to decrease as population and water demand grows, and (ii) comprehensive and updated information regarding actual water use is difficult to obtain, especially across different water use sectors, such as agriculture.

treated wastewater, treating surface water, and desalinating brackish or ocean water."[32] Already, Oʻahu was the site of the seminal and protracted Waiāhole Ditch dispute, concerning diversions from streams and dike-impounded groundwater systems in windward Oʻahu.[33]

Molokaʻi

In the sixteen aquifer systems that cover the island-wide Molokaʻi water management area, the Kualāpuʻu aquifer system is the most heavily utilized, at about 2.1 million gallons per day. Existing water use permits account for 97 percent of its sustainable yield (although presently, the reported use is significantly less).[34] Molokaʻi is home to recent disputes over water allocation, resulting in the Hawaiʻi Supreme Court's review of decisions by the Water Commission in two cases.[35]

Other Islands

In addition to these specifically identified areas, other areas and communities are also vulnerable to climate change-related risks. For example, an estimated 30,000 to 60,000 people in Hawaiʻi depend on rain catchment for their water supply.[36] The majority of those people are located on the Island of Hawaiʻi, in the Puna, Kaʻu, and Hāmākua districts. The efficacy of rain catchment is obviously directly tied to rainfall. During periods of drought, catchment users often must rely on imported water, including tankers and bottled water.[37]

Climate phenomena, such as increased storm intensity and rising sea level, can threaten every community by exacerbating infrastructure problems

And every community is susceptible to water infrastructure breakdown. On Kauaʻi, where "most of the county's water systems are operating near their capacity,"[38] a November 2011 electrical problem at the Kalaheo Well prevented pumps from refilling a storage tank. Users were instructed to limit water use to "essential needs."[39] In the same week, a power outage on Maui knocked out wells in Waiheʻe and Waiehu, affecting roughly half the water supply for the Central/South Maui water system. Users were asked to conserve water and turn off irrigation systems. In one of the county tanks, the water level fell to 1.5 feet before pumping was restored.[40] Climate phenomena, such as increased storm intensity and rising sea level, can threaten every community by exacerbating these types of infrastructure problems.

1.3 Observed Climate Trends and Impacts on Hawaiʻi's Water Resources

The above snapshot of Hawaiʻi's water cycle and water uses illustrate that although Hawaiʻi enjoys relatively abundant resources, a variety of factors contribute to present and future stresses on those resources. Unlike some other locations, Hawaiʻi's isolated island communities cannot respond to a water emergency by simply transporting water from elsewhere. Maintaining sustainable water resources into the indefinite future is an obvious and urgent priority for government, business, and private parties.

Climate change further sharpens this need for careful water management. The Hawaiʻi Legislature, like governments and scientists all around the world, has recognized that "climate change poses a serious threat to the economic well-being, public health, natural resources, and the environment of Hawaiʻi."[41] The particular risks of climate change impacts on water resources in Hawaiʻi are also well recognized.[42] These conclusions are entirely consistent with recent scientific observations of Hawaiʻi's climate:

Declining Rainfall. Rainfall in Hawaiʻi has steadily trended downward. From 1933 to 2002, twelve of fourteen rain gauge stations, spanning every island, observed declining rainfall.[43] Other studies similarly measured declining rainfall from 1980 through 2000.[44] Scientists continue to work on refining global models for future climate change, and applying them to the Hawaiʻi region; one such recent study projected a continuing decline in rainfall.[45]

Declining Stream Flow. The decline in rainfall is consistent with a similar downward trend in base flow (i.e. the flow of ground water into streams). This decline was observed in streams around the state from 1940 to 2002.[46] This trend has alarming implications for Hawaiʻi's water resources; declining rainfall means less stream flow and lower groundwater recharge rates.[vii] Hawaiʻi's water budget is fundamentally changing.

Rising Sea Level. Sea level in Hawaiʻi has risen approximately 0.6 inches or more per decade over the last century.[47] Globally, the rate of sea-level rise has accelerated (doubling since 1990), such that a rise of 3 feet or more is expected by 2100.[48] In Hawaiʻi, rising sea level is expected to alter the transition zone between fresh and salt water, increasing seawater intrusion into coastal aquifers and wells.

Rising Air Temperatures. Hawaiʻi also is getting warmer. Air temperature data shows an upward trend, especially pronounced in the last 30 to 40 years (approximately 0.16 °F per decade). This is lower than the global trend (0.36 °F per decade). However, at higher elevations—areas critical to cloud formation and recharge—the rate in Hawaiʻi is faster (0.48 °F per decade).[49] Other physical processes related to this warming can also have important impacts. For example, scientists infer that rising temperatures and changing atmospheric cycles may result in a shallower cloud zone, due to: (i) a potential decline in the height of a the trade wind inversion, which controls the top of the cloud layer; and (ii) a potential rise in the lifting condensation level, or the height at which water condenses in rising air.[50] A thinning cloud layer threatens a cascade of resulting effects, such as declining fog drip, changes in vegetation (triggering a potential *feedback loop*,[viii] because vegetation can impact runoff and soil infiltration),[ix] and overall lower recharge rates. Higher temperatures also could lead to

[vii] The specific effect on recharge depends on a complex mix of factors including soil type, vegetation, and the timing and duration of rainfall events. *See* G. H. C. Ng et al., *Probabilistic Analysis of the Effects of Climate Change on Ground Water Recharge*, 46 Water Res. Research W07502 (2010).

[viii] *Feedback loops* are a common consideration in climate science because feedback can affect the intensity of climate phenomena. A feedback loop is an interaction between processes in the climate system, whereby the "result of an initial process triggers changes in a second process, that in turn influences the first one. A positive feedback intensifies the original process, and negative feedback reduces it." *See* Intergovernmental Panel on Climate Change, *Fourth Assessment Report*, Annex 1 Glossary 943 (2007), *available at* http://www.ipcc.ch/pdf/glossary/ar4-wg1.pdf (entry for "climate feedback").

[ix] For example, overgrazing and erosion on Kahoʻolawe upset its water balance by increasing surface runoff and decreasing soil infiltration and aquifer recharge. *See generally* K. J. Takasaki, *Water Resources of the Island of Kahoolawe, Hawaii: Preliminary Findings, U.S. Geological Survey Water-Resources Investigations Report 89-4209* (1991), *available at* http://pubs.er.usgs.gov/publication/wri894209.

increased water demand by users,[51] and to changes in the rates of evaporation and transpiration (the return of water vapor to the air by plants).[52]

The picture is clear—Hawai‘i is feeling the effects of climate change. These observed changes are also consistent with other climate-related trends in and around Hawai‘i, such as increasing sea surface temperatures, and ocean acidification.[53] And scientists continue to monitor and investigate other potential hazards of climate change. The most serious threats include: (i) changes in the trade wind regime that is so key to Hawai‘i's orographic rainfall; (ii) changes in the frequency and intensity of storm events (a phenomenon being observed elsewhere in the world); and (iii) longer or more frequent droughts, interspersed with intense storm events associated with increased runoff and lower groundwater recharge.[54]

The picture is clear—Hawai‘i is feeling the effects of climate change

These observations and risks demand immediate action. Responses include *mitigation*—attempting to limit the magnitude of future climate change, and *adaptation*—working to enhance Hawai‘i's resilience to climate change impacts that, at this stage, are unavoidable.

2. General Principles of Climate Change Adaptation

Adapting to shifts and variability in climate obviously is not a new human endeavor. In Hawai‘i, for example, traditional practices have included monitoring local changes in wind patterns and *limu* (seaweed) growth, as signals of coming drought.[55] In contrast, failure to adapt to climate variability and its effect on water resources has been linked to the collapse of entire societies elsewhere.[56]

Climate Adaptation Means

(1) Ensuring that existing laws, policies, and procedures account for climate trends, variability, and uncertainty.

(2) In the future, maintaining the flexibility to act on new information from climate scientists.

(3) Routinely considering how the future climate may affect the outcomes of decisions, and using that understanding to make more informed decisions.

Box 1

2.1 Adaptive Resource Management Describes Laws and Policies That Promote Sustainability and Resilience in the Face of Climate Change Impacts

The goal of adaptive resource management is to increase *resilience* and reduce *vulnerability* to climate change-related risks.[x] From a law and policy perspective, this primarily means: (1) ensuring that current policies and procedures account for climate trends,

[x] In this context, *resilience* means the ability to respond to negative impacts of climate change on the availability and sustainability of natural resource systems, the ability to return the resource to a sustainable state, and the ability to ensure that the resource and human communities recover from any such impacts relatively quickly. *Vulnerability* means the initial susceptibility of resources and human communities to such negative impacts from climate change.

variability, and uncertainty; and (2) ensuring that, when decision-makers receive new information from climate scientists in the future, they can appropriately act on that information with the policies and procedures in place.[57] A United Nations case study on climate adaptation in London summarizes adaption particularly well; to paraphrase—adaptation is not just about creating new policies, but about routinely considering how the future climate may affect the outcomes of decisions and using that understanding to make more informed decisions.[58]

Adaptation is not just about creating new policies, but about routinely considering how the future climate may affect the outcomes of decisions and using that understanding to make more informed decisions

Increasing awareness of climate-related risks has led to a rapid increase in the number of scholars and governments (federal,[59] state,[60] and local[61]) studying the ways in which the management of natural resources can adapt to those risks. This field is generally termed "adaptive resource management." Cities and states across the United States and the rest of the world are working on this type of climate adaptation. Examples include: California, Washington, New York, Alaska, San Francisco, San Diego, Salt Lake City, Chicago, London, and Melbourne, among others.

2.2 "Adaptation" vs. "Mitigation"

"Adaptation"[xi] is not the same as climate change "mitigation," although the phrases are sometimes interchanged. Mitigation efforts, such as laws seeking to reduce greenhouse gas emissions, focus on ways that human responses might reduce anthropogenic (human-caused) drivers of climate change. In Hawai'i, climate change legislation to date has primarily focused on mitigation; in 2007 the state's Global Warming Solutions Act (Act 234) declared a policy of reducing greenhouse gas emissions to 1990 levels by 2020.[62]

Adaptation supplements, but does not replace, mitigation. Adaptive measures are receiving increasing attention. Among other reasons, it is well recognized that mitigation can only reduce, but cannot entirely avoid, the impacts of climate change. In addition, climate change is largely a "no-analog" issue—it implicates changes at scales and rates that are unprecedented in the human experience.[63] Mitigation measures are therefore only a partial response.

2.3 Four Characteristics of Adaptive Management

In the face of a "no-analog" future, scholars and governments have concluded that innovative and adaptive management strategies are required to ensure the sustainability of critical resources, such as water.[64] Thus, climate adaptation has been analyzed in many different contexts, such as water resources, agriculture, energy development, habitat protection, and coastal zone management. And as a result, many different formulations of adaptation have been developed. Surveying this work reveals that the meaning of "adaptive" is highly con-

[xi] The Intergovernmental Panel on Climate Change ("IPCC") has defined climate adaptation as "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities." *See Climate Change 2007: Impacts, Adaptation, and Vulnerability: Contribution of Working Group II to the Fourth Assessment Report of the IPCC* 6 (2007).

text-specific, depending on the location and nature of the resource being managed, and the nature of the risks to that resource.

However, several fundamental characteristics are woven throughout many different formulations of adaptation. These fundamental "adaptive characteristics" are:

(1) ***Forward-looking.*** There is general agreement that climate change adaptation requires management techniques that are forward-looking, with a focus on long-range planning, and a preference for crisis avoidance over crisis mitigation. A number of water utilities across the country have similarly recognized that:

> Traditionally, water resource planning has used recorded weather and hydrology to represent future supply conditions.… It was assumed that the hydrologic determinates of future water resources—temperature, precipitation, streamflow, ground water, evaporation, and other weather dependant factors—would be the same as they had been in the past. While there may have been large variations in observed weather, it was assumed that weather statistics would stay the same and variability would not increase in the future. This core planning assumption is often referred to as *climate stationarity.*[65]

Climate change disrupts that assumption. Management techniques that rely too heavily on historical observations to inform decision-making will lack the capacity to address "no-analog" climate change scenarios.[66] In the face of such changes, prudent water resource planning must consider the long-term impacts of climate change on the sustainability of water resources. [67]

(2) ***Flexible.*** Predictions of future climate conditions inherently involve some degree of uncertainty. Thus, adaptive management must acknowledge a lack of complete understanding of the resource being managed.[68] Nonetheless, decisions must be made now.[69] Adaptation requires that once an uncertainty is resolved, for example by the introduction of new scientific data, prior decisions can be revisited. The management scheme must be flexible to allow for such revision.

(3) ***Integrated.*** Climate change implicates systemic threats that cut across existing physical boundaries and political divisions. Thus, adaptive management favors integrated solutions and policies, over piecemeal ones.[70]

(4) ***Iterative.*** The uncertainty, variability, and potentially devastating effects of climate change require vigilant awareness of changing conditions. Thus, adaptation starts with ongoing monitoring, reporting, and evaluation of the resource being managed, and of climate trends and effects. Then, this information is incorporated into management decisions, in an ongoing feedback cycle.[71]

Together, these four characteristics define management techniques with: (i) the capacity to understand the effects of climate change on the resource being managed; and (ii) the ability to use that understanding to inform future decisions, and to revise past ones.

2.4 Adaptation as a State and Local Function and an Opportunity for Economic Benefit

In contrast to climate mitigation, which often starts at broader international or national levels, adaptation has much closer ties to state and local decision-making.[72] Researchers have noted a variety of factors driving this phenomenon.

First, state and local governments, businesses, and private citizens are on the "front line" of climate change.[73] The immediate economic and societal impacts of climate change (such as increased infrastructure costs, reduced access to resources, and physical damage) are primarily local, rather than national. Second, state and local governments regularly make resource management decisions with long-term local implications; "today's choices will shape tomorrow's vulnerabilities."[74] Third, preparing for climate change, by adopting adaptive strategies to reduce vulnerability, can lower the future costs of climate response and mitigation—costs that would otherwise have significant impact at the state and local levels. Fourth, the available choices may be greater when "preparing for, rather than reacting to, climate change."[75]

The immediate economic and societal impacts of climate change (such as increased infrastructure costs, reduced access to resources, and physical damage) are primarily local

And finally, implementing adaptive strategies can have immediate co-benefits at the community level.[76] For example, water conservation efforts, an adaptive preparation for drought risk, can also (i) reduce present-day energy and infrastructure costs; (ii) lower wastewater discharge; and (iii) preserve natural stream environments for habitat, protected uses, and recreational purposes. Alternate measures, such as desalinating seawater (or brackish ground water) to replace unsustainably managed ground and surface water, can be a more expensive approach. Desalination is energy-intensive; it requires the construction of new infrastructure in the valuable coastal zone, and presents problematic issues associated with habitat destruction, salt disposal, and other impacts.[77] Thus, the initial capital costs for desalination in Hawai'i are "high."[78] Added to this, economists have estimated that the ongoing cost of desalination in Hawai'i is as high as $7 per thousand gallons.[79] For comparison, the Honolulu Board of Water Supply retail rate for ordinary domestic use is presently $2.79 per thousand gallons. A proposed rate increase, to approximately $4.42 by 2015, has recently invoked a firestorm of public comment. The cost for recycled wastewater for industrial users in the Pearl Harbor areas is approximately $4-5 per thousand gallons.[80]

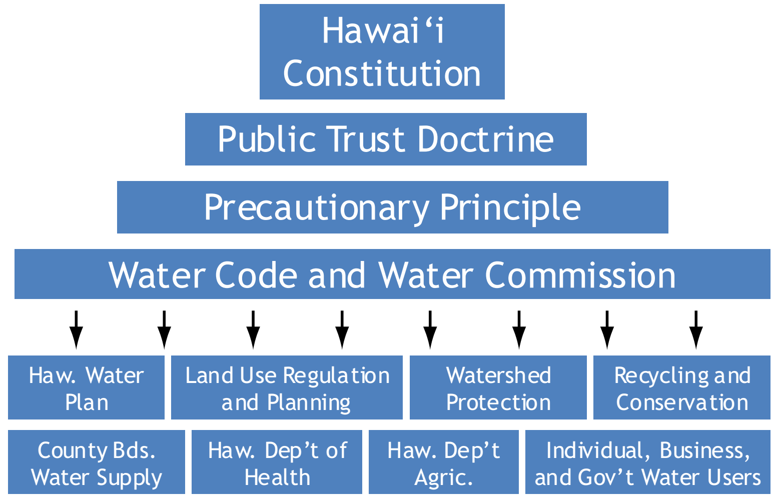
Avoiding the need to supplement groundwater systems, and instead protecting existing watersheds and their valuable contribution to groundwater recharge, thus has a potentially substantial economic and political benefit.[81]

3. Adaptive Tools and Mandates in Hawai'i's Current Law and Policy Framework

To implement adaptive resource management strategies, scholars often recommend a first step of reviewing the legal system to identify barriers to adaptation, and then removing those barriers by adopting a foundational legal and policy framework that can accommodate adaptive characteristics and tools. In many respects, that initial barrier has already been crossed in Hawai'i. Close inspection of Hawai'i's legal framework for water resource management demonstrates that it *mandates* an adaptive approach.

The following analysis does not attempt to outline the entire scope of water management in Hawai'i; instead, it highlights portions of existing laws, policies, and tools that are particularly relevant to adaptive water resource management. Those laws and policies also can support, in varying degrees, implementation of additional adaptive tools and policies, such as those identified in Section 4 of this paper.[xii]

Figure 7. Law and Policy Framework for Water Resource Management in Hawai'i



In brief, Hawai'i's mandate for adaptive management starts with the overlay of express constitutional provisions that require the "protection" and "conservation" of water resources. This focus on preservation is bolstered by the state's public trust over all water resources. At their core, these mandates are adaptive. For example, the Hawai'i Supreme Court has described the legal framework for water resource management as forward-looking, with a "*global, long-term perspective*." That framework, by "*its very nature, does not remain fixed for all time, but must conform to changing needs and conditions*." Furthermore, this framework is required to be implemented in an integrated fashion, with a single agency (the Water Commission) acting as the primary guardian over all water resources and water uses. As a result, the State Water Code and related plans and regulations contain a variety of provisions that empower adaptive management techniques.

3.1 Constitutional Protection of Water Resources

Under a variety of provisions adopted through the landmark state constitutional amendments in 1978, the Hawai'i Constitution expressly protects water resources in a number of ways. All of these protections are relevant to the potentially devastating impact of climate change on water resources.

[xii] In 1994 this legal framework was described in detail in conjunction with a legislatively mandated review of the first five years of water resource management under the 1987 State Water Code. *See* State Water Code, Act 45 § 5., 1987 Haw. Sess. Laws Vol. 1, 101 (codified at Haw. Rev. Stat. §174C); *see also* Review Comm'n on the State Water Code, State of Haw., Study of Laws, Administrative Rules, and Regulations Relating to the Protection, Regulation, and Management of Water Resources in Hawai'i (1994).

The description and analysis presented here essentially update the 1994 review, as of 2011, and fill in questions that have been answered in the intervening 17 years—with special emphasis on climate change adaptation.

3.1.1 Article XI – Constitutional Mandates for the Conservation and Protection of Water Resources

Article XI, Section I of the Hawai'i Constitution mandates that the state and its political subdivisions "shall conserve and protect" all natural resources, expressly including water resources. This protection is for "the benefit of present and future generations." At a fundamental level, the Hawai'i Constitution thus imposes a mandate of conservation and protection, on an intergenerational timescale.[82] This is exactly the type of forward-looking focus, on long-term sustainability that characterizes adaptive management.

In addition, water is the only natural resource treated with its own section of the constitution. Article XI, Section 7 establishes a mechanism for the required protection of water resources, and clarifies 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 is required to "establish a water resources agency" which is responsible for establishing "procedures for regulating all uses of Hawai'i's water resources," including:

- Setting overall water conservation, quality, and use policies;
- Defining beneficial and reasonable uses;
- Protecting ground and surface water resources, watersheds and natural stream environments; and
- Establishing criteria for water use priorities.

Once again, these remarkable Constititional provisions illustrate Hawai'i's adaptation-friendly approach to water resource management. The broad mandate of a water resource agency, to "establish procedures for regulating *all uses* of Hawai'i's water resources," is inherently an integrated approach, rather than a piecemeal one. As further described below, the product of this Section 7 is the Water Commission and the State Water Code.

Conservation and Development of Resources

For the benefit of present and future generations, the State and its political subdivisions **shall conserve and protect** Hawai'i's natural beauty and **all natural resources**, including land, **water**, air, minerals and energy sources, 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.

All public natural resources are held in trust by the State for the benefit of the people.

Haw. Const. Art. XI, § 1

Box 2

Water Resources

The State has an obligation to protect, control and regulate the use of Hawaii'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 Hawaii's water resources**.

Haw. Const. Art. XI, § 7

Box 3

This comprehensive and conservation-based approach to water resource management lies in stark contrast to some other jurisdictions, which may struggle to reconcile adaptive management with inchoate regulatory schemes, or incompatible water rights and priorities based in the *common law*.[xiii] In this way, Hawai‘i has been cited as an example of a potentially adaptation-ready legal framework.[83]

A third section of Article XI also has implications for water resource management. Article XI, Section 9 (Box 4) creates a constitutional right to a protected environment, through laws relating to "conservation, protection and enhancement of natural resources." This guarantee can be enforced through a private right of legal action, "against any party, public or private."[84] This right has important implications for environmental laws, such as natural resource protection. For example, the barrier of "standing" is substantially lowered in environmental rights cases.[85] Standing is a legal doctrine that requires every plaintiff to show that they have suffered an injury for which the law allows them to seek redress in the courts. In part because the constitution expressly allows a violation of environmental rights to comprise this injury, public enforcement is a hallmark in Hawai‘i environmental law. The public, and public interest groups, can assist in enforcing water resource management decisions and plans, and can also challenge those decisions, if they are not consistent with public rights.

Environmental Rights

Each person has the right to a clean and healthful environment, as defined by laws relating to environmental quality, including control of pollution and **conservation, protection and enhancement of natural resources**. **Any person may enforce this right against any party, public or private, through appropriate legal proceedings**, subject to reasonable limitations and regulation as provided by law.

Haw. Const. Art. XI, § 9

Box 4

3.1.2 Article XII – Constitutional Protection of Traditional and Customary Rights

The Hawai‘i Constitution, in Article XII Section 7 (Box 5), protects the traditional and customary rights of Native Hawaiians. A number of such rights are closely tied to water resources. Indeed, these close ties are reflected by the fact that in ‘ōlelo Hawai‘i (the Hawaiian language), the terms for law (kānāwai) and wealth (waiwai) are rooted in water (wai).[86]

As a result of the close connection between water resources and traditional and customary rights, the water resource management scheme in

Traditional and Customary Rights

The State reaffirms and **shall protect** all rights, customarily and traditionally exercised for subsistence, cultural and religious purposes and possessed by ahupua‘a tenants who are descendants of native Hawaiians who inhabited the Hawaiian Islands prior to 1778, subject to the right of the State to regulate such rights.

Haw. Const. Art. XII, § 7

Box 5

[xiii] *Common law* is the body of law based on decisions by courts through time, rather than law established by the legislature. Thus, in the water law context, the common law is contrasted against statutes such as Hawai‘i's comprehensive Water Code (Haw. Rev. Stat. Ch. 174C). Nonetheless, despite the enactment of the Water Code in Hawai‘i, certain aspects of the common law on water allocation and rights remain in place in certain areas of the state. This is described in more detail in Section 3.6 below.

Hawai'i incorporates specific protections for such rights.[87] The State Water Code (see Box 6; also described in more detail below in Section 3.5) identifies some examples of Native Hawaiian water rights that "shall not be abridged" by the water management scheme.[88] These examples include the cultivation of kalo (taro) and the gathering of various species of plants and animals.[89] The Water Code also requires that decisions related to the "planning for, regulation, management and conservation of water resources… shall incorporate and protect adequate reserves of water for current and foreseeable development and use of Hawaiian home lands…."[90]

The effects of climate change can impact these rights. Decreased stream flow, for example, presents a hazard for kalo cultivation, which typically relies on (but does not consume) a continuous flow of water.[91] Similarly, decreased stream flow and declining rainfall

Native Hawaiian Water Rights

Traditional and customary rights of ahupua'a 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, opae, o'opu, limu, thatch, ti leaf, aho cord, and medicinal plants for subsistence, cultural, and religious purposes.

Haw. Rev. Stat. § 174C-101(c)

Box 6

Photo: Zena Grecni

Lo'i kalo (taro pond fields) rely on, but generally do not consume, a continuous supply of flowing water.

can impact the habitats of endemic and culturally important species such as ʻoʻopu, ʻōpae, hīhīwai, hapawai, and pīpīwai.[92] According to the Department of Land and Natural Resources: "Maintaining the natural patterns of water flow in streams is the single most important requirement for protection of native Hawaiian stream animals."[93]

Thus, Article XII's protection of traditional and customary rights is interconnected with, and bolsters, Article XI's protection of water resources. And in the same fashion, this protective mandate inherently requires a forward-looking and adaptive approach to managing water resources in the face of climate change.

3.2 The Public Trust Doctrine

Both as a product of the constitutional provisions described above ("All public natural resources are held in trust by the State for the benefit of the people"), and as a product of Hawaiʻi's common law dating back at least to the Kingdom of Hawaiʻi,[94] the public trust doctrine is another fundamental overlay on water resource management in Hawaiʻi. In short, the public trust doctrine grants authority to—and imposes a duty upon—the state to serve as trustee and "ensure the continued availability and existence of its water resources for present and future generations."[95]

The doctrine and its effect on water resource management have been addressed by a number of Hawaiʻi Supreme Court decisions in the time since the 1978 constitutional amendments were adopted. Box 7 summarizes key characteristics of the doctrine under Hawaiʻi law.[96] Those characteristics illustrate numerous additional examples of Hawaiʻi's adaptation-friendly legal framework.[97]

The public trust encompasses four distinct purposes for water resources: (1) water resource protection; (2) domestic use protection; (3) protection of Native Hawaiian traditional and customary rights;[98] and (4) reservations in favor of the State Department of Hawaiian Home Lands.[99] These protected public rights in water resources are rendered "superior to the prevailing private interests in the resources at any given time."[100] Thus, the Hawaiʻi Supreme Court has sagely observed that

> the constitutional requirements of "protection" and "conservation," the historical and

Key Characteristics of Hawaiʻi's Public Trust Doctrine

- "requires planning and decisionmaking from a **global**, **long-term perspective**"
- "applies to **all water resources** without exception or distinction"
- "by its very nature, does not remain fixed for all time, but **must conform to changing needs and conditions**"
- "the policy of **comprehensive resource planning** [is] intrinsic to the public trust concept"
- requires that water resource management decisions must be "made with a level of **openness**, **diligence**, and **foresight** commensurate with the **high priority** that these rights command under the laws of our state"
- "well established" as a "**fundamental principle** of constitutional law in Hawaiʻi," and "its principles permeate the State Water Code"

Box 7 [96]

> continuing understanding of the trust as a guarantee of public rights, and the reality of the "zero-sum" game between competing water uses demand that any balancing between public and private purposes begin with a presumption in favor of public use, access, and enjoyment.[101]

The doctrine also imposes on the state an "affirmative duty to take the public trust into account in the planning and allocation of water resources."[102]

3.3 The Precautionary Principle

As a corollary to these constitutional provisions and the public trust doctrine, Hawai'i law also mandates the application of the *precautionary principle*, summarized in Box 8.[103] Although the precautionary principle is widely recognized in a variety of legal contexts, in Hawai'i its genesis is tied directly to water management. The specific formulation quoted in Box 8 originated in a decision rendered by the Water Commission, and was later adopted by the Hawai'i Supreme Court when it reviewed of the Water Commission's decision.[104]

> ### The Precautionary Principle
>
> "[W]here there are present or potential threats of serious damage, lack of full scientific certainty should not be a basis for postponing effective measures to prevent environmental degradation. Awaiting for certainty will often allow for only reactive, not preventative, regulatory action."
>
> Box 8 [103]

The principle also is particularly relevant to climate change, which as described in Section 1, presents a "potential threat of serious damage," to water resources, yet inherently involves a "lack of full scientific certainty" as to the particular scope and timing of that threat. The precautionary principle effectively advocates an adaptive approach. Adaptive measures are defined, in part, by this type of *a priori* acknowledgement that there is a lack of complete understanding of future changes to water resources. This is the key ingredient triggering the need for a preventative, flexible, and iterative approach that incorporates ongoing monitoring, data gathering, and evaluation as part of the management process.

Describing the principle further, the Hawai'i Supreme Court adapted the following from the "lodestar" opinion of another court, which it deemed "illuminating" in relation to the public interest in water resource management:[105]

> Regulators such as the Commission must be accorded flexibility, a flexibility that recognizes the special judicial interest in favor of protection of the health and welfare of the people, even in areas where certainty does not exist.
>
> Questions involving the environment are particularly prone to uncertainty. Yet the statutes—and common sense—demand regulatory action to prevent harm, even if the regulator is less than certain that harm is otherwise inevitable.

> Undoubtedly, certainty is the scientific ideal—to the extent that even science can be certain of its truth. Awaiting certainty, however, will often allow for only reactive, and not preventative, regulation. **[Some] suggest that anything less than certainty, that any speculation, is irresponsible. But when statutes seek to avoid environmental catastrophe, can preventative, albeit uncertain, decisions legitimately be so labeled?**[106]

It is apparent that the precautionary principle is a recognized precept at various levels in Hawai'i's water resource management system. For example, the Honolulu Board of Water Supply has described the central elements of the principle. Quoting from its most recent Watershed Management Plans:

- 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.[107]

Plainly, these goals are adaptive in nature, and if implemented, can increase resilience to climate change.[xiv]

[xiv] Note that in other contexts and jurisdictions, the precautionary principle can also have other meanings and implications. For example, the principle can require that the proponent of a regulated activity must bear the burden of proof on issues such as threats to human health or the environment. *See, e.g.*, C. R. Sunstein, *Beyond the Precautionary Principle*, 151 Univ. Penn. L. Rev. 1003 (2003) (working version *available at* http://www.law.uchicago.edu/files/files/38.crs_.precautionary.pl-lt.pdf). This burden-shifting is not always associated with the precautionary principle in Hawai'i, although under the State Water Code, water use permit applicants face the burden of demonstrating that the proposed water use can be accommodated by the existing water supply. *See infra* Section 3.6.1. Some commentators, like Professor Sunstein, have attacked strict formulations of the precautionary principle for imparting a paralyzing effect on the decisions of regulators and stakeholders alike. But even Professor Sunstein describes formulations such as Hawai'i's, which allow for regulation even in the face of uncertain risks as "sensible" and "important."

Other formulations of the precautionary principle inject a cost-benefit requirement into regulatory analysis. This is not incorporated into Hawai'i's formulation, and in general Hawai'i law defers to regulatory agencies to determine whether such an analysis is appropriate (unless the analysis is prescribed by statute). *See Life of the Land v. Ariyoshi*, 59 Haw. 156, 165, 577 P.2d 1116, 1121 (1978) (rejecting the argument that an environmental impact statement, prepared in connection with the construction of water pipeline projection in Central Maui, was required to incorporate a cost-benefit analysis). However, note that the *Ariyoshi* case was decided before the adoption of the State Water Code. In the Code, the definition of "reasonable-beneficial use" of water does include an economic component: "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." Haw. Rev. Stat. § 174C-3; *see also infra* Section 3.6.1.

3.4 Adaptive Mandates and Authority of the Commission on Water Resource Management

As required by Article XI, Section 7 of the constitution, the Hawai'i Legislature established a water resources agency to "establish procedures for regulating all uses of Hawai'i's water resources"—the Hawai'i Commission on Water Resource Management (the "Water Commission" or the "Commission"). As with the scope of the public trust doctrine, several recent Hawai'i Supreme Court opinions have described the role of the Commission.

> The constitution designates the Commission as the *primary guardian* of public rights under the [water resources] trust. As such, the Commission must not relegate itself to the role of a mere umpire passively calling balls and strikes for the adversaries appearing before it, but instead must take the initiative in considering, protecting, and advancing public rights in the resource *at every stage of the planning and decisionmaking process*.[108]

In addition to establishing the Water Commission, the legislature also described the Commission's mandate. This includes, among other things:

- investigating "all aspects of water use";
- designating water resource management areas where resources are "threatened by existing or proposed withdrawals of water";
- engaging in continuing study of those areas where salt water intrusion is a threat to freshwater resources;
- cataloguing and maintaining "an inventory of all water uses and water resources"; and
- planning and coordinating "programs for the development, conservation, protection, control, and regulation of water resources, based upon the best available information."[109]

Once again, it is evident that the Commission is empowered to adopt an adaptive approach, demonstrated, for example, by the call for an integrated inventory of all uses and resources, and ongoing monitoring and study related to the protection of water resources.

3.5 Adaptive Mandates and Characteristics of the State Water Code and the Hawai'i Water Plan

The legislature carried out its constitutional mandate to create the Water Commission via the 1987 enactment of the State Water Code (the "Water Code" or the "Code"), codified as Hawai'i Revised Statutes ("Haw. Rev. Stat.") Chapter 174C. Among other reasons, the Water Code is notable because even before climate change was widely recognized as a direct threat to Hawai'i's water resources, the drafters of the Code molded a system with forward-looking policy foundations, an integrated regulatory scheme, and a mandated proactive planning process.

3.5.1 Water Code Policy Statement

Haw. Rev. Stat. § 174C-2[xv] declares the policy underlying the Code, including: "There is a need for a program of comprehensive water resources planning to address the problems of supply and conservation of water." The Code's policy statement then establishes a dual mandate. First, the Code establishes a policy of "maximum beneficial use" of water resources.[110] This first mandate is qualified by the second—which establishes a policy of ensuring adequate "preservation and enhancement" of water resources for several specially protected objectives, including traditional and customary Hawaiian rights, public water supply, municipal uses, public recreation, agriculture, and ecological balance, among others.[111] These objectives are "declared to be in the public interest."[112] The Hawai'i Supreme Court has noted that the Water Code's policy statement generally mirrors the public trust principle, and "emphasizes the essential feature of the public trust, *i.e.*, the right of the people to have waters protected for their use."[113]

The adaptive features of this policy are readily evident; protection, maintenance, preservation, and enhancement are to receive "special consideration"[114] under "a program of comprehensive water resources planning."[115] Indeed, even the "maximum beneficial use" prong is adaptive, insofar as it requires a forward-looking approach; if water resources are not managed to increase their resilience to climate change, they cannot be maximally used. Furthermore, the policy does not call for "maximum use," or for merely "beneficial use." "Maximum beneficial use," especially when read in conjunction with the relevant constitutional principles, requires that the use must be beneficial, rather than harmful, and that water must be protected and sustainably managed. The Hawai'i Supreme Court has explained that "unlike other jurisdictions … the object is not maximum consumptive use, but rather the most equitable, reasonable, and beneficial allocation of state water resources, with full recognition that resource protection also constitutes 'use.'"[116]

The court has also explained the overall effect of the dual policy mandate is a "higher level of scrutiny for private commercial interests."[117] "In practical terms, this means that the burden lies with those seeking or approving such uses to justify them in light of the purposes of the trust."[118]

[xv] H.R.S. §174C-2:

(a) 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.

(b) 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.

(c) 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.

(d) 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.

(e) 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.

3.5.2 Adaptive Planning with the Hawaiʻi Water Plan

The broad powers and duties conferred by the Water Code are implemented in a number of ways. At the core of this framework is the Hawaiʻi Water Plan, described by Haw. Rev. Stat. § 174C-31. The Water Plan is comprised of four parts:

1. Water Resource Protection Plan ("WRPP"), prepared by the Commission;
2. Water Use and Development Plans ("WUDPs"), prepared by each county and by the State Department of Agriculture;
3. State Water Projects Plan, prepared by the engineering division of the State Department of Land and Natural Resources; and
4. Water Quality Plan, prepared by the State Department of Health.

By forcing these four tools to be coordinated and implemented within a single integrated Water Plan, this basic structure exemplifies an adaptive approach.

3.5.3 Adaptive Capacity in the Water Resource Protection Plan and Water Use and Development Plans

The Water Commission's most recent WRPP, updated in 2008, spans more than 550 pages, and is densely packed with data, policy and planning goals, recommendations, and assessments. The Water Code mandates this approach, by issuing a broad directive for the Commission to:

- Study and inventory existing water resources, and methods of conserving and augmenting such resources;
- Review existing and contemplated needs and uses of water;
- Study the quantity and quality of water needed for existing and contemplated uses, including irrigation, power development, geothermal power, and municipal uses; and
- Study other related matters such as drainage, reclamation, flood hazards, and other issues related to the protection, conservation, quantity, and quality of water.[119]

With this information, the WRPP is required to include an evaluation of the existing and contemplated uses of water, the impact of those uses on water resources, and the consistency of those uses with the objectives and policies of the Water Plan. The WRPP is also required to identify programs to conserve and protect water resources.[120]

A number of planning features relevant to adaptation are present in the WRPP. For example, it recognizes the need for a "'rigorous and systematic' approach to resource monitoring across the State."[121] "Continuous and consistent water data collection is critical to [the Water Commission's] ability to protect water resources."[122] Present monitoring activities include:

- Vertical-profile conductivity and temperature data, indicating the extent of salt water intrusion and the behavior of the freshwater and transition zone over time. This data is collected from state, Honolulu Board of Water Supply, U.S. Geological Survey, and private *deep monitor wells*[xvi];
- Instantaneous and long-term continuous 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, the U.S. Geological Survey, the state, and privately operated rain gauges; and
- Fog drip data from state fog drip stations.[123]

One important source of this monitoring capacity is a cooperative agreement between the Water Commission and the U.S. Geological Survey, to gather stream, spring flow, water level, and rainfall data. However, it appears that reductions in the state budget for this agreement have created the need for the Water Commission to seek funding assistance from other programs and agencies, including county water departments.[124]

In conjunction with the WRPP, each county is required to prepare a WUDP, and the State Department of Agriculture is required to prepare a state WUDP for agricultural uses. The county WUDPs are required to inventory existing water uses, future land uses and related water needs, resulting "problems and constraints," and regional water development plans, including recommendations and alternatives. The state's agricultural WUDP is similarly designed to inventory irrigation systems and agricultural water sources, identify current and future water needs, and establish short- and long-range plans to repair and manage agricultural water systems. Like the WRPP, the WUDPs are intended as comprehensive planning tools. They span hundreds of pages with a multitude of assessments, recommendations, and plans for many different aspects of water resource management.

Nonetheless, the full potential of these documents as adaptive planning tools can be improved, and several proposed methods are recommended in Section 4 of this paper. For example, tools are proposed to enhance monitoring efforts, to better plan for climate change impacts, and to integrate the water planning process with the watershed protection process.

3.6 The Scope of the Water Code and Bifurcated Nature of Hawai'i's Water Management Scheme

The Water Code defines its scope in terms just as broad as the Commission's authority: "All waters of the state are subject to regulation under the provisions of this chapter unless specifically exempted."[125] "No state or county government agency may enforce any statute, rule, or order affecting the waters of the State…inconsistent with the provisions of this chapter."[126] This broad scope and authority places the Water Commission in the ideal position to foster the implementation of an integrated, rather than piecemeal, resource management scheme.

However, one potential barrier to the implementation of a fully integrated and adaptive system is that Hawai'i's water resource management regime is presently bifurcated. In designated Water Management Areas

[xvi] *Deep monitor wells* penetrate deeply into the basal lens and can be used to detect changes in the transition zone and the thickness of the freshwater lens. These wells can therefore help to manage pumpage and construct more detailed models of aquifer behavior.

("WMAs"), the Commission has at its disposal a number of administrative tools, including the authority to control water allocation via the water use permit system. In non-designated areas, the Commission's tools are more limited, as described below. As a result, WMA designation is itself a tool to increase adaptive capacity.

3.6.1 Designated Water Management Areas

The Water Commission is empowered to designate WMAs, either under criteria applicable to ground water, or to surface water:

> When it can be reasonably determined, after conducting scientific investigations and research, that the water resources in an area may be threatened by existing or proposed withdrawals or diversions of water, the commission shall designate the area for the purpose of establishing administrative control over the withdrawals and diversions of ground and surface waters in the area to ensure reasonable-beneficial use of the water resources in the public interest.[127]

"It shall be the duty of the chairperson to make recommendations when it is desirable or necessary to designate an area where there is factual data for a decision by the commission."[128] Designation also requires public notice and hearing.

In addition, designation confers significant regulatory tools upon the Commission. In designated areas, the permitting provisions of the Code prevail over common law water rights.[129] Under Haw. Rev. Stat. § 174C-48, when an area is designated, all withdrawals, diversions, impoundments, or consumptive uses of water require a permit from the Commission.[130] To obtain permits, applicants must establish that their proposed use of water:

- Can be accommodated with the available water source;
- Is a reasonable-beneficial use, meaning "use of water in such 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";
- Will not interfere with existing uses; and
- Will not interfere with the rights of the Department of Hawaiian Home Lands.[131]

These permitting requirements impose on applicants "the burden of justifying their proposed uses in light of protected public rights in the resource."[132] Applicants also bear the burden of "demonstrat[ing] the absence of practicable mitigating measures, including the use of alternative water sources," or making their use more efficient.[133] These are powerful tools for climate change adaptation.

The permitting process also confers on the Commission the regulatory power to impose conditions on each permit, and to modify or revoke permits if it is later determined, for example, that the available water source is inadequate to accommodate the use.[134] This power to grant, condition, modify, and revoke a permit is inherently adaptive, because it allows the Commission to revaluate and modify water uses in light of changing conditions. Another example of an adaptive characteristic of the permitting process in designated areas is that they may be transferred, if the conditions and use remain unchanged. The flexibility to transfer water between users has been identified as one potential adaptation strategy.[135] Section 4 of this paper suggests additional permit conditions to further extend these adaptive capabilities.

3.6.2 Non-Designated Areas

The bifurcated WMA process should not be interpreted to mean that the Water Code and Commission cannot regulate water in non-designated areas. To the contrary, the Code expressly states that "all waters" are subject to regulation, and that "[t]he Commission shall have jurisdiction statewide to hear any dispute regarding water resource protection, water permits, or constitutionally protected water interests, or where there is insufficient water to meet competing needs for water, whether or not the area involved has been designated as a water management area under this chapter."[136] Accordingly, various provisions of the Code apply even in non-designated areas. For example, Haw. Rev. Stat. § 174C-71, which requires the protection of instream uses of water, "operates independently" of the WMA designation and permitting process.[137] Under Haw. Rev. Stat. § 174C-91 to -95, all stream diversion works are subject to registration and permitting requirements. Under Haw. Rev. Stat. §§ 174C-82 to -87, all wells are similarly subject to registration, permitting, and reporting requirements. The Commission's Well Construction and Pump Installation standards include adaptive features, such as limiting the depth of new wells to one quarter the thickness of the basal lens.[xvii]

The Code also allows the Commission to require water use reporting irrespective of whether an area is designated as WMA.[138] For example, the administrative rules enacted pursuant to the Code required, in 1988, that any person making use of a well or stream diversion "in any area of the state" was required to submit a declaration of their use to the Commission.[139] The rules also allow the Commission to require that the owner or operator of any well or stream diversion meter their total water usage, and report it monthly to the Commission.[140] Thus, it is clear that the Water Plan provides for the adaptive characteristic of monitoring and data gathering, even in non-designated areas.

4. Law and Policy Tool Kit: Twelve Tools for Implementing Hawai'i's Adaptive Mandate

As illustrated in the above section, numerous portions of Hawai'i's law and policy regime for water resources incorporate the capability to implement climate change adaptation. And a number of adaptive mandates are created by the Water Code, and by the controlling principles of the constitution, the public trust doctrine, and the precautionary principle.

Having cleared the first hurdle to achieving an adaptive water management system, the next step is to examine whether there are specific tools within that regime that can be used more effectively. Twelve such tools

[xvii] *See* Hawaii Well Construction and Pump Installation Standards, §2.2. This requirement is forward-looking, in the sense that it may limit the need to backfill wells, or construct new wells, if sea-level rise (or overpumping) alters the height of the transition zone.

in Hawaiʻi's "tool kit" are identified here, with a description of the basic mechanisms and models. They are grouped into three categories: (1) policy and planning-based tools; (2) regulatory tools; and (3) market-based tools. All twelve of these tools are consistent with the mandates imposed by Hawaiʻi's existing law and policy framework, and each can enhance Hawaiʻi's ability to adapt to climate change. However, the path to fully implementing any particular tool will require further work on the mechanisms of implementation, and the associated relative costs and benefits. Here, the estimated cost (High, Moderate, Low) and time frame (Short, Medium, Long) of implementation for each tool is presented with a qualitative description.

The cost estimate is intended to assess the cost to the lead agency. For example, a "High" implementation cost designates a tool that will require large amounts of specially designated agency funding or staffing. A "Low" implementation cost indicates that the tool can be largely accommodated within existing processes and programs, or indicates that the recommended approach represents a cost-saving over presently implemented alternatives.

The assessment of the implementation time frame represents the estimated time to fully implement each tool and realize its adaptive benefits, rather than the time required to start the process. For some tools, immediate benefits can be realized even upon partial implementation, on a shorter time frame. A "Long" time frame indicates that that implementation is expected to realize adaptive benefits over the general course of the presently used planning horizon (approximately 20 years). A "Short" time frame means implementation can be accomplished in the more immediate future.

These twelve tools are consistent with Hawaiʻi's existing law and policy framework and each can enhance Hawaiʻi's ability to adapt to climate change

These qualitative metrics allow for relative comparisons between the tools, but implementation will require work to identify further definitive, quantitative projections. Moreover, variables such as cost and time are often interdependent; on an unlimited budget implementation times will be shorter, but at lower cost implementation is often necessarily a slower process.

Note that this white paper is the first phase in a multi-year project by the Center for Island Climate Adaptation and Policy to support the efforts of the Water Commission and other agencies to adopt climate adaptation measures. To that end, subsequent phases will include collaborative education and outreach activities with agency staff and decision-makers, to help refine and implement the tools and policies chosen by water experts "on the ground."

4.1 Policy and Planning Tools

The four-part Hawaiʻi Water Plan, described above, is the primary framework for water resource policy and planning in Hawaiʻi. The tools described here are intended to work within that framework to increase the overall adaptive capacity of Hawaiʻi's water resource management scheme. Following the summary presented in Table 3, more specific challenges and recommendations related to each tool are described below.

Table 3. Adaptive Policy and Planning Tools

Incorporate Climate Change Planning Into the Hawai'i Water Plan
The Hawai'i Water Plan is a comprehensive tool to aid long-term planning for water resources. However, for that tool to be used effectively, all four parts of the Water Plan should expressly address climate change issues and climate change scenario planning.

Adaptive Characteristics: (1) **Forward-looking**; (2) **Flexible**; (3) **Integrative**; (4) **Iterative**

Existing Model: **Long-term climate scenario planning** (e.g., California Water Plan)

Implementation Time Frame: **Long**   Implementation Cost: **Moderate**

Lead Agency: **Water Commission**

Initial Steps: Revise Water Commission's Statewide Framework for the Hawai'i Water Plan, with express directive to incorporate climate change planning into each Plan component.

Potential Barriers: Must identify (and then regularly revise in accord with new scientific findings and models) applicable assumptions and time horizons for climate scenario planning.

(See 4.1.1)

Enforce Five-Year Updates to the Hawai'i Water Plan
The process for updating the Water Plan is in flux. Some portions have been updated recently, while others have not changed since 1990. Regular, iterative updates are necessary for the Water Plan to serve as an adaptive tool.

Adaptive Characteristics: (1) **Flexible**; (2) **Integrative**; (3) **Iterative**

Existing Model: E.g., **California Water Plan**, **Melbourne Water Supply and Demand Strategy**

Implementation Time Frame: **Medium**   Implementation Cost: **Moderate**

Lead Agency: **Water Commission**   Support: All agencies involved in the Hawai'i Water Plan.

Initial Steps: Water Commission directive to update all elements of the Hawai'i Water Plan on a five-year cycle. Identification of most effective enforcement options.

Potential Barriers: Agency funding and staff-resource constraints.

(See 4.1.2)

Expand Models of Water- and Climate-Conscious Land Use Plans and Policies
Continued integration of land use and water resource planning, as illustrated by Maui's Water Availability Policy, empowers an integrated and adaptive approach.

Adaptive Characteristics: (1) **Forward-Looking**; (2) **Flexible**; (3) **Integrative**

Existing Model: **Maui County Water Availability Policy**

Implementation Time Frame: **Medium**   Implementation Cost: **Low**

Lead Agency: **County councils**

Initial Steps: Counties to adopt appropriate policies, ordinances, and plans to more fully integrate land use and water planning.

Potential Barriers: Requires county legislation and political will.

(See 4.1.3)

(continued on next page)

Table 3. Adaptive Policy and Planning Tools (continued)

Adopt Existing Models to Integrate Watershed Conservation with Water Resource Planning
Combining the watershed protection process with the Hawai'i Water Plan (via each county's Water Use and Development Plan) can empower the adaptive goals of monitoring and integration.

Adaptive Characteristics: (1) **Forward-Looking**; (2) **Integrative**

Existing Model: **O'ahu WUDP and Watershed Management Plans**

Implementation Time Frame: **Medium** Implementation Cost: **Moderate to High**

Lead Agency: **County Water Supply** Support: **Water Commission; DLNR**

Initial Steps: Counties to revise internal process for WUDP preparation.

Potential Barriers: Requires county legislation and Water Commission approval. Potentially higher costs and longer time frame for WUDP preparation.

(See 4.1.4)

Finalize and Implement Mandatory Water Conservation and Recycling Plans
Some initial steps have been made toward compiling mandatory water conservation and recycling plans. Those plans should be finalized and implemented by each county.

Adaptive Characteristics: (1) **Forward-Looking**; (2) **Flexible**; (3) **Integrative**; (4) **Iterative**

Existing Models: **DLNR Prototype Water Conservation Plan; Maui County Conservation Policy; Victoria, Australia Water Saving Rules; 2008 WRPP**

Implementation Time Frame: **Medium** Implementation Cost: **Moderate to High**

Lead Agency: **County Water Supply** Support: **DOH; Water Commission; legislators**

Initial Steps: Counties to work with federal and state agencies, subject matter experts, and water users to identify appropriate conservation and recycling tools, and to adopt appropriate policies, ordinances, and plans.

Potential Barriers: Requires: (i) legislative action; (ii) coordinating of federal, state, and county agencies involved in water resources, wastewater, and water quality; (iii) identifying technological solutions and markets for recycled water; (iv) enforcing conservation measures.

(See 4.1.5)

4.1.1 Incorporate Climate Change Planning into the Hawai'i Water Plan

Challenge. Presently, the four-part Hawai'i Water Plan, even where it has been very recently updated, only briefly or tangentially addresses climate change. (As mentioned in Section 3.5.2, the four parts are the Water Resource Protection Plan (WRPP), the Water Use and Development Plan (WUDPs), the State Water Projects Plan, and the Water Quality Plan). Thus, despite the potential for adaptive planning under the Water Code, it appears that climate adaptation is not yet a fully implemented principle of the water planning process in Hawai'i.

For example, the 2010 update to the Hawai'i County WUDP does not address climate change at all. Similarly, a 2010 draft WUDP for Maui's Central District contains the following note:

> The mass flow analyses are based on *historical* stream flows. *No specific consideration is made regarding trends* in drought severity or frequency *or anticipated climate change*. The analyses *could* be revised based on specific assumptions regarding future stream flows.[141]

In this regard, the Maui WUDP appears to follow the lead of the most recent update of the Water Commission's WRPP, which was prepared before the benefit of more recent work on climate change, water resources, and adaptation. (For example, it was drafted before publication of the latest report from the Intergovernmental Panel on Climate Change.)

The 2008 WRPP and other updated parts of the Water Plan recognize climate change risks, such as declining rainfall, declining base flow, increased evaporation, and other potentially harmful trends in the hydrologic balance, as well as risks associated with changes in the frequency and duration of droughts, and with rising salt water intrusion into near shore aquifers.[142] The 2008 WRPP also includes a variety of climate-related recommendations, with heavy focus on potential (and potentially expensive) research regarding broad climate-related topics (Box 9). Other parts of the WRPP similarly recommend monitoring for climate-related issues, for example, by drilling deep monitor wells,[143] by increasing rainfall collection data,[144] and by incorporating climate change data into recharge analysis.[145] All of these are adaptive, in the sense that they call for gathering data in a forward-looking manner. However, these measures identified in the 2008 WRPP do not represent the full spectrum of available adaptive planning tools.

The WRPP takes a less adaptive approach by framing its climate-related recommendations largely in terms of monitoring "uncertainty" in the future (concluding that "more research is needed to determine more specifically what these [climate change] impacts would include"), rather than ongoing adaptation efforts.[146] Thus, much like the Maui WUDP quoted above, the risk of climate change is acknowledged, but

Climate Change-Related Recommendations

Given the high degree of uncertainty as to how climate change will impact Hawaii's freshwater supplies, [the Commission] should seek appropriate legislative funding to undertake the following investigative actions in pursuit of fulfilling [the Commission's] mandate for comprehensive water resource planning to address the supply and conservation of water:

- Conduct research on the impacts of global climate change to long-term precipitation patterns in Hawaii.
- Conduct research on how global climate change would impact Hawaii's hydrologic budget and water resources.
- Conduct research on how global climate change would impact Hawaii's potable and non-potable water demands.
- Develop improved El Nino forecasting tools.
- Together with the county water departments, design and implement mitigation measures to address the range of potential impacts to Hawaii's water resources due to global climate change; identify critical water sources and design mitigation alternatives that may include actions such as partial backfilling of deep wells, construction of hydraulic barriers, and relocation of wells further inland.
- Encourage sustainable water supply practices.

See 2008 WRRP, at 7-59

Box 9

not fully addressed. A lone paragraph at the end of the five recommendations suggests possible responses to sea-level rise. But that paragraph does not meet the same standard of robust and detailed planning that is evident for other issues covered in the Water Plan.

The recently released Koʻolau Loa Watershed Management Plan for Oʻahu also appears to mostly follow the WRPP's example, by similarly identifying a few contingencies that "could be evaluated" with respect to the effect of rising sea level on aquifers, and briefly discussing global trends and uncertainties in climate modeling.[147] For critical water resources, more climate-related planning is necessary.

Adaptive Recommendation. The 2008 WRPP is absolutely correct in concluding that ongoing research is a necessary part of dealing with climate change and analyzing current and future trends. And no doubt, the benefit of additional time and research in the intervening years since the WRPP was last updated also comes with the additional benefit of more information and capabilities regarding climate change hazards.

Based on the recognized "potentially devastat[ing]" risks identified, and on the precautionary principle, planning can (and prudently should) begin to immediately address those risks. In a 2000 document, the Water Commission issued directions that WUDPs should include "a robust evaluation and assessment process emphasizing the integration of various planning scenarios into a strategic decision making process that addresses uncertainties, environmental externalities and public needs."[148]

As a first step, this directive should be amended to expressly include climate change impacts among the planning scenarios in all four parts of the Water Plan.[xviii] For example, the Maui WUDP, rather than relying solely on "historical stream flows" should account for the best available information on observed or predicted stream flow trends.[149]

As a second step, climate-related water planning should be modeled more closely on examples like the most recent California Water Plan, which included a 35-page chapter devoted to climate adaptation.[150] That chapter included analysis and planning for water resources through 2050, under: (a) various climate change scenarios addressing potential variations in future precipitation and temperature; and (b) various narrative scenarios concerning factors such as population growth and land use. The result is effectively a matrix presenting a range of estimates for future water demand. This allows an assessment of whether existing plans and policies can accommodate those ranges—i.e. whether the water planning process is flexible enough to adapt under various scenarios.

Implementing the above steps in Hawaiʻi would allow for more adaptive planning, and would promote a more forward-looking and proactive approach to climate-related hazards. In California's model, this type of *scenario planning*[xix] is used to organize and understand the various factors impacting future water demand,

[xviii] There is no question that the Water Commission is authorized to require such an analysis; Haw. Admin. R. § 13-170-4 states that the "Commission may add to the Hawaii water plan any other…directions, or objectives it feels necessary or desirable for the guidance of the counties in the administration and enforcement of this chapter."

[xix] *Scenario planning* refers to a method of analyzing how long-term plans are affected by changes in projected variables. The result is to assess those plans under more than one set of assumptions. For example, rather than assuming that sustainable yield is fixed and assessing the sustainability of projected future demand against that fixed variable, scenario planning calls for estimating a range of potential future sustainable yields (based on estimated climate-related changes to recharge rates or salt-water intrusion, for example). Then, multiple scenarios can be tested by assessing projected demand against the upper and lower end of that range of projected

and to test the ability of water management strategies to adapt to those factors. Such tests can include evaluating robustness, sustainability, economic costs and benefits, and other relevant performance factors. In Hawai'i, existing county planning procedures already include, to varying extents, scenario-based projections for population growth, economic growth, and land use changes that contribute to water demand. These can presumably be adopted for use in conjunction with climate scenarios, much like California's scenario planning.

California's estimated climate change scenarios were adopted from a separate state action team on climate change. Although Hawai'i, as a smaller and more isolated state, may not have the same resources presently at hand, similar information is available from a variety of resources, and more information is likely to become available in time. Those resources include, for example, the technical reports and scientific literature cited in the 2008 WRPP's acknowledgement of climate hazards. Additional resources, which are either available, or are in development, include:

- A presently available updated precipitation frequency atlas for Hawai'i, based on records from 15 to 100 years in length.[151]
- A freshly updated Hawai'i rainfall atlas—in digital form—that incorporates a record that is approximately one-third longer than that used in the previous 1986 version. In addition to high resolution mapping of monthly and annual rainfall, the new atlas also investigates historical rainfall trends and assesses the uncertainty of predicting future rainfall patterns from the historic record.[152]
- A forthcoming estimation of the spatial distribution of evapotranspiration, including examination of the amount and causes of its seasonal and interannual variability.[153]
- Updated water budget estimates and groundwater recharge analysis. For O'ahu, the U.S. Geological Survey is currently conducting recharge and sustainable yield analysis for the Pearl Harbor Aquifer with the Honolulu Board of Water Supply, and for the entire island of O'ahu with the Water Commission.[154] Similar efforts, incorporating climate data, will be necessary for other islands and aquifers.

Various efforts are also underway to summarize updated findings on climate change. For example, the next updated report from the U.S. National Climate Assessment program is expected to be available in 2012, and will include an assessment of the latest information on climate change impacts in Hawai'i and the Pacific region.[155]

That regional assessment will be contributed by the Pacific Islands Regional Climate Assessment program ("PIRCA"). PIRCA is an ongoing collaborative program aimed at making regional climate change information and products more available to government agencies, non-government organizations, businesses, and community groups.[156] The PIRCA "network of networks" coordinates a number of efforts to assess climate change impacts and adaptation, and it is intended to support a sustained regional climate assessment process. The Pacific Regional Integrated Sciences and Assessments program ("Pacific RISA") is an example of one such net-

sustainable yields. A similar planning method is already used in some aspects of the Hawai'i Water Plan. For example, the County of Hawai'i WUDP assesses future water allocation by comparison against high and low estimates of future agricultural demand and against both the maximum demand estimated under zoning laws and under the county's general plan. *See infra* Section 4.1.3.

work. Pacific RISA's current efforts include working with the U.S. Geological Survey, and with the University of Hawaiʻi's Water Resources Research Center and International Pacific Research Center, to develop improved models of groundwater recharge and sustainability, and to "downscale" global climate models. This "downscaling" is the process of adapting global climate models (with coarse resolution) to provide information at higher resolution so that it is more specifically applicable to Hawaiʻi and other parts of the Pacific.[157]

In addition, the University of Hawaiʻi will host the Pacific Island Climate Science Center, part of a national network of climate centers charged with providing "federal, state and local agencies access to the best available science regarding climate change and other landscape-scale stressors."[158]

Together, resources such as PIRCA, Pacific RISA, and the Pacific Islands Climate Science Center can inform the Hawaiʻi Water Plan and allow it to adopt a model of climate scenario planning.

4.1.2 Enforce Five-Year Updates to the Hawaiʻi Water Plan

Challenge. As described above, the components of the Hawaiʻi Water Plan provide a vehicle for long-term water planning, with significant adaptive potential. Insofar as adaptive management is defined in part by iterative data gathering, monitoring, and evaluation, the information and evaluation required in the various parts of the Hawaiʻi Water Plan mandates an adaptive approach, and should, if fully implemented, foster the early identification of climate change risks and efficient implementation of adaptive solutions.

However, such data gathering and evaluation must be part of an *ongoing* process, rather than take the form of a single static plan. Presently, some portions of the Water Plan have been recently updated, while others have not. Enforcement of regular iterative updates to all portions of the Water Plan is necessary, especially in the face of climate change.

The Water Commission's 2000 Framework described this need: "water resource planning is an ongoing process that requires a dynamic framework which results in planning documents that provide alternative strategies addressing future uncertainties."[159] Thus, the Commission clarified that the Water Plan is envisioned as a "'living document,' which over several plan iterations will result in a truly comprehensive water resource plan."

The 2000 Framework recommended the following updated schedule and planning horizon: "State and county agencies must adopt a 20-year planning horizon with requirements for regular five-year updates. Each five-year update cycle shall commence on the 3rd year, with adoption of a revised [Hawaiʻi Water Plan] by the 5th year."

The iterative update process envisioned by the Commission is underway, but it does not appear to be fully implemented

The iterative update process envisioned by the Commission is underway, but it does not appear to be fully implemented. The State Water Projects Plan and state agricultural WUDP were last updated in 2003. County WUDPs (first prepared in 1990) are presently at various stage of being updated. For example, on Oʻahu, the process has evolved such that the updated WUDPs will essentially be comprised of eight regional Watershed Management Plans, which address the requirements of both the Water Plan and Act 152's watershed protection master plan. The Waiʻanae and Koʻolau Loa watershed management plans were completed in August 2009. As of November 2010, the Koʻolau Poko Watershed Management Plan remained in draft form.

Hawai‘i County's WUDP was updated in August 2010. Various drafts of an updated Maui WUDP are in progress, but are still in the process of being approved. In 2007, the Kaua‘i Board of Water Supply announced that an updated WUDP was a year-end priority. As of August 2011, no update has been presented to the Water Commission.[160] The final component of the Water Plan, the Department of Health's Water Quality Plan, has not been updated since 1990 and is not currently being updated.[xx]

Adaptive Recommendation. To implement the iterative approach recommended in the Water Commission's 2000 Framework, enforcement of the five-year update process is necessary. As explained in the Framework, iterative updates are expected to be faster, more efficient, and less costly than re-working the entire planning process at every update, with decades in between. This iterative approach thus requires updating only portions of the Water Plan components at each step, rather than revising the entire document at every phase. This should help to alleviate funding and staffing concerns that arose in the context of the most recent round of updates.

The Framework's recommendation for five-year updates is not limited by the Water Code and related rules, nor is the Water Commission limited by any specific enforcement mechanism. Instead, these issues fall within the Water Commission's broader powers and its mandate to direct the formulation of all parts of the Hawai‘i Water Plan. For example, the Commission is empowered to add any "directions, or objectives it feels necessary or desirable for the guidance of the counties in the administration and enforcement" of the Water Code and related rules.[161] Also, WUDPs "shall be consistent with the water resource protection plan and the water quality plan."[162] To the extent that the WRPP is updated every five years, this mandated consistency would require similarly periodic updates to the WUDPs. Furthermore, a five-year period is plainly within a reasonable time frame envisioned under the Water Code; the original WUDPs were to be prepared within *three years* of the Code's adoption.[163]

The Commission's enforcement powers are similarly broad, allowing for injunctive relief, damages, fines (up to $5000 per day), and an award of attorneys' fees and costs in favor of the Commission.[164] And other

[xx] As the last holdout in the update process, the Department of Health's Water Quality Plan ("WQP") may represent the highest priority item for updating. *See* Haw. Rev. Stat. § 174C-68(b) (requiring that the WQP "shall be periodically reviewed and revised by the department of health as needed"). Other parts of the Water Plan are required to maintain consistency with the WQP. *See, e.g.*, Haw. Rev. Stat. § 174C-31(b)(1). Thus, an outdated WQP represents a hurdle and unwarranted burden in updating the Water Plan's other components. Furthermore, post-1990 changes in state and federal water quality regulations have created a host of new water quality standards and programs that warrant attention in an updated WQP. A number of water quality issues also have particular relevance to climate adaptation. These include, for example, water quality issues related to water recycling, the use of non-potable water for irrigation, establishing water quality criteria for WMA designation, and establishing appropriate limits and guidelines for brine disposal in desalination (to allow for more accurate estimates of the cost of desalination in comparison to conservation or other measures).

On the WQP, the Water Commission has specific authority to engage in rulemaking, if necessary, to enforce the Department of Health's obligation to provide updated information. *See* Haw. Rev. Stat. § 174C-67(a) ("The department of health shall submit to the commission such information as the commission shall require as prescribed in its rules … .").

One potential approach to updating the WQP, to alleviate concerns about staffing and funding requirements, is to integrate the process with the Department of Health's obligation to update its Continuing Planning Process ("CPP") under § 303(e) of the Clean Water Act. An updated CPP, prepared with the assistance of federal funding, could thus serve as a core component of an updated WQP. A focus on climate change adaptation would also be consistent with federal Environmental Protection Agency recommendations. *See, e.g.*, Envtl. Prot. Agency, *National Water Program Guidance, Fiscal Year 2012* 3 (2011), *available at* http://www.epa.gov/planandbudget/annualplan/FY12_OW_NPM_Gdnce.pdf.

enforcement mechanisms are also available. For example, the Commission may revoke a county's water permits for "[a]ny violation of any provision" of the Water Code.[165] The plain language of this section of the Code (along with the Commission's broad powers, arising directly under the constitution) indicates that the Commission has great power to ensure that counties comply with their obligation to "prepare" and "maintain" the WUDPs.[166]

In addition to enforcing regular updates, The Water Commission should revisit, and cautiously apply, the previously recommended 20-year planning horizon. Climate change phenomena implicate trends much longer than 20 years. For example, declining base flow is evident dating all the way back to 1933. Similarly, water infrastructure, such as pipelines and pump stations, are designed to last more than 20 years.[167] To ensure that such issues are handled appropriately, not all aspects of the planning process can occur on a strict 20-year horizon.[168]

The California Water Plan and planning documents in other locations[169] exemplify the model proposed here. The California Plan was updated in 2005 and again in 2009. Its analysis is projected out to 2050, a 40-year planning horizon. The Hawai'i Water Plan should adopt and enforce similar principles.

4.1.3 Expand Models of Water- and Climate-Conscious Land Use Plans and Policies

Challenge. State and county planning processes inevitably intersect with water use. For example, the State Planning Act references numerous objectives and policies related to water resources, in contexts ranging across policies on natural resource protection, conservation, water facilities development, promotion of agriculture, county general planning, economic priorities, and land use.[170] Furthermore, July 2011 amendments to the State Plan added sustainability as one of six "major areas of statewide concern which merit priority attention."[171] This additional focus on sustainability injects an extra dose of adaptation into the state planning policy. For example, "sustainability" is defined to include the forward-looking policy of "[m]eeting the needs of the present without compromising the ability of future generations to meet their own needs."[172] The "[p]riority guidelines and principles" also include the same forward-looking focus on future generations, along with "[e]ncouraging planning that respects and promotes living within the natural resources and limits of the state."[173] The amendments also have integrative features, such as (i) "[c]onsidering principles of the ahupuaa system," and (ii), emphasizing that responsibility for achieving sustainability falls on "everyone, including individuals, families, communities, business, and government."[174]

This statewide policy is intended to filter into planning at the county level, where more specific land use plans depend directly on water availability for implementation, and affect water resources by impacting watersheds and water demand. Also, the Water Code requires that all parts of the Water Plan (including county WUDPs) "shall proceed in coordination with and with attention to the Hawaii state plan."[175]

However, the detailed water planning process, and the water-related mandates in the Hawai'i Constitution and Water Code, may not always be consistent with the county land use plans and policies. Several stark examples are found in Hawai'i County's 2010 WUDP update. That update includes projections of water demand for each hydrologic unit on the Island of Hawai'i, under the scenario of a "full build-out" to the extent allowed under the county's general plan and zoning plan. For the West Mauna Kea Aquifer Sector Area, the sustainable yield is 24 million gallons per day ("mgd").[176] The projected total demand, under the fully developed general plan, greatly exceeds this sustainable yield—ranging from 52 mgd (assuming minimum agricultural demand component) to 187 mgd (assuming maximum agricultural demand component).[xxi] For full development under the existing zoning map and ordinances, the range is 14 to 151 mgd.[177] The WUDP concludes that maximum density build-out "is not sustainable," and that "water resource planning for the sector area is important."[178] Similar conclusions are applicable for land use plans in a number of other hydrologic units on the island.[179]

Table 4. Comparison of Sustainable Yield to Maximum Projected Demand

Aquifer Sector Area (Hawai'i Island)	Sustainable Yield (mgd)	Maximum Projected Demand – General Plan (mgd)	Maximum Projected Demand – Zoning (mgd)
West Mauna Kea	24	151	187
Kohala	154	174	208
Southwest Mauna Loa	130	143	123
Northwest Mauna Loa	30	89	18
Hualālai	56	282	115

As a result of these potentially dramatic gaps[180] between sustainable yield and demand under the county land use plans, the WUDP identifies potential steps and barriers for avoiding over-allocation, such as implementing demand-side conservation measures, developing non-potable water resources, or transferring water between hydrologic units ("which will likely necessitate infrastructure upgrades.").[181] But using the land use planning and approval process to avoid over-allocation is not presented as a front-line option. Furthermore, the projected gaps do not account for climate change or other impacts on sustainable yield. Although demand is generally projected to increase for every hydrologic unit over the WUDP's 20-year planning horizon, the sustainable yield is projected as flat.

There is a disconnect between Hawai'i County's land use vision and its water reality

Plainly, there is a disconnect between Hawai'i County's land use vision and its water reality. Hawai'i needs to identify better mechanisms for integrating land and water use planning, and for ensuring that land use plans do not unilaterally defeat the adaptive mandates of the Water Code and Water Plan.

Adaptive Recommendation. Maui's recently adopted "Water Availability Policy" illustrates an example of attempting this type of integration.[182] The policy begins by affirming that "water is a natural and cultural resource that must be protected, preserved, and managed as a public trust."[183] The general purpose of the policy is to require "verification of a long-term, reliable supply of water before subdivisions are approved."[184] A long-term reliable supply of water is defined to mean either a county water source (i.e., a source subject to the scrutiny of

[xxi] The WUDP notes that "[a]gricultural water use is difficult to determine due to lack of available data." Thus, it presents two agricultural water use estimates for each aquifer system in the full build-out scenario. "This identifies a range of agricultural water use, which considers the best and worst case scenarios on an interim basis, until the next phase of the [state's agricultural WUDP]." *See Hawai'i County Plan Update*, *supra* note 176, at ES-6 to -7.

the county WUDP and water planning process), or a non-county source that is verified as able to meet the long-term projected demand for water. The policy also adds various other requirements to the subdivision process, such as requiring that final subdivision plat maps must be submitted with a statement of the water system to be installed, again verifying its long-term viability.[185]

The policy is also implemented by requiring that the director of the county Department of Water Supply comment on engineering reports for new wells.[186] The county director provides input on fourteen criteria, including several that are directly relevant to the Hawai'i Water Plan. These include analyzing for potential effects on sustainable yield, instream flow standards, traditional and customary Native Hawaiian Rights, and "cumulative impacts" on water resources within the county, in addition to considering other relevant issues from the Water Commission's WRPP. This review also examines compliance with State Water Code and county water reporting requirements. The effect is to integrate the county's review with the Hawai'i Water Plan, the county General Plan, and the relevant community plans.[187] Furthermore, this review presents an additional source of information and assessment, in conjunction with the Water Commission's well construction and pump installation permitting process.[xxii] This is particularly relevant in areas that have not been designated Water Management Areas, because the fourteen factors reviewed by the county have the potential to render the level of scrutiny more closely akin to the water use permitting process in designated areas.

In addition to these integrative functions, the "Water Availability" process also implicates other adaptive characteristics. For example, it requires a forward-looking approach, because the county is required to review "data relating to quality and quantity of the source waters under normal conditions and during stress periods, drought, or heavy precipitation."[188]

4.1.4 Adopt Existing Models to Integrate Watershed Conservation with Water Reource Planning

Challenge. Land use also impacts water resources in other ways, beyond just the allocation of water. For example, urbanization of natural watersheds increases runoff, impacting stream flow and reducing groundwater recharge. And even without urbanization, watershed protection is necessary. A healthy watershed is characterized by natural processes in dynamic equilibrium, such that the climate, soils, plants, animals, streams, and groundwater recharge are all functioning in a balanced and sustainable way.[189] An unhealthy watershed disrupts that balance, and is often characterized by invasive plants and animals, increased erosion, and disruptions to stream flow and recharge.[190] Climate change impacts, such as increased storm intensity, can

A healthy watershed is characterized by natural processes in dynamic equilibrium, such that the climate, soils, plants, animals, streams, and groundwater recharge are all functioning in a balanced and sustainable way

[xxii] The Commission's requirements for well construction and pump installation also include several adaptive features, such as (i) protection of water resources through prescribed well construction standards and optimization of well depths and (ii) monitoring and data gathering via flowmeters and pump tests. *See* DLNR, Comm'n on Water Res. Mgmt., *Hawaii Well Construction and Pump Installation Standards* (2004), *available at* http://hawaii.gov/dlnr/cwrm/regulations/hwcpis04.pdf.

Photo: Zena Grecni

Forested watershed near Maunawili Falls on O'ahu.

exacerbate this problem, making it even more important to manage and protect watersheds for the future, as an integral component of water resource management.

Adaptive Recommendation. In 2000, the Hawai'i Legislature passed Act 152, Relating to Watershed Protection. The Act required the development of a watershed protection master plan to identify and protect priority watersheds. Because of the intimate tie between watersheds and water resources, on O'ahu the watershed protection and water resource protection processes have been combined. Adopting a quasi ahupua'a-based model, the island is broken into several regions, each with a separate watershed management plan.[191] These regional plans, once complete, are envisioned to together comprise the overall Water Use and Development Plan (required under the Water Code).[192] This integrated approach can empower adaptation in a number of ways. For monitoring and planning for specific impacts on watersheds has a concomitant adaptive effect on recharge, and thus water availability. Similarly, other "on the ground" watershed protection efforts, such as forestry management, invasive species control, and watershed partnerships are all examples of adaptive measures for water resources. This approach is recommended as an adaptive model for other counties. This model is also consistent with the recent sustainability amendments to the State Plan, which encourage "principles of the ahupuaa system."[193]

4.1.5 Finalize and Implement Mandatory Water Conservation and Recycling Plans

Challenge. Under the current scenario of decreasing rainfall and base flow, water conservation is a critical component of climate adaptation and water resource management. Indeed, many adaptation plans from around the world implement system-wide plans, policies, and requirements for water conservation and recycling.

Hawaiʻi's efforts are more fragmented. For example, the Water Commission's Drought Plan (last updated in 2005) integrates drought-related monitoring and responses between the state and counties (which maintain their own "Drought Mitigation Strategies"), and leverages the support of many other entities, such as the University of Hawaiʻi, National Weather Service, U.S. Geological Survey, and the National Drought Mitigation Center.

Water conservation and reuse do not have a similarly coordinated plan. The Water Commission has asserted that although it "is responsible for planning and coordinating of a water conservation plan," it does not have the authority to implement water conservation measures except in designated Water Management Areas, or during water emergency situations.[194] The Commission recommended a coordinated approach, perhaps similar to the Drought Plan, with the state providing guidance and general conservation plan components that can be adapted to local conditions. To that end, the state developed a Prototype Water Conservation Plan as a model for other agencies, but largely deferred to the counties to enact appropriate ordinances, rules, and regulations to institute mandatory conservation.

To date, no county has adopted such a comprehensive plan. However, some examples of existing county rules regarding conservation and recycling can be a starting point. The Honolulu Board of Water Supply, for example, mandates the use of non-potable water for large landscaped areas, where a suitable non-potable supply is available.[195] Other efforts focus more on issues such as emergency conservation in the event of a designated period of low ground water,[196] or regulating (rather than promoting) recycling efforts.[197] While these efforts are laudable, they are only a beginning.

Adaptive Recommendation. Hawaiʻi can increase its resilience to declining water supply, or more frequent drought, by redoubling efforts to implement mandatory water conservation and recycling throughout the state. For example, in 2006 Maui announced a broad water conservation policy, with the goal of enacting a water conservation plan by the end of 2007:

> A water conservation plan is essential to preserve water resources and to reduce the risk and severity of water shortages. Such a plan will significantly reduce the long-term and short-term consumption of water, thereby preserving available water for the future requirements of the County, while minimizing the hardship caused to the general public.[198]

To date, the county has not adopted a plan, although it appears that the issue is being revisited. The county recently published a request for proposals to complete the conservation plan and to design a portfolio of conservation programs to capture 15 percent of conservation potential[xxiii] over five years.[199]

[xxiii] Water *conservation potential* generally refers to water savings that could be achieved with no reduction in customers' ability to use water or in their satisfaction with water services. A conservation potential assessment considers the cost, volume, and reliability of conservation opportunities, but does not consider water shortage actions such as irrigation bans that would reduce customer service. *See, e.g.*, Seattle Pub. Utilities, *Water Conservation Potential Assessment, Executive Summary* (1998), *available at* http://www.seattle.gov/util/groups/public/@spu/@csb/documents/webcontent/spu01_002152.pdf; San Francisco Public Utilities Commission, Wholesale Customer Water Conservation Potential Technical Report (2004), *available at* http://bawsca.org/docs/Final_SFPUCConsTechReport_Dec292004.pdf.

And although there is no comprehensive conservation and recycling plan, some incremental provisions are in place. For example, the mayor of Maui recently set a goal of increasing recycled water reuse from its current level (approximately 25 percent) to 100 percent.[xxiv] In 1996, Maui adopted a mandatory recycled water use ordinance, requiring that improved commercial property must "connect to available reclaimed water service for irrigation purposes, including but not limited to golf courses, landscaping and agricultural uses."[200] The 2009 amendments to the county code place restrictions on the use of potable water for golf courses[201] and limit potable water use to "domestic use in homes and businesses."[202] Water recycling and conservation similarly occur in various contexts in other counties (such as the Honolulu Board of Water Supply's water reuse program),[xxv] without fully integrated or mandatory plans. The Water Commission is also presently studying a statewide water conservation program with the goal of implementing conservation policies and practices for all water use sectors.

The state Prototype Plan, the Maui conservation policy, the observations and recommendations in Section 7 of the 2008 WRPP, and the Commission's 2004 Hawaii Water Reuse Survey and Report (and its forthcoming conservation plan) can serve as templates for each county to finalize enforceable water conservation and recycling efforts statewide. And, many other models are available to supplement that process. Melbourne, Australia has faced a history of drought problems, and as a result has instituted firm water conservation planning, spanning a range of efforts. These include measures such as water-conserving building and irrigation requirements, storm water harvesting, water auditing, and conservation tariffs, among other efforts. Melbourne's approach (now broadened to include the entire state of Victoria) has been cited as an adaptive model.[203] It also has regulatory characteristics, such as a set of "Permanent Water Saving Rules" that are applicable even in non-drought years. With five simple rules governing just a few aspects of outdoor residential water use, such as gardening and pools, it was expected that that the city could reduce overall water consumption by 2–3 percent. These permanent rules are accompanied by five stages of increasingly strict water use restrictions, applicable only during droughts. As a result of this overall scheme for water management and conservation, water consumption dropped by 22 percent from the 1990s to 2006.[204]

4.2 Regulatory Tools

Because of its broad jurisdiction, the Water Commission is Hawai'i's primary regulatory body for water resource management. Table 5 summarizes ways in which existing regulatory tools deployed by the Water Commission can be made more adaptive. This section then describes, in more detail, the challenges and recommendations related to each tool.

[xxiv] Consistently, the County of Maui General Plan calls for phasing out the use of injection wells to dispose of wastewater effluent. *See, e.g.*, Maui, Haw., Ordinance No. 3732, *Countywide Policy Plan* 71 (2010).

[xxv] For example, the Honouliuli Water Recycling Facility opened in 2000 on Oahu, and recycled or non-potable water is directed toward uses such as golf course irrigation. These efforts, and various other components of conservation and recycling programs are described in the 2008 WRPP, at 7-1 to 7-55.

Table 5. Adaptive Regulatory Tools

Adopt Climate-Conscious Sustainable Yield and Instream Flow Standards
Sustainable yield and instream flow standards form the heart of the water planning process under the Water Code. They should account for climate change and potential impacts, and they should be reevaluated on a regularly scheduled basis.

Adaptive Characteristics: (1) **Forward-looking**; (2) **Flexible**; (3) **Integrative**; (4) **Iterative**

Existing Model(s): **"Clearly Sustainable Yield"**

Implementation Time Frame: **Medium** Implementation Cost: **Low**

Lead Agency: **Water Commission**

Initial Steps: In connection with a climate-conscious Hawai'i Water Plan, Water Commission to establish long-term schedule for reevaluating sustainable yields and instream flow standards, with direct links to updated climate change data products.

Potential Barriers: (i) Regularly revising applicable numerical models to incorporate observed and expected climate-related trends for each aquifer system; (ii) revising instream flow standards may be more costly than revising sustainable yield, because of the expense of stream-specific studies (in comparison to more widely applicable sustainable yield models).

(See 4.2.1)

Enforce and Expand Statewide Water Use Monitoring and Reporting
Monitoring and reporting requirements contained in water use permits (for designated Water Management Areas) and reporting of water use (even in non-designated areas) are critical components of adaptive water resource management. These requirements must be enforced.

Adaptive Characteristics: (1) **Forward-looking**; (2) **Integrative**; (3) **Iterative**

Existing Model: **State Water Code**

Implementation Time Frame: **Short** Implementation Cost: **Moderate**

Lead Agency: **Water Commission**

Initial Steps: Support and expedite existing efforts to streamline and digitize the reporting process, and expand it to include automated internet publication of all reported data.

Potential Barriers: Requires: (i) integration of Water Commission's existing databases; (ii) enforcement for non-compliance with reporting requirements.

(See 4.2.2)

(continued on next page)

Table 5. Adaptive Regulatory Tools (continued)

Expand Water Management Areas
Under the Water Code, more adaptive tools and strategies are applicable in WMAs than in non-designated areas. Protection against climate hazards is enhanced by the designation of WMAs for both surface water and groundwater resources.

Adaptive Characteristics: (1) **Forward-looking**; (2) **Integrative**

Existing Model(s): **Existing WMAs**; **1994 Review Commission Report on the State Water Code**

Implementation Time Frame: **Long** Implementation Cost: **High**

Lead Agency: **Water Commission** Support: **County WUDP**; **state legislature**

Initial Steps: Water Commission to assess climate change impacts and identify non-designated areas that are most threatened, or that have the greatest adaptive potential for protecting recharge and watersheds.

Potential Barriers: Requires: (i) lengthy Water Commission process; (ii) regulatory capacity for ongoing management of expanded designated areas. Potential challenges from water users and developers.

(See 4.2.3)

Adopt More Adaptive Conditions for Water Use, Well Construction, and Stream Diversion Permits
The standard and special conditions applicable to such permits should be amended to enhance adaptive capabilities such as monitoring and forward-looking flexibility. Proposed amendments are suggested, to empower use monitoring, rain and stream monitoring, and permit compliance inspections.

Adaptive Characteristics: (1) **Forward-looking**; (2) **Flexible**; (3) **Integrative**; (4) **Iterative**

Existing Model(s): **Existing permit conditions**

Implementation Time Frame: **Short** Implementation Cost: **Low**

Lead Agency: **Water Commission**

Initial Steps: Water Commission to revise the standard conditions for new water use permits, and identify opportunities to revise existing permit conditions.

Potential Barriers: (i) Additional enforcement burden on Water Commission; (2) possible user opposition.

(See 4.2.4)

4.2.1 Adopt Climate-Conscious Sustainable Yield and Instream Flow Standards

Challenge. The sustainable yields for aquifers, and the acceptable instream flow standards for surface waters, are critical concepts at the very core of water management under the Water Code. They must be managed with a careful eye on climate-related impacts.[xxvi]

[xxvi] Although sustainable yield and instream flow standards are analogous concepts (with sustainable yield applied to aquifer extraction, and instream flow standards applied to surface stream flow), they are not identical. This leads to potential confusion. Note that in the face of threats to a water system, the appropriate measure may often be to reduce the amount of water that may be extracted from that system. This would be a *reduction* in the sustainable yield, but an *increase* in the instream flow standard.

As part of the Water Plan, the Commission is required to divide each county into a hydrologic unit (a "surface drainage area or a ground water basin or a combination of the two").[205] For each unit, the Commission is required to: (1) inventory all water resources, systems, and uses; (2) determine the quantity of water not presently used; and (3) identify "potential threats to water resources, both current and future."[206]

For each unit, the Commission is also required to establish a sustainable yield and an instream flow standard and protection program (see Boxes 10 and 11). These concepts are directly tied to water use in designated Water Management Areas, because evaluation of a permit application—specifically whether the use can be "accommodated with the available water source"—turns, in part, on whether the use conforms with the established sustainable yield and/or instream flow standard applicable in a given area. But, they are also relevant tools in non-designated areas, because one of the criteria used to evaluate whether enhanced regulation is appropriate is whether water use is approaching or affecting the sustainable yield or instream flow standard.

Sustainable Yield

"[T]he 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."

Haw. Rev. Stat. § 174C-3.

Box 10

Instream Flow Standard

"[A] quantity or flow or depth of water which is required to be present at a specific location in a stream at certain specified times of the year to protect fishery, wildlife, recreational, aesthetic, scenic, and other beneficial instream uses."

Haw. Rev. Stat. § 174C-3.

Box 11

Sustainable yield and instream flow standards create essential benchmarks for proposed and existing uses, statewide. Because they are so critical to the state's management regime, they must incorporate climate change awareness and adaptation. For example, climate adaptation expert Robin Kundis-Craig has concluded that "maximum sustainable yield" is a poorly adaptive benchmark.[xxvii] She instead presents a compelling case for "clearly sustainable yield." This approach would be consistent with Hawai'i law, which calls for "the most equitable, reasonable, and beneficial allocation of state water resources, with full recognition that resource protection also constitutes 'use.'"[207]

[xxvii] Professor Kundis-Craig explains that:

> [O]ne of the more troubling legacies of natural resource management in the United States is that "sustainable yield" standards tend to err on the side of more human harvest or extraction rather than institutionalizing any kind of precautionary principle or margin of error in favor of the species or ecosystem. Thus, even before climate change, these natural resource management regimes rarely achieved true "sustainable" use of the relevant resources.… Climate change impacts further problematize the whole concept of "sustainable yield." How do regulators decide what a sustainable take might be when… ecosystems are transforming all the time?

Kundis-Craig, *supra* note 66, at 47-48.

Adaptive Recommendation. To make these key measures more adaptive, two discrete steps should be taken.

First, all analyses of sustainable yield and instream flow standards should be required to expressly account for climate-related trends and impacts. Presently, the Water Commission reports that sustainable yield is generally determined based on historical pumpage, chloride level, and water-level data, along with numerical models and hydrologic studies.[208] The Commission similarly maintains a set of various physical and sociological criteria for assessing instream flow standards.[209]

To enhance forward-looking capability, climate-related trends and predictions (such as the declining trend in base flow) should be incorporated into these lists of criteria, to select aquifer yields and instream flow standards that are sustainable in the long term. For example, climate trends have particular relevance to recharge analysis. The 2008 WRPP recognized that improved recharge analysis was necessary to refine sustainable yield estimates, and generally recognized that "[c]limate change and data from the last 25 years should also be included into recharge analysis."[210] However, the "critical issues" identified for recharge did not include climate trends.[211] Similarly, the specific recommendations for recharge assessment recommended using 1986 rainfall data as a minimum standard.[212]

This historical view is not optimally adaptive. The process should strive for a forward-looking approach, and should incorporate information from observed trends and modeled predictions, where available. As described above in Section 4.1.1, a variety of resources are available for updated climate information, and programs are in place to provide additional information in the coming years. Promisingly, there are indications that the Water Commission is incorporating climate change analysis into recent works, and that effort should be applauded and supported.

After the first step of ensuring that climate trends and impacts are accounted for in determining sustainable yields and instream flow standards, the second step is that these tools must be regularly reevaluated. This is consistent with the Water Code, which calls for sustainable yield to be "reviewed periodically."[213] Promisingly, the 2008 WRPP included a wholesale evaluation of sustainable yield in essentially every hydrologic unit. Furthermore, the Commission cited the precautionary principle, to justify generally (although not always) selecting the lower yield, where several values were available. The Commission reported that 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." However, prudent planning counsels for avoiding a system where sustainable yield is reviewed only on a case-by-case basis.[214] Thus, the reevaluation process should be formally incorporated into every WRPP update, issued every five years.

Regular planning on this front is especially important because when such reevaluation concludes that a modification is necessary, the process can be lengthy. Indeed, the Hawaiʻi Supreme Court reinforced the importance of avoiding an ad hoc process. The court clarified that sustainable yield/instream flow standard determinations should not wait until disputes regarding water use arise, and cannot occur in conjunction with review of a water use permit application.[215] Instead, modifying sustainable yield or the instream flow standard requires an independent due process procedure, with notice and public hearing.[216]

4.2.2 Enforce and Expand Statewide Water Use Monitoring and Reporting

Challenge. Data gathering, monitoring, and reevaluation are key components of adaptive management. The Water Code empowers the Water Commission to require water users, whether in designated Water Management

Areas or in non-designated areas, to monitor and report their water usage, on a monthly basis.[217] Where the Commission deems it appropriate, such reporting can also include information such as salinity and water level.[218] Unfortunately, a 2009 report to the state legislature identified significant problems with the reporting regime during the first 20 years of the Water Code. Of the 359 permits reviewed, 67 percent were found to be non-compliant with their reporting requirements or unaware of them.[219]

The same problem is readily evident even in non-designated areas. The Water Code envisioned that such users would submit a declaration of water use, within one year after the rules implementing the Water Code were adopted (in 1988).[220] After the Commission determined that a given declared use was reasonable and beneficial, a certificate of that use was to be issued.[221] Unfortunately, the system never worked that way. More than 7000 declarations were filed, but only a handful of certificates were issued, in part because of the problems with verifying the reported information.[222]

Adaptive Recommendation. The Commission's power to require ongoing reporting is a key component of adaptive management. Several steps should be taken to put this system back on track, and to enhance enforcement. The Water Commission has embarked on a plan to automate the reporting process via a proprietary web-based system. This plan should be encouraged and supported, and should be extended to apply to both permit holders, and to water-user reporting in non-designated areas. However, the effort should not stop there. The collected data should be published (also via the web), to allow for public access and to aid in enforcement. The Water Code empowers the Commission to enforce reporting requirements, via penalties of up to $5000 per violation per day, and via revocation of water use permits for willful violation of any reporting conditions.[223] The state's Department of Land and Natural Resources Civil Resource Violation System should immediately be used to support such efforts. And finally, the problems were identified for the legislature in a report required by the Water Code only every 20 years.[224] Going forward, the reporting status should be internally reviewed far more frequently than every 20 years.

4.2.3 Expand Water Management Areas

Challenge. Under the scheme established by the Water Code, more adaptive tools and strategies are available in designated Water Management Areas ("WMAs"), where the Commission may exercise its powers related to required water use permits, than in non-designated areas where use permits are not required. In addition to the powers of the permitting process, designation can also promote adaptation through improved monitoring and inventorying of water resources.

When the Water Code was adopted, it was apparently not intended that the bifurcated designated/non-designated system would be permanent.[225] A review commission was established and tasked with reporting to the legislature on various matters, including the adoption of a statewide permit system.[226] The commission recommended such a system in 1994, but it has not been adopted. Presently, only Moloka'i, most of O'ahu, and the 'Iao aquifer on Maui have been designated as ground WMAs. In 2008, Na Wai 'Eha, Maui was designated as the first surface WMA since the Code's inception. Thus, the remaining non-designated areas cannot enjoy the benefit of the Water Code's full panoply of adaptive features.

Adaptive Recommendation. The Water Commission should begin the process of determining which non-designated areas of the state are most threatened by climate-related trends, and commence the process of designating such areas as WMAs**.** The Commission is granted broad power to designate WMAs, guided by various criteria to determine whether designation is appropriate. For groundwater WMAs, those criteria include whether:

- use or authorized planned use may cause the maximum rate of withdrawal to reach 90 percent of the sustainable yield;
- the Department of Health determines that water quality degradation is occurring or is threatened;
- groundwater levels decline;
- existing withdrawals endanger the ground water due to the encroachment of salt water;
- excessive preventable waste of ground water is occurring; or
- serious disputes respecting the use of ground water are occurring.[227]

For surface WMAs, the criteria include whether:

- regulation is necessary to preserve diminishing surface water supply for future needs, evidenced by declining water levels "not related to rainfall variations";
- regulation is necessary to preserve diminishing surface water supply for future needs, evidenced by increasing or proposed diversions of surface waters which may detrimentally affect existing instream uses or prior existing offstream uses;
- diversions of stream waters are reducing the capacity of the stream to assimilate pollutants; or
- serious disputes respecting the use of surface water resources are occurring.[228]

However, the Hawaiʻi Supreme Court has concluded that irrespective of "how many or how few of the criteria are applicable, *the Commission shall designate an area as a WMA 'when it can be reasonably determined…that the water resources in an area may be threatened by existing or proposed withdrawals or diversions of water.*'"[229] The decision to designate an area is committed to the Commission's expertise; it is not judicially reviewable. But the court has clarified that the "Commission's erroneous *refusal* to designate a WMA, on the other hand, would be in breach of its constitutional and statutory duties," such that judicial review may be available in that circumstance.[230]

Climate-related phenomena, such as the declining trends in rainfall and base flow, unquestionably pose a threat to water resources. WMA designation is a long process. The earlier that a threatened hydrologic system is designated, the more effective the process can be in protecting the threatened resource. Taking a precautionary approach, the Commission should begin the process of designating those areas that are most sensitive to climate phenomena.

In the interest of efficiency and consistency, this process can also be approached from a planning perspective. Utilizing components of the Hawaiʻi Water Plan, regular updates (see Section 4.1.1) can serve as a vehicle for: (i) assessing threats, including climate change; (ii) analyzing non-WMAs with respect to the designation criteria listed above; (iii) identifying areas appropriate for designation; and (iv) developing plans to minimize the potential that the designation criteria will be triggered.

4.2.4 Adopt More Adaptive Conditions for Water Use, Well Construction, and Stream Diversion Permits

Challenge. There are important regulatory powers associated with the required water use permits in designated WMAs, and with well construction and stream-diversion permits even in non-designated areas. Among those powers is the important ability to grant permits subject to standard conditions, or special conditions tailored to each permit. This power should be exercised to enhance adaptive features of the permitting system. The Commission's practice is that as older permits are transferred, updated, or modified, the standard conditions are updated to conform to current requirements.[231]

Adaptive Recommendation. We propose several "adaptive" amendments to the standard or special conditions. These are presented as amendments to the conditions accompanying water use permits, but may also be adapted to work with well construction or stream diversion permits. The proposed amendments supplement existing conditions that already exhibit some aspects of adaptive capacity. For example, the existing standard conditions allow for modification of permits, to protect or conserve water resources, or if sustainable yield is reduced. This "living permit" system (i.e. a permit that is not fixed for all time, but instead is subject to changing conditions and limitations) promotes adaptive flexibility.

This "living permit" system (i.e. a permit that is not fixed for all time, but instead is subject to changing conditions and limitations) promotes adaptive flexibility

The standard conditions presently address monitoring and reporting.[232] On this front, however, the permit conditions can be made more adaptive. For example, the permit conditions should clarify that the Commission reserves the right to require monitoring and reporting of additional data, if it becomes appropriate. The Commission should also require permit holders to report on system losses and other appropriate inefficiencies, and to report conservation efforts.

The following revised standard condition No. 10 is proposed to address this issue (language to be added is underlined, while language to be deleted shows a strike through):

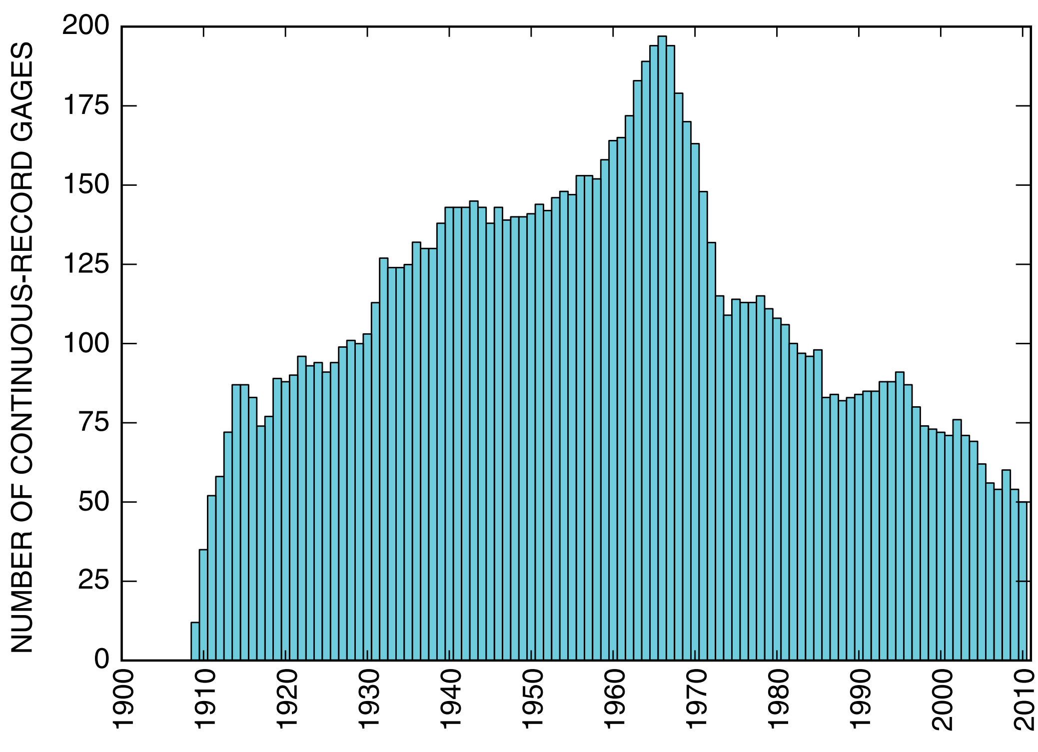
> An approved flowmeter(s) must be installed to measure monthly withdrawals and a monthly record of withdrawals, salinity, temperature, ~~and~~ pumping times, and system losses must be kept and reported on a monthly basis to the Commission on Water Resource Management on forms provided by the Commission ~~on a monthly basis (attached)~~ or electronically, in the manner prescribed by the Commission. Annually, the permit holder shall report, in the manner required by the Commission, all water conservation efforts. The Commission reserves the right to modify or waive these reporting requirements as it deems appropriate.

Since the permitting process exempts individual water users who make withdrawals for domestic purposes, it is reasonable to assume that most of the class of users who are permit holders will suffer little or no additional burden in complying with this standard condition.[233] Indeed, the Water Code expressly imposes the burdens of stewardship and monitoring onto permit holders.[234]

Relatedly, climate change scientists, the Water Commission, the U.S. Geological Survey, and others have acknowledged the important need to maintain a robust network of rain gauges, stream gauges, deep monitor wells, and other indicia of the hydrologic cycle, around the state. For rain and stream monitoring, this is especially critical in areas with an existing long-term data record, where long-term climate-related trends and impacts on water resources can be observed. Additional deep monitor wells, which directly observe conditions in the basal aquifers, have been identified as especially important for Kaua'i, Maui, and Hawai'i, where such aquifers are often expected to supply new development. Presently, all but six of the state's 40[xxviii] deep monitor wells are on O'ahu.[235]

Unfortunately, support for monitoring appears to be in decline. For example, the number of continuous-record stream gauges around the state has dropped, from a maximum of nearly 200 in the 1960s, to less than

Figure 8. Reductions in Hawai'i's Stream Flow Monitoring, 1965–2010



U.S. Geological Survey figure illustrating a dramatic decline in the number of stream flow monitoring stations since the 1960s.

Courtesy of U.S. Geological Survey, Pacific Water Science Center.

[xxviii] Furthermore, only 13 of those deep monitor wells are operated by the Water Commission or U.S. Geological Survey, away from pumping fields. The remaining wells are operated by the Honolulu Board of Water Supply ("BWS"), and are likely influenced by close proximity to BWS pumping facilities.

70 today. To address this need, the permit system should incorporate a mechanism for requiring, where appropriate, permit holders to monitor both inputs to and outputs from water cycle. Thus, in addition to the standard condition No. 10 above, we propose the following special condition, to be used where applicable:

> An approved rain gauge/stream gauge (or other measure of water balance) must be installed and maintained in the vicinity of <insert location >, with the resulting data reported monthly to the Commission in accordance with these permit conditions. Alternatively, the permit holder may satisfy this condition by electing to: (i) pay an annual rain gauge/stream gauge monitoring fee established by the Commission; or (ii) join a monitoring consortium approved by the Commission. In any event, it is the permit holder's ultimate obligation to ensure that monthly reports are timely submitted to the Commission.

Deep well monitoring cannot be tied to individual permits in the same way, but can perhaps be supported via the implementation of more meaningful application and permit fees, or through an annual monitoring fee, as further described below.

The same 2008 report that identified worrisome non-compliance with reporting requirement also reported that 36 percent of the permits reviewed did not properly identify the location of the water source or end use. Thirteen percent of the permits reviewed suffered from overpumping. Twelve percent of the permits were not investigated in the field "because of a complete lack of response from permit holders, or because scheduled visits were cancelled by the permit holder with no further correspondence."[236] These permit holders included one federal agency, three state agencies, four county departments, nineteen corporations, and several major nonprofit and business organizations.[237] It appears that Hawaii Administrative Rules § 168-15, which requires that all well operators allow for inspection access, was ineffective.

The conditions checked during each field visit included verifying well location, flowmeter installation and function, end use type and location, and wasting of water,[238] none of which are specifically addressed by the monthly and annual reporting forms currently provided by the Commission.[239] These inspections yielded valuable information. For example, 37 percent of the inspected wells lacked an approved flowmeter.

To address these problems, a standard condition providing for regular compliance inspections is proposed:

> The permit holder must provide inspection access to all areas and information associated with the relevant water withdrawal and use. To fund these inspections, the permit holder is required to pay an annual inspection fee established by the Commission. Alternatively, the permit holder may submit, on an annual basis, inspection reports prepared by a third-party inspector approved by the Commission.[xxix]

[xxix] This proposed condition is similar to the BWS requirement for annual testing of backflow prevention devices. *See* Honolulu Bd. of Water Supply, R. & Reg. § 2-213.3.

4.3 Market-Based Tools

Public trust and other protected uses limit the extent that water can be commoditized or taxed in Hawai‘i. Nonetheless, a number of markets are tied to water use. Thus, it is possible to use market-based tools to incentivize adaptive measures. Table 6 summarizes several such tools. This section then describes challenges and recommendations related to each tool.

Table 6. Adaptive Market-Based Tools

Encourage Water-Conscious Construction and Modifications with Green-Building Benefits and Credits

New development, and redevelopment, present an opportunity to incorporate water-conserving infrastructure and practices. State and local government should enhance "green-building" efforts with (1) county rebates and utility credits and (2) state income tax credits directed specifically at water conservation.

Adaptive Characteristics: (1) **Forward-looking**; (2) **Flexible**; (3) **Integrative**

Existing Model(s): **Hawai‘i Energy Program**; **Hawai‘i renewable energy tax credit**; **Haw. Rev. Stat. § 46-19.6** (expediting building permit process for green-building projects).

Implementation Time Frame: **Long** Implementation Cost: **Moderate**

Lead Agency: **County Water Supply** Support: **County councils and state legislature**

Initial Steps: County and state agencies to identify appropriate conservation incentives.

Potential Barriers: Requires: (i) county and state legislation; (ii) assessing and balancing the effect of implementation cost on revenue, with cost savings.

(See 4.3.1)

Relate Water Commission Fees More Closely to the Cost of Water Management and Watershed Protection

It appears that the fees presently charged in connection with obtaining and maintaining water-related permits are not consistent with the Water Commission's cost of managing water resources. Changes to the fee structure, and the collection of penalties for non-compliance, can help to narrow that gap.

Adaptive Characteristics: (1) **Flexible**; (2) **Integrative**; (3) **Iterative**

Existing Model(s): **DLNR dam safety regulations** (proposed H.A.R. § 13-190)

Implementation Time Frame: **Short** Implementation Cost: **Moderate**

Lead Agency: **Water Commission**

Initial Steps: Water Commission to identify areas for appropriate and reasonable fees.

Potential Barriers: Requires: (1) Water Commission rulemaking process; (2) public outreach to assess and address possible water user opposition; (3) ongoing enforcement capacity.

(See 4.3.2)

(continued on next page)

Table 6. Adaptive Market-Based Tools (continued)

Adopt a Public Goods Charge for Water Use

An across-the-board fee for water use can impart a conservation price signal, and fund the cost of water management and conservation.

Adaptive Characteristics: (1) **Flexible**; (2) **Integrative**; (3) **Iterative**

Existing Model(s): **California energy public goods charge**; **county property tax regime**

Implementation Time Frame: **Medium** Implementation Cost: **Low**

Lead Agency: **Water Commission** Support: **County water supply**; **county councils and state legislature**

Initial Steps: Identify appropriate mechanisms for assessing and collecting public goods charge.

Potential Barriers: (1) May require state and county legislation (limited implementation without legislation may be possible by county water supply boards); (2) public outreach campaign to assess and address possible user opposition.

(See 4.3.3)

4.3.1 Encourage Water-Conscious Construction and Modifications with Green-Building Benefits and Credits

Challenge. Presently, the price of water to the end user is often insufficient to promote market-related conservation. This could change, however. At current levels of groundwater recharge, economists have modeled a sharp increase in the "scarcity" rent associated with water, under various watershed degradation scenarios. In such a scenario, the price of water would rise. Of course, a substantial price increase would be accompanied by a variety of thorny problems. In many respects, demand for water is inelastic; some users cannot forgo water because it is too expensive. The public trust doctrine and the associated protected uses of water also limit the extent of water commoditization and taxation in Hawai‘i. Nonetheless, some aspects of water use, such as distribution for municipal domestic use or for commercial irrigation, are subject to various market-related forces.[240] The challenge for climate change adaptation is to identify available tools in that arena, while protecting the availability of the water supply for protected uses.

Adaptive Recommendation. One potential solution is to promote water-conscious infrastructure through market-related regimes that are not directly tied to water use. For example, building code and plumbing code requirements can affect water use at the end user, without directly involving the "market" for water.[xxx] In the same fashion, the state and counties should continuously identify and adopt measures to promote the use of water-conserving infrastructure, through tax credits, rebates, or other benefits.[xxxi]

[xxx] For example, low-flow plumbing fixtures must be used in new construction. *See, e.g.*, M.C.C. § 16.20A.680; , Honolulu Revised Ordinances ("H.R.O.") § 19-4.1(25). Honolulu also requires that all nonresidential properties be retrofitted with low-flow plumbing fixtures. *See* H.R.O. § 30-4.2.

[xxxi] At the federal level, a 2007 Executive Order that directed agencies to reduce potable water consumption intensity by 2 percent per year, through 2015, was recently extended to 2020. *See* Exec. Order No. 13514, 74 Fed. Reg. 52, 118 (Oct. 08, 2009). At the state

Aspects of this model are already in use with regard to energy. For example, renewable energy installations can be eligible for significant state and federal tax credits, and for exemptions from property taxes. Energy conservation, such as through the use of solar water heaters, compact fluorescent light bulbs, and energy efficient appliances, is promoted via rebates administered by the Hawai'i Energy Program.[241] These rebates are funded by a small fee placed on electric bills on the islands of O'ahu, Lānai, Moloka'i, and Hawai'i.

No comparable comprehensive system is presently in place for water conservation in Hawai'i, although smaller and more fragmented pilot programs for water conservation have been tested, in various contexts.[242] O'ahu's toilet rebate program was estimated to save 4.6 billion gallons of water during its life, but expired in 2010 because of "current economic conditions."[243] Elsewhere, the ratepayer-funded rebate model has been applied broadly to water conservation. In Australia, for example the city of Melbourne and state of Victoria instituted a system of rebates for water audits, water efficient toilets and showers, rainwater collection systems, greywater recycling systems, rain sensors, and a host of other water conservation measures.[244] It is estimated that the rebate program has helped to conserve over 700 million gallons of water per year.[245]

Las Vegas offers rebates for items such as irrigation controllers that adjust watering schedules based on weather conditions or other factors. In a related program, the water authority helps consumers and businesses identify landscape contractors who are specially trained in water-efficient landscaping and irrigation design, and provides rebates for the installation of such features.[246] In some respects, the Las Vegas model regarding rebates is especially relevant to Hawai'i. For example, both places employ tourism as a central industry. In Las Vegas, hotel laundry service is one area where conservation retrofitting, with financial assistance from the water authority, yielded substantial cost savings to go along with dramatic water savings.[247]

Because technology is continually improving and broadening the available arsenal of water-conserving measures, the list of rebate-eligible items can grow. And, that list is not limited to plumbing fixtures. For example, in Hawai'i permeable pavement and vegetated swales can impact the water cycle by affecting groundwater recharge and storm runoff. Continued efforts to identify and promote these types of infrastructure will allow Hawai'i to adopt an integrated approach by tackling water conservation from multiple angles.

Presently, it appears that there is only one statewide program conferring benefits for water-conscious infrastructure in Hawai'i. Under Haw. Rev. Stat. § 46-19.6, counties are required to give priority to building permits that incorporate environmentally conscious design standards. This approach should be expanded, to include: (1) rebates or water bill credits for water conservation devices or technology, funded by a fee assessed under each county's municipal water supply system—modeled after (or managed in conjunction with) the Hawai'i Energy Program; (2) income tax credits for water-conscious construction or reconstruction—modeled after (or managed in conjunction with) the renewable energy state income tax credit; and (3) refinements to local plumbing codes to require higher efficiency water fixtures and appliances.

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level, Governor's Administrative Directive No. 06-01 (January 20, 2006) instructed agencies to implement water efficiency practices in operations to reduce waste and increase conservation, and required that building projects be designed and constructed to receive certification from the United States Green Building Council for meeting Leadership in Energy and Environmental Design standards.

4.3.2 Relate Water Commission Fees More Closely to the Cost of Water Management and Watershed Protection

Challenge. Irrespective of the costs (or cost savings) associated with adaptive management techniques, it is clear that the Water Commission's expenses incurred in managing Hawai'i's water resources are not tied, in any fashion, to the cost of water use and other permits, nor to the cost of watershed protection efforts. Especially in the present situation—where voluntary use reporting has suffered serious compliance problems, and private and government entities at every level are being squeezed for funding—this imbalance poses a problem. While there are broad benefits arising from the Water Commission's work, such that those benefits should be borne statewide, there are other aspects of the Commission's work that are more closely tied to individual permit holders or applicants.

Adaptive Recommendation. The Commission should identify and quantify costs that are tied to particular processes or users, and recover those costs through an appropriate fee structure. For example, the application process for water use, well construction, and stream channel alteration permits are plainly tied to a subset of users (i.e. the applicants). Those applicants receive a significant benefit from their permit, and thus it is appropriate to shift some or all of the expenses of the permitting and regulatory process onto such applicants.

Presently, the fee for such applications is nominal, only $25.[248] Moreover, governmental entities are exempt from application fees, and private applicants are required to pay only a single water use permit application fee even when applying for multiple withdrawals.[249] Other governmental functions in Hawai'i utilize a different approach. For example, in the state's dam safety regulations, there are no exemptions for multiple related applications.[250] Moreover, the changes recently proposed by the State Department of Land and Natural Resources include a number of significant application fees, ranging from $400 for a certificate to impound water to thousands of dollars for dam alteration or construction permits.[251] The regulations also impose an annual fee, which can range from $500 to thousands of dollars, depending on the size of the dam. All of these fees are intended to defray the cost of regulating dams, and were deemed important enough to include even over the objection of affected dam owners.

Following that model, the fee for applications submitted to the Water Commission should be tied more directly to (i) the quantity of water impacted (for example, the amount of water requested in a water use permit, or the well pumping capacity for a well construction permit), and (ii) the cost of watershed protection efforts necessary to maintain the resource which is to be extracted. Under Haw. Rev. Stat. § 174C-5.5, the Water Commission is empowered to collect such fees and administrative charges, and to deposit the money into a fund used exclusively for its water resource management duties. However, because the current $25 fee is embodied in the existing administrative rules, a rule-making procedure would be required to alter the fee structure.

As with dam regulation, annual fees can also be used as a tool, especially where they are associated with monitoring, reporting, or inspecting water facilities (see Section 4.2.4, regarding proposed permit conditions), or where they are tied to watershed protection and planning. We suggest a tiered fee structure. For example, lower fees (or exemptions as appropriate) can be adopted for public trust or low-impact uses, with higher fees for other uses. In addition, ICAP recommends revisiting the blanket exemption for governmental entities, who are among the state's largest water users (such entities are not exempt from filing fees for water pollution control permit applications issued by the State Department of Health).[252] Eliminating or limiting this exemption can help to more directly tie the cost of water management to the price of water delivery.

4.3.3 Adopt a Public Goods Charge for Water Use

Challenge. Excessive water consumption imposes a cost on everyone, via the obvious effect on water availability, but also through sometimes-hidden externalities such as additional energy consumption. Similarly, developing or neglecting critical watersheds also imposes external costs on water resource availability. In a market system operating at theoretical perfect efficiency, market price signals would account for these effects; a higher price would limit excessive use, and pay for all externalities. But, as described above, water use in Hawai'i cannot rely solely on a market system. Other methods must be identified to impart a price signal on excessive water use, and to promote the development of conservation and recycling infrastructure.

Excessive water consumption imposes a cost on everyone

Adaptive Recommendation. A public goods charge levied on water use can be an adaptive tool, to impart a price signal on excessive water use a while simultaneously providing a funding source to lower the cost of water management, conservation, and recycling. A recent study by the California Public Utilities Commission concluded that a public goods charge could have exactly these twin effects.[253] Dual concerns for water and energy use triggered the study, and the public goods charge was modeled on a 1996 charge successfully implemented in the energy sector. That charge is credited with helping to keep California's per capita energy use much lower than the U.S. average. Its per capita water use, on the other hand, is on par with the U.S. average. Promisingly, the Water Commission has commenced a process for assessing the viability of a similar "water stewardship fee."

The adoption of a public goods charge on water use in Hawai'i can be an adaptive tool, to impart a price signal on water use and to generate funds to pay for conservation measures and infrastructure. However, unlike the administrative fees and expenses described above, the direct imposition of a public goods charge on the end user is not as clearly within the Water Commission's presently enumerated powers. Instead, this function would likely require legislation at the state level (perhaps by authorizing the Commission, or the counties, to assess the charge for all metered water uses, across all water use sectors, akin to the property tax model[xxxii]). Indeed, the boards of water supply already utilize variations of a public goods charge. For example, the Honolulu Board of Water Supply charges an additional $0.01 per thousand gallons for every additional $600,000 incurred in power costs, or in environmental compliance fees.[254] The benefits of a broader system, whether at the county or state level, is that the proceeds of the charge could (i) attach to all metered uses, not just water delivered by each respective board of water supply; and (ii) allow the Commission or counties to use the proceeds for all water management, conservation, and watershed protection efforts, including those by the boards of water supply, DLNR-administered public-private Watershed Partnerships, or others. However, the

[xxxii] *See* Haw. Rev. Stat. § 246A-1 (transferring authority over property taxes from the state to the counties).

broader approach also faces a higher implementation barrier, especially the need for authorization by the state legislature, and the development of procedural infrastructure for assessing and collecting the charge.

The California study reviewed several methods for assessing such a charge, and determined that a volumetric fee (i.e. charged per volume of water consumed) is more equitable and practical than a flat fee, or a fee assessed as a percentage of as user's water bill.[255] A tiered fee structure can differentiate between various water uses, such as protected public trust uses and non-protected uses.

To illustrate the revenue-generating power of a public goods charge on water, consider that the municipal daily water demand on Oʻahu exceeds 150 million gallons per day.[256] A public goods charge of ten cents per thousand gallons (the current Board of Water Supply retail rate ranges from $2.79 to $5.01 per thousand gallons for residential use) could generate nearly $5.5 million per year, without even accounting for military and other uses. These funds could be applied to water resource management, conservation, and recycling activities. Improved conservation and recycling will lead to lower per capita demand on groundwater and surface water resources, and thus lower the effective rate of the public goods charge.

5. Conclusion: A Call to Adaptive Action

Viewed through the lens of Hawaiʻi's water law and planning framework, observed climate trends point toward two important conclusions. First, climate change adaptation is not a "tomorrow" issue. Second, adaption cannot be forestalled because the full menu of future risk is "uncertain." A central concept of adaptation planning is that uncertainty is *always* a factor in the long-term management of resources such as water. Laws, policies, and procedures are adaptive when they can tackle the observed effects of climate change, and when they can flexibly address changing demands and conditions in the uncertain future.

A central concept of adaptation planning is that uncertainty is always a factor in the long-term management of resources such as water

The law and policy framework for managing water in Hawaiʻi—including constitutional protections, the precautionary principle, the Water Code, the Water Plan, and corresponding state and local rules, regulations, and plans—allows for exactly this type of adaptive management. This is because the existing framework incorporates numerous examples of mandates that are forward-looking, flexible, integrative, and iterative. The tools recommended in this white paper are consistent with that framework and are extensions of existing (or at least, presently contemplated) processes, plans, and regulations. Thus, these tools can maximize the benefits of adaptation, while minimizing any burdens. The critical next step is to use these tools to launch adaptation into action.

Appendix A: Twelve Adaptive Tools for Water Resource Management in Hawai'i

Adaptive Policy and Planning Tools

1 – Incorporate Climate Change Planning Into the Hawai'i Water Plan

The Hawai'i Water Plan is a comprehensive tool to aid long-term planning for water resources. However, for that tool to be used effectively, all four parts of the Water Plan should expressly address climate change issues and climate change scenario planning.

Adaptive Characteristics: (1) **Forward-looking**; (2) **Flexible**; (3) **Integrative**; (4) **Iterative**

Existing Model: **Long-term climate scenario planning** (e.g., California Water Plan)

Implementation Time Frame: **Long** Implementation Cost: **Moderate**

Lead Agency: **Water Commission**

Initial Steps: Revise Water Commission's Statewide Framework for the Hawai'i Water Plan, with express directive to incorporate climate change planning into each Plan component.

Potential Barriers: Must identify (and then regularly revise in accord with new scientific findings and models) applicable assumptions and time horizons for climate scenario planning.

(See 4.1.1)

2 – Enforce Five-Year Updates to the Hawai'i Water Plan

The process for updating the Water Plan is in flux. Some portions have been updated recently, while others have not changed since 1990. Regular, iterative updates are necessary for the Water Plan to serve as an adaptive tool.

Adaptive Characteristics: (1) **Flexible**; (2) **Integrative**; (3) **Iterative**

Existing Model: E.g., **California Water Plan**, **Melbourne Water Supply and Demand Strategy**

Implementation Time Frame: **Medium** Implementation Cost: **Moderate**

Lead Agency: **Water Commission** Support: All agencies involved in the Hawai'i Water Plan.

Initial Steps: Water Commission directive to update all elements of the Hawai'i Water Plan on a five-year cycle. Identification of most effective enforcement options.

Potential Barriers: Agency funding and staff-resource constraints.

(See 4.1.2)

3 – Expand Models of Water- and Climate-Conscious Land Use Plans and Policies

Continued integration of land use and water resource planning, as illustrated by Maui's Water Availability Policy, empowers an integrated and adaptive approach.

Adaptive Characteristics: (1) **Forward-Looking**; (2) **Flexible**; (3) **Integrative**

Existing Model: **Maui County Water Availability Policy**

Implementation Time Frame: **Medium** Implementation Cost: **Low**

Lead Agency: **County councils**

Initial Steps: Counties to adopt appropriate policies, ordinances, and plans to more fully integrate land use and water planning.

Potential Barriers: Requires county legislation and political will.

(See 4.1.3)

(continued on next page)

Appendix A: Twelve Adaptive Tools (continued)

Adaptive Policy and Planning Tools (continued)

4 – Adopt Existing Models to Integrate Watershed Conservation with Water Resource Planning

Combining the watershed protection process with the Hawai'i Water Plan (via each county's Water Use and Development Plan) can empower the adaptive goals of monitoring and integration.

Adaptive Characteristics: (1) **Forward-Looking**; (2) **Integrative**

Existing Model: **O'ahu WUDP and Watershed Management Plans**

Implementation Time Frame: **Medium** Implementation Cost: **Moderate to High**

Lead Agency: **County Water Supply** Support: **Water Commission; DLNR**

Initial Steps: Counties to revise internal process for WUDP preparation.

Potential Barriers: Requires county legislation and Water Commission approval. Potentially higher costs and longer time frame for WUDP preparation.

(See 4.1.4)

5 – Finalize and Implement Mandatory Water Conservation and Recycling Plans

Some initial steps have been made toward compiling mandatory water conservation and recycling plans. Those plans should be finalized and implemented by each county.

Adaptive Characteristics: (1) **Forward-Looking**; (2) **Flexible**; (3) **Integrative**; (4) **Iterative**

Existing Models: **DLNR Prototype Water Conservation Plan; Maui County Conservation Policy; Victoria, Australia Water Saving Rules; 2008 WRPP**

Implementation Time Frame: **Medium** Implementation Cost: **Moderate to High**

Lead Agency: **County Water Supply** Support: **DOH**; **Water Commission**; **legislators**

Initial Steps: Counties to work with federal and state agencies, subject matter experts, and water users to identify appropriate conservation and recycling tools, and to adopt appropriate policies, ordinances, and plans.

Potential Barriers: Requires: (i) legislative action; (ii) coordinating of federal, state, and county agencies involved in water resources, wastewater, and water quality; (iii) identifying technological solutions and markets for recycled water; (iv) enforcing conservation measures.

(See 4.1.5)

Adaptive Regulatory Tools

6 – Adopt Climate-Conscious Sustainable Yield and Instream Flow Standards

Sustainable yield and instream flow standards form the heart of the water planning process under the Water Code. They should account for climate change and potential impacts, and they should be reevaluated on a regularly scheduled basis.

Adaptive Characteristics: (1) **Forward-looking**; (2) **Flexible**; (3) **Integrative**; (4) **Iterative**

Existing Model(s): **"Clearly Sustainable Yield"**

Implementation Time Frame: **Medium** Implementation Cost: **Low**

Lead Agency: **Water Commission**

Initial Steps: In connection with a climate-conscious Hawai'i Water Plan, Water Commission to establish long-term schedule for reevaluating sustainable yields and instream flow standards, with direct links to updated climate change data products.

Potential Barriers: (i) Regularly revising applicable numerical models to incorporate observed and expected climate-related trends for each aquifer system; (ii) revising instream flow standards may be more costly than revising sustainable yield, because of the expense of stream-specific studies (in comparison to more widely applicable sustainable yield models).

(See 4.2.1)

7 – Enforce and Expand Statewide Water Use Monitoring and Reporting

Monitoring and reporting requirements contained in water use permits (for designated Water Management Areas) and reporting of water use (even in non-designated areas) are critical components of adaptive water resource management. These requirements must be enforced.

Adaptive Characteristics: (1) **Forward-looking**; (2) **Integrative**; (3) **Iterative**

Existing Model: **State Water Code**

Implementation Time Frame: **Short** Implementation Cost: **Moderate**

Lead Agency: **Water Commission**

Initial Steps: Support and expedite existing efforts to streamline and digitize the reporting process, and expand it to include automated internet publication of all reported data.

Potential Barriers: Requires: (i) integration of Water Commission's existing databases; (ii) enforcement for non-compliance with reporting requirements.

(See 4.2.2)

(continued on next page)

Appendix A: Twelve Adaptive Tools (continued)

Adaptive Regulatory Tools (continued)

8 – Expand Water Management Areas

Under the Water Code, more adaptive tools and strategies are applicable in WMAs than in non-designated areas. Protection against climate hazards is enhanced by the designation of WMAs for both surface water and groundwater resources.

Adaptive Characteristics: (1) **Forward-looking**; (2) **Integrative**

Existing Model(s): **Existing WMAs**; **1994 Review Commission Report on the State Water Code**

Implementation Time Frame: **Long** Implementation Cost: **High**

Lead Agency: **Water Commission** Support: **County WUDP**; **state legislature**

Initial Steps: Water Commission to assess climate change impacts and identify non-designated areas that are most threatened, or that have the greatest adaptive potential for protecting recharge and watersheds.

Potential Barriers: Requires: (i) lengthy Water Commission process; (ii) regulatory capacity for ongoing management of expanded designated areas. Potential challenges from water users and developers.

(See 4.2.3)

9 – Adopt More Adaptive Conditions for Water Use, Well Construction, and Stream Diversion Permits

The standard and special conditions applicable to such permits should be amended to enhance adaptive capabilities such as monitoring and forward-looking flexibility. Proposed amendments are suggested, to empower use monitoring, rain and stream monitoring, and permit compliance inspections.

Adaptive Characteristics: (1) **Forward-looking**; (2) **Flexible**; (3) **Integrative**; (4) **Iterative**

Existing Model(s): **Existing permit conditions**

Implementation Time Frame: **Short** Implementation Cost: **Low**

Lead Agency: **Water Commission**

Initial Steps: Water Commission to revise the standard conditions for new water use permits, and identify opportunities to revise existing permit conditions.

Potential Barriers: (i) Additional enforcement burden on Water Commission; (2) possible user opposition.

(See 4.2.4)

Adaptive Market-Based Tools

10 – Encourage Water-Conscious Construction and Modifications with Green-Building Benefits and Credits

New development, and redevelopment, present an opportunity to incorporate water-conserving infrastructure and practices. State and local government should enhance "green-building" efforts with (1) county rebates and utility credits and (2) state income tax credits directed specifically at water conservation.

Adaptive Characteristics: (1) **Forward-looking**; (2) **Flexible**; (3) **Integrative**

Existing Model(s): **Hawai'i Energy Program**; **Hawai'i renewable energy tax credit**; **Haw. Rev. Stat. § 46-19.6** (expediting building permit process for green-building projects).

Implementation Time Frame: **Long** Implementation Cost: **Moderate**

Lead Agency: **County Water Supply** Support: **County councils and state legislature**

Initial Steps: County and state agencies to identify appropriate conservation incentives.

Potential Barriers: Requires: (i) county and state legislation; (ii) assessing and balancing the effect of implementation cost on revenue, with cost savings.

(See 4.3.1)

11 – Relate Water Commission Fees More Closely to the Cost of Water Management and Watershed Protection

It appears that the fees presently charged in connection with obtaining and maintaining water-related permits are not consistent with the Water Commission's cost of managing water resources. Changes to the fee structure, and the collection of penalties for non-compliance, can help to narrow that gap.

Adaptive Characteristics: (1) **Flexible**; (2) **Integrative**; (3) **Iterative**

Existing Model(s): **DLNR dam safety regulations** (proposed H.A.R. § 13-190)

Implementation Time Frame: **Short** Implementation Cost: **Moderate**

Lead Agency: **Water Commission**

Initial Steps: Water Commission to identify areas for appropriate and reasonable fees.

Potential Barriers: Requires: (1) Water Commission rulemaking process; (2) public outreach to assess and address possible water user opposition; (3) ongoing enforcement capacity.

(See 4.3.2)

(continued on next page)

Appendix A: Twelve Adaptive Tools (continued)

Adaptive Market-Based Tools (continued)

12 – Adopt a Public Goods Charge for Water Use

An across-the-board fee for water use can impart a conservation price signal, and fund the cost of water management and conservation.

Adaptive Characteristics: (1) **Flexible**; (2) **Integrative**; (3) **Iterative**

Existing Model(s): **California energy public goods charge**; **county property tax regime**

Implementation Time Frame: **Medium** Implementation Cost: **Low**

Lead Agency: **Water Commission** Support: **County water supply**; **county councils and state legislature**

Initial Steps: Identify appropriate mechanisms for assessing and collecting public goods charge.

Potential Barriers: (1) May require state and county legislation (limited implementation without legislation may be possible by county water supply boards); (2) public outreach campaign to assess and address possible user opposition.

(See 4.3.3)

Appendix B: Lists of Figures, Tables, Boxes

List of Figures

List of Tables

List of Boxes

Citations and Authorities

[1] Comm'n on Water Res. Mgmt., State of Haw., *Water Resource Protection Plan* 7-56, 7-58 (2008) ("*2008 Water Resource Protection Plan*"), *available at* http://hawaii.gov/dlnr/cwrm/planning_wrpp.htm (emphasis added).

[2] *See, e.g.*, C. Fletcher, *Hawai'i's Changing Climate, Briefing Sheet* 2010 2 (2010), *available at* http://www.soest.hawaii.edu/coasts/publications/ClimateBrief_low.pdf. Also, snowfall is not uncommon on Hawai'i's three highest peaks, and observers occasionally report ice, sleet, and hail falling from the sky. *See, e.g.*, W. G. Wylie, *Tropical ice storms—Winter invades Hawaii*, 11 Weatherwise 3, 84–90 (1958); T. A. Jaggar, Jr., *The Outbreak of Mauna Loa, Hawaii, 1914*, 39 Am. J. Sci. 167, 172 (1915).

[3] *See, e.g.*, P. C. Ekern, *Direct Interception of Cloud Water on Lanaihale, Hawaii*, 28 Soil Sci. Soc'y Am. Proc. 419 (1964); J. O. Juvik & P. C. Ekern, *A climatology of mountain fog on Mauna Loa, Hawaii Island* (Water Res. Resarch Ctr., Univ. of Haw., Technical Report No. 118, 1978).

[4] Reader-friendly summaries of Hawai'i climate dynamics and rainfall distribution include Prevailing Trade Winds: Climate and Weather in Hawai'i (M. Sanderson ed., 1993) and T. W. Giambelluca & T. A. Schroeder, *Climate*, *in* Atlas of Hawai'i 49-59 (S. P. Juvik & J. O. Juvik eds., T. Paradise, chief cartographer, 3d ed. 1998).

[5] *See* P.-S. Chu & H. Chen, *Interannual and Interdecadal Rainfall Variations in the Hawaiian Islands*, 18 J. Climate 4796, 4809 (2005) ("Hawaii tends to be dry during most of the El Niño and wet during most of the La Niña events.").

[6] Based on analysis of data from J. F. Kenny et al., *Estimated use of water in the United States in 2005: U.S. Geological Survey Circular 1344* (2009), *available at* http://water.usgs.gov/watuse/data/2005/index.html.

[7] Fletcher, *supra* note 2, at 2; *see also* D. S. Oki, *Surface Water in Hawaii: U.S. Geological Survey Fact Sheet 045-03* (2003), *available at* http://pubs.usgs.gov/fs/fs04503/htdocs/fs045-03.html.

[8] G. W. Tribble, *Ground Water on Tropical Pacific Islands—Understanding a Vital Resource: U.S. Geological Survey Circular 1312* 1, 24 (2008), *available at* http://pubs.usgs.gov/circ/1312/. *Aquifer* is the scientific term for a distinct, underground geologic region that stores ground water.

[9] *Id*. at 24.

[10] Based on analysis of data from Kenny et al., *supra* note 6.

[11] *See* Tribble, *supra* note 8, at 5.

[12] *See id*.

[13] *Id*. at 5, 8.

[14] *See, e.g.*, 40 C.F.R. § 143.3.

[15] Honolulu Bd. of Water Supply, *Ko'olau Poko Watershed Management Plan - Public Review Draft* D-10 (2010) ("*Ko'olau Poko WMP*"), *available at* http://www.boardofwatersupply.com/cssweb/display.cfm?sid=2174.

[16] *See* Tribble, *supra* note 8, at 9.

[17] See *id*.; *see also* Pacific Legacy, Inc., *Archaeological Inventory Survey for the Proposed Auwahi Wind Farm Ahupua'a of Auwahi, District of Kahikinui, Island of Maui, Hawai'i* 254, *in* Draft Environmental Impact Statement, Auwahi Wind Farm, 'Ulupalakua Ranch, Maui, Hawai'i Appendix E (2011).

[18] *See* Tribble, *supra* note 8, at 11-12.

[19] *See id*. at 13.

[20] *See id*.

[21] *See* S. B. Gingerich, *Ground-Water Availability in the Wailuku Area, Maui, Hawai'i, U.S. Geological Survey Scientific Investigations Report 2008–5236* 17 (2008), *available at* http://pubs.usgs.gov/sir/2008/5236/.

[22] *See id*.; *see also* J. A. Engott & T. T. Vana, *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 2007-5013* 48-49 (2007), *available at* http://pubs.usgs.gov/sir/2007/5103/sir2007-5103.pdf.

[23] *See* Gingerich, *supra* note 21, at iv.

[24] *See*, *e.g.*, Honolulu Bd. of Water Supply, *Ko'olau Loa Watershed Management Plan* 2-12 (2009) ("*Ko'olau Loa WMP*"), *available at* http://hawaii.gov/dlnr/cwrm/planning/KoolauLoaWatershedManagementPlan.pdf.

[25] *See generally* T. Dunne & L. B. Leopold, Water in Environmental Planning (1978) for a general discussion of the hydrologic cycle and its relationship with human activity.

[26] *2008 Water Resource Protection Plan*, *supra* note 1, at 6-10.

[27] *See id*. at 6-26. U.S. Census data for 2010 are available at http://www2.census.gov/census_2010/04-Summary_File_1/Hawaii/. For 2030 population figures, *see* Dep't of Bus., Econ. Dev. & Tourism, State of Haw., *Population and Economic Projections for the State of Hawai'i to 2035* 2 (2009), *available at* http://hawaii.gov/dbedt/info/economic/data_reports/2035LongRangeSeries. Note that the water demand data from the *2008 Water Resource Protection Plan* appears to account for only municipal water use and may be over a decade old. *See 2008 Water Resource Protection Plan*, *supra* note 1. On O'ahu, for example, more recent 2005 data from the Honolulu Board of Water supply shows that permitted groundwater allocation for all sectors was 294 mgd, and actual water use was 187 mgd. *See Ko'olau Loa WMP, supra* note 24, at table OV-6. The challenge of obtaining uniform and updated water demand estimates statewide illustrates a need for improved water use monitoring, discussed further in Section 4.

[28] *See* W. Meyer & T. K. Presley, *The Response of the Iao Aquifer to Ground Water Development, Rainfall, and Land-Use Practices Between 1940 and 1998, Island of Maui, Hawaii, U.S. Geological Survey Water-Resources Investigations Report 00-4223* 50 (2001), *available at* http://pubs.usgs.gov/wri/wri00-4223. Related data is also available from the U.S. Geological Survey at http://hi.water.usgs.gov/recent/iao/chloride.html.

[29] *See* Meyer & Presley, *supra* note 28, at 52.

[30] *See id*. at 30.

[31] *See Recent hydrologic conditions, Iao and Waihee acquifer areas, Maui, Hawaii*, U.S. Geological Survey, http://hi.water.usgs.gov/recent/iao/chloride.html.

[32] *2008 Water Resource Protection Plan*, *supra* note 1, at 7-1.

[33] *See In re Waiahole Ditch* ("*Waiahole II*"), 105 Haw. 1, 93 P.3d 643 (2004); *In re Waiahole Ditch* ("*Waiahole I*"), 94 Haw. 97, 9 P.3d 409 (2000).

[34] *2008 Water Resource Protection Plan*, *supra* note 1, at 6-18, 6-15.

[35] *See In re Kukui (Molokai), Inc.*("*Kukui*"), 116 Haw. 481, 174 P.3d 320 (2007); *In re Wai'ola O Moloka'i, Inc.* ("*Wai'ola*"), 103 Haw. 401, 83 P.3d 664 (2004).

[36] *See* P. S. H. Macomber, Coll. of Tropical Ag. & Human Res., Univ. of Haw. at Mānoa, *Guidelines on Rainwater Catchment Systems for Hawaii* 3 (2010), *available at* http://www.ctahr.hawaii.edu/oc/freepubs/pdf/rm-12.pdf.

[37] *See id*. at 10.

[38] Dep't of Water, Cnty. of Kaua'i, http://www.kauaiwater.org/Kdow/payingforwater.html.

[39] *See Kauai residents asked to conserve water because of pump outage*, Honolulu Star-Advertiser, Nov. 3, 2011, *available at* http://www.staradvertiser.com/news/breaking/133208783.html.

[40] *See Power outage knocks out Central Maui water wells*, Maui News, Nov. 3, 2011, *available at* http://www.mauinews.com/page/content.detail/id/554980/Power-outage-knocks-out-Central-Maui-water-wells.html?nav=10.

[41] Act 234 § 1, 2007 Haw. Sess. Laws 697, 698 (Haw. 2007).

[42] *See, e.g.*, *2008 Water Resource Protection Plan*, *supra* note 1, at 7-56.

[43] *See* D. S. Oki, *Trends in Streamflow Characteristics at Long-Term Gauging Stations, Hawaii, U.S Geological Survey Scientific Investigations Report 2004–5080* 1, 23 (2004) *available at* http://pubs.usgs.gov/sir/2004/5080/pdf/sir20045080.pdf.

[44] *See* Chu & Chen, *supra* note 5, at 4796; *see also* H. F. Diaz et al., *Rainfall changes in Hawaii during the last century* (Am. Meteorol. Soc., 16th Conference on Climate Variability and Change, San Diego, Calif., 2005), *available at* http://ams.confex.com/ams/Annual2005/techprogram/paper_84210.htm, *follow* "Extended Abstract" hyperlink.

[45] *See* O. Timm & H. F. Diaz, *Synoptic-Statistical Approach to Regional Downscaling of IPCC Twenty-First-Century Climate Projections: Seasonal Rainfall over the Hawaiian Islands*, 22 J. Climate 4261, 4279 (2009). This work describes a recent effort to analyze the linkages between global climate change and rainfall in Hawai'i by downscaling global circulation models to the Hawai'i region. This exercise resulted in continuing projected changes in mean seasonal rainfall by the end of the twenty-first century (5 to 10 percent decrease in winter and 5 percent increase in summer). A map-based tool for exploring these projections in greater detail is available at http://apdrc.soest.hawaii.edu/gg/rainSD.php.

[46] *See* Oki, *supra* note 43, at 59.

[47] *See* Fletcher, *supra* note 2, at 3 (citing the Honolulu tide record at *Sea Levels Trends*, National Oceanographic and Atmospheric Administration, http://tidesandcurrents.noaa.gov/sltrends/sltrends.html); *see also* D. J. Caccamise et al., *Sea Level Rise at Honolulu and Hilo, Hawaii: GPS estimates of differential land motion*, 32 Geophys. Res. Lett. L03607 (2005).

[48] *See* M. Vermeer & S. Rahmstorf, *Global sea level linked to global temperature*, 106.51 Proceedings Nat'l Acad. Sci. 21527 (2009).

[49] *See* T. W. Giambelluca et al., *Secular temperature changes in Hawai'i*, 35 Geophys. Res. Lett. LI2702 (2008).

[50] Similarly, changes in the height, thickness, and persistence of the trade wind inversion—which blocks ascending air and inhibits high-level cloud development—could result in decreased precipitation, but the linkages with climate change are less certain. *See* Guangxia Cao et al., *Inversion variability in the Hawaiian trade wind regime*, 20 J. Climate 1145, 1156 (2008).

[51] "Because of the effects of temperature on the controls of evaporation, especially relative humidity, the environmental demand for water under a 2°C temperature increase would lead likely be about 8% greater than at present." T. W. Giambelluca et al., Comm'n on Water Res. Mgmt., State of Haw., *Drought in Hawaii, Report R88* 85 (1991) (citing T. W. Giambelluca, *Groundwater Recharge of the Pearl Harbor-Honolulu aquifer under three scenarios of climate change* (International Seminar of Climatic Fluctuations and Water Management, Cairo, Egypt, Dec. 1989)).

[52] *See, e.g.*, Comm'n on Water Res. Mgt., State of Haw., *Instream Flow Standard Assessment Report, Island of Maui Hydrologic Unit 6054, Ohia*, §§ 2.4, 2.5 (2009) (stating that "Hawaii's trade winds and the temperature inversion layer greatly affect solar radiation levels, the primary heat source for evaporation, and that evaporation and transpiration can significantly affect water yield because it determines the amount of rainfall that becomes streamflow.").

[53] *See* Fletcher, *supra* note 2, at 4.

[54] *See* P. Y. Groisman et al., *Contemporary changes of the hydrological cycle over the contiguous United States, trends derived from in situ observations*, 5 J. Hydrometeorology 64-85 (2004); Fletcher, *supra* note 2, at 3 ("Between 1958 and 2007, the amount of rain falling in the very heaviest downpours [defined as the heaviest 1% of all events] has increased approximately 12% in Hawai'i."); P.-S. Chu et al., *Changes in Precipitation Extremes in the Hawaiian Islands in a Warming Climate*, 23 J. Climate 4881, 4887, 4898 (2010) (explaining that the annual maximum number of consecutive dry days has been increasing since the 1950s, and longer dry periods [35–80 days] have occurred more frequently in the last 30 years).

Similarly, the results of a recent downscaling exercise "reproduce[s] the trend toward fewer heavy rain events in the years after the Pacific climate shift in the mid-1970s" and "indicate[s] small changes in the projected number of heavy rainfall days with large uncertainties resulting from disparities among the climate models." O. E. Timm et al., *Projection of changes in the frequency of heavy rain events over Hawaii based on leading Pacific climate modes*, 116 J. Geophys. Res. 1 (2011); *see also* C. Fletcher et al., Living on the Shores of Hawaii: Natural Hazards, the Environment, and Our Communities 123 (2010) ("As if this is not bad enough, global warming models also suggest that in a warmer atmosphere the precipitation events will be fewer but more intense with the net result that less water is likely to infiltrate to the water table, with most of it simply running into the ocean in the short period of the storm.").

[55] *See* E. Enos & G. Hovey, Div. of Forestry & Wildlife, State of Haw., *Bringing Down the Water*, *in* Wao Akua Sacred Source of Life 93, 99 (2003).

[56] *See, e.g.*, D. A. Hodell et al., *Possible Role of Climate in the Collapse of Classic Maya Civilization* 375 Nature 391 (1995) (correlating isotopic records of a peak dry period to the collapse of the Classic Maya civilization); P. D. deMenocal, *Cultural Responses to Climate Change During the Late Holocene*, 292 Science 667 (2001) (discussing correlations between climate variability and the collapse of Akkadian society in Mesopotamia, the Roanaoke English settlement in North America, and several societies in Pre-Columbian Central and South America).

[57] For example, publications and case studies emanating from local governments around the world are catalogued by the Climate Adaptation and Knowledge Exchange, http://www.cakex.org.

[58] *See* A. Nickson, *Cities and Climate Change: Adaptation in London, UK*, at 14, prepared for Cities and Climate Change: United Nations Human Settlements Program Global Report on Human Settlements (2011), *available at* http://www.unhabitat.org/downloads/docs/GRHS2011/GRHS2011CaseStudyChapter06London.pdf.

[59] *See, e.g.*, Global Change Research Act, 15 U.S.C. Ch. 56A (1990) (establishing the United States Global Change Research Program, http://www.globalchange.gov).

[60] *See, e.g.*, Washington State Agency Climate Leadership Act, Rev. Code. Wash. Ch. 43.21M (2009) (requiring the formation of an "integrated climate change response strategy to better enable state and local agencies, public and private businesses, non-governmental organizations, and individuals to prepare for, address, and adapt to the impacts of climate change"); *see also State and Local Adaptation Plans*, Georgetown Climate Center, http://www.georgetownclimate.org/adaptation/adaptation-plans.php

(describing adaptation initiatives in Alaska, California, Colorado, Connecticut, Florida, Maine, Maryland, Massachusetts, New Hampshire, New York, Oregon, Virginia, and Washington).

[61] For example, the Water Utility Climate Alliance (http://www.wucaonline.org) consists of ten local water-related agencies such as the San Francisco Public Utilities Commission, the New York City Department of Environmental Protection, and the San Diego County Water Authority. The goals include developing adaptation strategies and improving and expanding climate change research to aid water managers in resource planning. Individualized climate adaptation plans are also being developed in various places. *See, e.g.*, New York City Dep't of Envtl. Prot., *Assessment and Action Plan* 48 (2008), *available at* http://www.nyc.gov/html/dep/html/news/climate_change_report_05-08.shtml (describing a "decades long process of adjusting New York City's water supply, drainage, and wastewater management systems to climate change").

[62] *See* Hawai'i Revised Statutes ("Haw. Rev. Stat.") § 342B-72.

[63] *See, e.g.*, *Climate Change 2007: The Physical Science Basis: Contribution of Working Group I to the Fourth Assessment Report of the IPCC* § 6.4.1.1, Fig. 6.4 (compiling studies of atmospheric carbon dioxide concentration from a number of sources and evidencing that the present concentration is far higher, and changing far more rapidly, than at any time in the past 20,000 years); *see also* J. B. Ruhl, *Climate Change and the Endangered Species Act: Building Bridges to the No-Analog Future*, 88 B.U. L. Rev. 1 (2008) (describing the "no analog" problem in the context of climate change and ecosystem management) (citing, for example, D. Fox, *Back to the No-Analog Future?*, 316 Science 823 (2007)).

[64] *See generally* H. M. Fussel, *Adaptation Planning for Climate Change: Concepts, Assessment, Approaches, and Key Lessons*, 2 Sustainability Sci. 265, 268 (2007).

[65] *See* E. Means et al., *Decision Support Planning Methods: Incorporating Climate Change Uncertainties into Water Planning*, *Water Utility Climate Alliance White Paper* 1 (2010), *available at* http://www.wucaonline.org/assets/pdf/pubs_whitepaper_012110.pdf.

[66] *See, e.g.*, R. Kundis-Craig, *Stationarity is Dead — Long Live Transformation: Five Principles for Climate Change Adaptation Law*, 34 Harv. Envl. L. Rev. 9, 53-54 (2010).

[67] *2008 Water Resource Protection Plan*, *supra* note 1, at 7-58 ("Prudent water resource planning should consider the long-term impacts of global climate change and how this could affect Hawai'i's water supplies ….").

[68] *See, e.g.*, Kundis-Craig, *supra* note 66, at 65.

[69] *See, e.g.*, *id.* ("Adjusting to climate change impacts and feedback loops will require regulatory and management agencies to respond to changing ecological conditions and changing goals on a more or less continuous basis, preferably … in response to continuous informational inputs regarding exactly what is occurring.").

[70] *See, e.g.*, P. Kirshen et al., *Interdependencies of urban climate change impacts and adaptation strategies: a case study of Metropolitan Boston*, 86 Climatic Change 105, 119 (2008); UN-Water, *Climate Change Adaptation: The Pivotal Role of Water* 2 (2010) *available at* http://www.unwater.org/downloads/unw_ccpol_web.pdf ("Climate change is a complex problem that has increased the need for an integrated, multi-sectoral and multidisciplinary response."); A. Camacho, *Adapting Governance to Climate Change: Managing Uncertainty Through a Learning Infrastructure*, 59 Emory L.J. 1, 25-29 (2009).

[71] *See, e.g.*, L. C. W. Binder et al., *Preparing for climate change in Washington State*, 102 Climatic Change 351 (2010); Kundis-Craig, *supra* note 66, at 40 ("Principle #1: Monitor and Study Everything All the Time").

[72] *See, e.g.*, Pew Ctr. on Global Climate Change, *Climate Change 101: Understanding and Responding to Global Climate Change* 4 (2011), *available at* http://www.pewclimate.org/docUploads/Adaptation_0.pdf; *see also* Binder et al., *supra* note 71, at 354.

[73] *See* Binder et al., *supra* note 71, at 354.

[74] *See id.*

[75] *See id.* at 355.

[76] *See id.*; *see also* Fussel, *supra* note 64, at 268.

[77] *Ko'olau Loa WMP, supra* note 24, at 6-21 ("Cost effectiveness and sensitive shoreline development issues are limiting factors for the development of a desalination plant in the Ko'olaupoko district.").

[78] *See id.* at 5-74 (comparing capital costs for various wells and stating, "[f]or comparison, recycled water costs are considered mid, and desalination would be high").

[79] *See* J. Roumasset & C. Wada, *Ordering Renewables: Groundwater, Recycling, and Desalination* § 2.2 (Dep't of Econ., Univ. of Haw. at Mānoa, Working Paper No. 11-5R, 2011), *available at* http://www.economics.hawaii.edu/research/workingpapers/WP_11-5R.pdf (citing B. Pitafi & J. Roumasset, *Pareto-Improving Water Management over Space and Time: The Honolulu Case*,

91 Am. J. Agric. Econ. 138 (2009)). The Honolulu Board of Water supply has estimated the cost of desalination at a proposed Kalaeloa plan at around $8.00 per gallon of capacity in capital cost, and $3.25 per thousand gallons in production cost, adjusted for inflation to 2010. *See* Honolulu Bd. of Water Supply, *Waianae Watershed Management Plan* 5-19 (2009), *available at* http://hawaii.gov/dlnr/cwrm/planning/WaianaeWatershedManagementPlan.pdf. Others have estimated the wholesale cost of desalinated water at around $5 per thousand gallons (roughly adjusted for inflation to 2011). *See* B. Kaiser et al., *Environmental Valuation and the Hawaiian Economy* 41 (1999), *available at* http://www.uhero.hawaii.edu/workingpaper/HawaiiEnviroEvaluation.pdf (citing D. L. Krulce et al., *Optimal Management of a Renewable and Replaceable Resource: The Case of Coastal Groundwater* (unpublished 1998)); *see also* D. L. Krulce et al., *Optimal management of a Renewable and Replaceable Resource: The Case of Coastal Groundwater*, 79 Am. J. Agric. Econ. 1218 (1997).

80 *See* Roumasset, *supra* note 79, at § 3 (also noting that some golf courses pay much lower rates for recycled water, but that those individual agreements set initial rates significantly below costs). Note also that the cost of recycled water for irrigation (approximately $1.54 per thousand gallons on Oʻahu) can be lower than the cost of dematerialized recycled water for industrial uses.

81 *See* B. Kaiser & J. Roumasset, *Valuing Indirect Ecosystem Services: the Case of Tropical Watersheds* (Econ. Research Org., Univ. of Haw., Working Paper, 2002), *available at* http://www.uhero.hawaii.edu/assets/EDE.pdf; *see also* B. Kaiser et al., *supra* note 79, at ii.

82 *See, e.g.*, *Waiahole I*, 94 Haw. at 139, 9 P.3d at 451 ("the state has a comparable duty to ensure the continued availability and existence of its water resources for present and future generations").

83 *See* R. Kundis-Craig, *Adapting to Climate Change: The Potential Role of State Common-Law Public Trust Doctrines*, 34 Vt. L. Rev. 781, 850-51 (2010).

84 "The legislature finds that article XI, section 9, of the Constitution of the State of Hawaiʻi has given the public standing to use the courts to enforce laws intended to protect the environment." *Kahana Sunset Owners Ass'n v. Maui Cnty. Council*, 86 Haw. 132, 134, 948 P.2d 122, 124 (1997).

85 *See, e.g., Life of the Land v. Land Use Comm'n of State of Hawaii*, 63 Haw. 166, 172, 623 P.2d 431, 438 (1981) (identifying Article XI, Section 9 as an example of a constitutionally declared policy on standing).

86 *See* D. K. Sproat, *Ola I Ka Wai: A Legal Primer for Water Use and Mgmt. in Hawaiʻi* 3 (2009), *available at* http://www.law.hawaii.edu/sites/www.law.hawaii.edu/files/news/WaterPrimer.pdf. Similar concepts regarding the ties between traditional and customary Native Hawaiian rights and water resources are expressed in a variety of other ways and contexts. *See, e.g*, Minutes for the Meetings of the State of Haw. Comm'n on Water Res. Mgmt., Dec. 15, 2004 (transcribing the comments of cultural historian Kepa Maly):

> One elder Hawaiian gentleman of the Kona District where no water flows above ground on a regular basis shared with me a riddle in Hawaiian. "He ma'i ka honua, he ʻaha la'au?" (The earth is ill, what is it's medicine?) Eia ka puana—here is the reply, "Ua! (Rain!) No ka mea, "Uwe ka lani, ho'ola ka honua!" Because when the rain falls—like tears—from the heavens, they give life, they nurture, they bring life to the earth!" This was a way the Hawaiian people have traditionally and over a long period of time looked at the wealth and the nature of resources around them, as living beings.

87 *See, e.g.*, Haw. Rev. Stat. § 7-1 ("The people shall also have a right to drinking water, and running water, and the right of way. The springs of water, running water, and roads shall be free to all, on all lands granted in fee simple; provided that this shall not be applicable to wells and watercourses, which individuals have made for their own use.").

88 *See id.* § 174C-101(c):

> 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, opae, oʻopu, limu, thatch, ti leaf, aho cord, and medicinal plants for subsistence, cultural, and religious purposes.

See also, e.g., *Waiʻola*, 103 Haw. at 419, 83 P.3d at 682 (noting that the State Commission on Water Resource Management, in evaluating an application for a water permit, considered "(1) whether traditional and customary native Hawaiian rights were exercised in the project area; (2) the extent to which, if such rights were being exercised, they would be affected by the proposed action; and (3) the feasible measures, if any, that could be undertaken by the Commission to protect these rights.").

89 *See* Haw. Rev. Stat. § 174C-101(c).

90 *Id.* § 174C-101(a); *see also* Hawaiʻi Homes Commission Act of 1920, as amended § 220(d) (requiring that "sufficient water shall be reserved for current and forseeable domestic, stock water, aquaculture, and irrigation activities on tracts leased to Native Hawaiians ….").

[91] *See Cultural Importance – Native Hawaiians and Streams*, State of Haw., DLNR Div. of Aquatic Res., http://hawaii.gov/dlnr/dar/streams_cultural_importance.html.

[92] *See Hawai'i Native Stream Animals*, State of Haw., DLNR Div. of Aquatic Res., http://hawaii.gov/dlnr/dar/streams_native_animals.html. Note that this list is not exhaustive; stream flow can also affect other species. For example, algal communities are at the base of the food chain in many stream ecosystems. The composition of those algal communities has been tied to stream depth and velocity. *See* DLNR Div. of Aquatic Res., State of Haw., *Seasonality of Algae in Waiāhole and Kahana Streams, Windward O'ahu, Hawai'i* 19 (Technical Report No. 04-01, 2004), *available at* http://hawaii.gov/dlnr/dar/pubs/seasonality.pdf.

[93] *See Hawaiian Streams*, State of Haw., DLNR Div. of Aquatic Res., http://hawaii.gov/dlnr/dar/streams.html.

[94] "The public trust in the water resources of this state, like the navigable waters trust, has its genesis in the common law." *Waiahole I*, 94 Haw. at 130, 9 P.3d at 442.

> [A] public trust was imposed upon all waters of the kingdom. That is, we find the public interest in the waters of the kingdom was understood to necessitate a *retention of authority* and the imposition of a concomitant *duty to maintain the purity and flow of our waters for future generations* and to assure that the water of our land are put to reasonable and beneficial uses.… "[W]e comprehend the nature of the State's ownership as a retention of such authority *to assure the continued existence* and beneficial application of the resources for the common good.

Id. (quoting *Robinson v. Ariyoshi*, 65 Haw. 641, 658 P.2d 287 (1982)) (emphasis added).

[95] *Waiahole I*, 94 Haw. at 139, 9 P.3d at 451; *see also id.* at 141, P.3d at 452 ("Under the public trust, the state has both the authority and duty to preserve the rights of present and future generations in the waters of the state.").

[96] The characteristics quoted in Box 7 are taken from: *Waiahole I*, 94 Haw. at 130, 9 P.3d at 442; *Kukui*, 116 Haw. at 490, 174 P.3d at 329; *Wai'ola*, 103 Haw. at 431, 83 P.3d at 694.

[97] In addition to the Hawai'i Supreme Court, others have also described Hawai'i's public trust doctrine in terms that illustrate its adaptive nature. *See, e.g.*, D. A. Antolini, *Water Rights and Responsibilities in the Twenty-first Century: A Foreword to the Proceedings of the 2001 Symposium on Managing Hawai'i's Public Trust Doctrine*, 24 U. Haw. L. Rev. 1, 5 (2001) ("The role of the public trust doctrine is 'the theoretical underpinning of a general legal superstructure that submits water rights and water uses to evolving community needs.'") (quoting Prof. Joseph Sax, *Proceedings of the 2001 Symposium on Managing Hawai'i's Public Trust Doctrine* 28).

[98] *Waiahole I,* 94 Haw. at 114 n.6, 9 P.3d at 426 n.6.

[99] *See Wai'ola*, 103 Haw. at 431, 83 P.3d at 694.

[100] *Waiahole I*, 94 Haw. at 114 n.6, 9 P.3d at 426 n.6.

[101] *Id.* at 142, 9 P.3d at 454.

[102] *Id.* at 141, 9 P.3d at 453.

[103] *Id.* at 154, 9 P.3d at 466 (internal quotation omitted).

[104] *See id.*; *see also Kukui*, 116 Haw. at 500, 174 P.3d at 339.

[105] *See Waiahole I*, 94 Haw. at 155 n.59, 9 P.3d at 467 n.59.

[106] *Id.* (quoting *Ethyl Corp. v. EPA*, 541 F.2d 1 (D.C. Cir. 1976)) (internal changes in *Waiahole I* not marked; bold emphasis added).

[107] *Ko'olau Loa WMP, supra* note 24, at app. B-15.

[108] *See Waiahole I*, 94 Haw. at 143, 9 P.3d at 455 (internal citations and quotations omitted).

[109] *See* Haw. Rev. Stat. § 174C-5.

[110] *See id.* § 174C-2(c).

[111] *See id.*

[112] *See id.*

[113] *Waiahole I*, 94 Haw. at 145-46, 9 P.3d at 457-58.

[114] *Id.* at 146, 9 P.3d at 458.

[115] *Id.* at 145-46, 9 P.3d at 457-58.

[116] *See Wai'ola*, 103 Haw. at 430, 83 P.3d at 693 (quoting *Waiahole I*, 94 Haw. at 140, 9 P.3d at 452) (internal quotation marks omitted).

[117] *Waiahole I*, 94 Haw. at 142, 9 P.3d at 454.

[118] *Id.*

[119] *See* Haw. Rev. Stat. § 174C-31(c).

[120] *See id.* § 174C-31(d)(3).

[121] *2008 Water Resource Protection Plan*, *supra* note 1, at 7-58.

[122] *Id.* at 4-2.

[123] *Id.*

[124] *Id.*; *see also Threatened Streamflow and Rainfall Stations*, U.S. Geological Survey, Pac. Islands Water Sci. Ctr., http://hi.water.usgs.gov/streamflow_discontinued_oct.html (identifying 22 monitoring stations likely to be discontinued by October 2011).

[125] Haw. Rev. Stat. § 174C-4(a)

[126] *Id.* § 174C-4(b).

[127] *Id.* § 174C-41(a).

[128] *Id.* § 174C-41(b).

[129] *Ko'olau Agric. Co. v. Comm'n on Water Res. Mgmt.* ("*Ko'olau Ag.*"), 83 Haw. 484, 491, 927 P.2d 1367, 1374 (1996).

[130] Haw. Rev. Stat. § 174C-48.

[131] *Id.* § 174C-49.

[132] *Waiahole II*, 105 Haw. at 15, 93 P.3d at 657 (quoting *Waiahole I*, 94 Haw. at 160, 9 P.3d at 472).

[133] *Id.*

[134] *See Kukui*, 116 Haw. at 500, 174 P.3d at 339 ("At the very least, the Commission should, as it did in this case, condition permits so as to confirm its constitutional and statutory authority to modify or revoke the permits if it should later determine that present instream flows are inadequate.") (quoting *Waiahole I*, 94 Haw. at 159-60, 9 P.3d at 471-72); *see also Wai'ola*, 103 Haw. at 444, 83 P.3d at 707 ("The Commission did not abuse its discretion in imposing a well monitoring system as a condition of granting" a permit); Haw. Rev. Stat. § 174C-56 (requiring that permits be reviewed at least once every twenty years to ensure that permit conditions are being complied with); *Id.* § 174C-50(h) (allowing the Commission to impose conditions on an existing use when two or more uses are deemed to be competing).

[135] *See* Binder et al., *supra* note 71, at table 2.

[136] *See* Haw. Rev. Stat. §§ 174C-4(a), -10.

[137] *See Waiahole I*, 94 Haw. at 148, 9 P.3d at 460 (explaining that Haw. Rev. Stat. § 174C-71 "operates independently of the procedures for water use regulation outlined in HRS chapter 174C, part IV").

[138] *See* Haw. Rev. Stat. § 174C-43 (empowering the Commission chairperson to require, in non-designated areas, "reports from water users as to the amount of water being withdrawn and as to the manner and extent of beneficial use").

[139] *See* Hawaii Administrative Rules ("Haw. Admin. R.") § 13-168-5.

[140] *See id.* § 13-168-7.

[141] Maui Dep't of Water Supply, *Draft Maui County Water Use and Dev. Plan, Central DWS Dist. Plan Update* Ex. A, 62 (2010) (emphasis added).

[142] *2008 Water Resource Protection Plan*, *supra* note 1, at 7-58.

[143] *Id.* at 4-41.

[144] *Id.* at 4-69.

[145] *Id.* at 4-41.

[146] *Id.* at 7-58.

[147] *Ko'olau Loa WMP, supra* note 24, at OV-26, 28, 1-3 to 1-4. Note, however, that the watershed planning model utilized for O'ahu's WUDP does indirectly address some climate adaptation issues, through watershed protection and other measures. This is

described in more detail in Section 4.1.4.

[148] Comm'n on Water Res. Mgmt., State of Haw., *Statewide Framework for Updating the Hawaii Water Plan* 3-28 (2000) ("*Statewide Framework*"), *available at* http://hawaii.gov/dlnr/cwrm/planning/framewrk.pdf.

[149] *See, e.g.*, Oki, *supra* note 43, at 23.

[150] *See* Dep't of Water Res., State of Cal., Bull. 160-09: Cal. Water Plan Update 2009, *Integrated Water Management., Vol. 1 The Strategic Plan* Ch. 5 (2009), *available at* http://www.waterplan.water.ca.gov/docs/cwpu2009/0310final/v1c5_uncertfuture_cwp2009.pdf.

[151] *See* S. Perica et al., *NOAA Atlas 14, Precipitation-Frequency Atlas of the United States, Volume 4 Version 3: Hawaiian Islands* (2011), *available at* http://nws.noaa.gov/oh/hdsc/PF_documents/Atlas14_Volume4.pdf.

[152] *See* T.W. Giambelluca, Q. Chen, A. G. Frazier, J. P. Price, Y.-L. Chen & P.-S. Chu, *The Rainfall Atlas of Hawai'i* (2011), *available at* http://rainfall.geography.hawaii.edu.

[153] *See* Minutes for the Meetings of the State of Haw. Comm'n on Water Res. Mgmt., Jan. 20, 2011.

[154] Previous work of this type analyzed the historic impact of land use changes and rainfall variability and the potential impact of different patterns of groundwater withdrawal, drought, streamflow restoration, and agricultural irrigation. *See* Engott & Vana, *supra* note 22, at 48-49; *see also* Gingerich, *supra* note 21, at iii. The most recent published analysis uses a daily time step for water budget accounting and addresses the role of fog drip in precipitation input; the replacement of alien forest vegetation with native species; and the potential impacts of future urbanization and climate change, *see* J. A. Engott, *A Water-Budget Model and Assessment of Groundwater Recharge for the Island of Hawai'i, U.S. Geological Survey Scientific Investigations Report 2011–5078* (2011), *available at* http://pubs.usgs.gov/sir/2011/5078/sir2011-5078.pdf.

[155] *See generally The National Climate Assessment*, United States Global Change Research Program, http://www.globalchange.gov/what-we-do/assessment.

[156] *See* Pacific Islands Regional Climate Assessment, http://www.pacificrisa.org/cms/index.php?option=com_content&view=article&id=265&Itemid=180.

[157] *See* Kevin Hamilton, *The Science of Climate Change in Hawai'i*, 11 Newsletter Int'l Pac. Research Ctr. 12 (2011); *see also Climate-Change Impacts in Hawai'i and US Pacific Islands*, 11 Newsletter Int'l Pac. Research Ctr. 22, *available at* http://iprc.soest.hawaii.edu/newsletters/iprc_climate_vol11_no1.pdf; *Physical Modeling: Assessing the Sustainability of Groundwater Resources Under Future Climate Change*, Pacific RISA, http://www.pacificrisa.org/cms/index.php?option=com_content&view=article&id=254&Itemid=172.

[158] *See* Press Release, U.S. Dep't of Interior, Secretary Salazar Names University of Hawaii-Manoa to Host Pacific Islands Climate Science Center (October 7, 2011), *available at* http://www.doi.gov/news/pressreleases/Secretary-Salazar-Names-University-of-Hawaii-Manoa-to-Host-Pacific-Islands-Climate-Science-Center.cfm.

[159] *Statewide Framework*, *supra* note 148, at 2-1.

[160] *See generally Hawaii Water Plan: County Water Use and Development Plan*, Comm'n on Water Res. Mgmt., State of Haw., http://hawaii.gov/dlnr/cwrm/planning_countyplans.htm.

[161] Haw. Rev. Stat. § 174C-31(n); *see also* Haw. Admin. R. § 131-170-4(a).

[162] Haw. Admin. R. § 131-170-32(b)(1).

[163] *See* Haw. Rev. Stat. § 174C-32 (c).

[164] *See id.* § 174C-15.

[165] *Id.* § 174C-58(3).

[166] *See id.* § 174C-31(a)-(b) (providing that WUDPs "shall be prepared" by the counties and that the counties shall bear the "cost of maintaining" the WUDPs).

[167] *See* Kaua'i Dep't of Water Supply, *Water Plan 2020* 4-7 (2001), *available at* http://www.kauaiwater.org/W2020Chap3-4.pdf.

[168] This may require minor modification of the Commission's rules. *See* Haw. Admin. R. §13-170-32(b)(3) ("Each water use and development plan shall consider a twenty-year projection period for analysis purposes.").

[169] *See, e.g.*, *Melbourne Water Supply-Demand Strategy 2006 – 2055* (2006) ("*Melbourne Strategy*"), *available at* http://www.melbournewater.com.au/content/library/water_storages/water_supply-demand_strategy.pdf (adopting a 50-year planning horizon, and five-year updates).

[170] *See, e.g.*, Haw. Rev. Stat. §§ 226-1, -5(7), -7(11), -11, -13, -14, -16, -58, -103(a)(2), -104(b)(3).

[171] *See* Act 181, S.B. 283, 26th Leg. (Haw. 2011).

[172] *Id*. (amending Haw. Rev. Stat. § 226-2).

[173] *Id*.

[174] *Id*.

[175] Haw. Rev. Stat. § 174C-32(b).

[176] *See* Cnty. of Haw., Dep't of Water Supply, *Hawai'i County Water Use and Development Plan Update* ES-10 (2010) ("*Hawai'i County Plan Update*"), *available at* http://hawaii.gov/dlnr/cwrm/planning/wudpha2010.pdf.

[177] *See id*. at ES-10.

[178] *Id*.

[179] *See id*. at ES-8 to -16.

[180] The maximum projections in this table are based on WUDP's the "worst case" projection for agricultural water use in each hydrologic unit. Projections assuming the "best case" for agricultural water use exceed the sustainable yield only for West Mauna Kea and Northwest Mauna Loa. *See id*.

[181] *Id*. at ES-8.

[182] Maui County Code ("M.C.C.") Ch. 14.12. Note that water availability rules and regulations are present in other counties (e.g., Honolulu Board of Water Supply Rule 1-101), but that such rules do not have the same overarching principle of aligning county-level land use planning with water planning. Those rules can be improved by adoption at the county ordinance level, along with a clear policy on land use and water planning, in the mold of Maui's policy.

[183] *Id*. § 14.12.010.

[184] *Id*.; *see also id*. § 18.04.020(G).

[185] *Id*. § 18.12.040.

[186] *Id*. § 14.12.050.

[187] *Id*. § 14.02.040.

[188] Haw. Admin. R. § 11-20-29(b)(2).

[189] *See Ko'olau Loa WMP*, *supra* note 24.

[190] *See, e.g.*, Oki, *supra* note 7.

[191] *See, e.g.*, *Water Commission Staff Submittal Recommending Adoption of Koolauloa Watershed Management Plan* 5 (March 16, 2011), *available at* http://hawaii.gov/dlnr/cwrm/submittal/sb201103D3.pdf.

[192] *See Ko'olau Loa WMP*, *supra* note 24, at OV-3. Each watershed management planning region corresponds with a county general plan land use district. The Board established this new planning framework based on a common denominator that "[l]and use plans and water use and development plans that support growth and existing communities on O'ahu must ensure that watersheds remain healthy through sustainable planning practices, watershed protection projects and best management practices that minimize impacts." *Id*.

[193] *See* Act 181, S.B. 283, 26th Leg. (Haw. 2011).

[194] *2008 Water Resource Protection Plan*, *supra* note 1, at 7-7; *see also* Haw. Rev. Stat. § 174C-62(g) (enabling the Commission to act during water emergencies).

[195] *See* Honolulu Bd. of Water Supply, R. & Reg. § 1-112.

[196] *See id*. §§ 3-319 to -323.

[197] *See id*. § 3-324. Note that the role of regulating recycled water use is an important, but that regulation alone is unlikely to promote more widespread recycling.

[198] M.C.C. §§ 14.03.010(C), 14.03.010, 14.03.0120.

[199] Maui Dep't of Water Supply, *Notice to Consultants, Job No. DWSP 2011-10*, Maui News, April 15, 2011.

[200] M.C.C. § 20.30.020A. This is a stronger approach than the 1991 Honolulu Board of Water Supply regulation that requires

customers with "existing services to use nonpotable water for irrigation of large landscaped areas such as golf courses, parks, schools, cemeteries, and highways," if the Department of Water Supply determines that a suitable nonpotable water supply is available**.** Honolulu Bd. of Water Supply, R. & Reg. § 1-112, Use of Nonpotable Water Required for Large Landscaped Areas.

201 M.C.C. § 14.08.030 ("No grading permit, grubbing permit, or building permit shall be approved for any new golf course if any amount of potable water will be used for irrigation and other nondomestic uses.").

202 *Id.* § 14.08.010.

203 The components of Melbourne's approach to water conservation are summarized in London Climate Change P'ship, *Adapting to Climate Change: Lessons for London* 132-141 (2006) ("*Lessons for London*"), *available at* http://www.sfrpc.com/Climate%20 Change/9.pdf.

204 *See Melbourne Strategy*, *supra* note 169, at 6.

205 *See* Haw. Rev. Stat. § 174C-3.

206 *See id.* § 174C-31(h) (emphasis added).

207 *See Wai'ola*, 103 Haw. at 430, 83 P.3d at 693 (quoting *Waiahole I*, 94 Haw. at 140, 9 P.3d at 452 (internal quotation marks omitted).

208 *See 2008 Water Resource Protection Plan*, *supra* note 1, at 3-90.

209 *See* Haw. Rev. Stat. § 174C-71(4) ("The Commission shall conduct investigations and collect instream flow data including fishing, wildlife, aesthetic, recreational, water quality, and ecological information necessary for determining instream flow requirements.").

210 *2008 Water Resource Protection Plan*, *supra* note 1, at 3-56.

211 *Id.*

212 *Id.* at 3-29.

213 *See* Haw. Rev. Stat. §174C-31(i)(2)

214 *Cf. 2008 Water Resource Protection Plan*, *supra* note 1, at 3-90 (explaining that sustainable yield will be reviewed on a "case-by-case basis in response to the availability of new data.")

215 *See Kukui*, 116 Haw. at 492-93, 174 P.3d at 331-32.

216 *See* Haw. Rev. Stat. § 174C-31(m), (p); *see also Kukui*, 116 Haw. at 492, 174 P.3d at 331 ("The sustainable yield figures are critical components of the state water plan, and may not be modified absent notice and public hearing.").

217 *See* Haw. Admin. R. § 13-168-6.

218 *See id.* § 13-168-7(b).

219 *See* Comm'n on Water Res. Mgmt., State of Haw., 20-Year Review of Water Use Permits, Rep. to the Twenty-Fifth Leg., at 1 (2008) ("*20-Year Review"), available at* http://hawaii.gov/dlnr/cwrm/reportstolegislature/CW2009_20YearReviewWUP.pdf.

220 *See* Haw. Rev. Stat. § 174C-26.

221 *See id.* § 174C-27.

222 Sproat, *supra* note 86, at 14 (citing Office of the Auditor, State of Haw., Rep. No. 96-3: Management Audit of the Commission on Water Resources Management 10, 11 (1996)).

223 *See* Haw. Rev. Stat. §§ 174C-15, 174C-58(2). Note that the relevant administrative rules have not yet been updated to reflect an allowable penalty of $5000, and instead describe penalties of $1000 per day. *See* Haw. Admin. R. § 13-168-3.

224 *See* Haw. Rev. Stat. § 174C-56.

225 *See Ko'olau Ag.*, 83 Haw. at 491, 927 P.2d at 1374 ("The legislature apparently did not contemplate that this anomaly would be a permanent feature of the Code.").

226 *See id.*

227 *See* Haw. Rev. Stat. § 174C-44.

228 *See id.* § 174C-45.

229 *Ko'olau Ag.*, 83 Haw. at 490-91, 927 P.2d at 1373 (quoting Haw. Rev. Stat. § 174C-41(a)) (emphasis added).

[230] *See id. at* 493-94 and n. 8, 927 P.2d at 1376-77 and n. 8.

[231] *See, e.g.*, *id.* at 4 n.1.

[232] *Id*. at app. A (Standard Condition 10).

[233] *See* Haw. Rev. Stat. § 174C-48.

[234] For example, under Haw. Rev. Stat. § 174C-49, as a precondition to obtaining a permit, water users are required to satisfy a number of sophisticated criteria to ensure that the proposed use is reasonable and beneficial. *See supra* Section 3.6.1.

[235] *2008 Water Resource Protection Plan*, *supra* note 1, at 4-41.

[236] *20-Year Review*, *supra* note 219, at 7.

[237] *Id*. at app. C (List of Permits Not Field Investigated).

[238] *Id*. at 6.

[239] Forms available at http://hawaii.gov/dlnr/cwrm/resources_permits.htm.

[240] *See, e.g.*, J. E. T. Moncur, *Water pricing, conservation, and urban water management* (Water Res. Research Ctr., Univ. of Haw., *Technical Report No. 167*, 1984) (finding that marginal price, household income, and rainfall all had significant effects on water demand from Honolulu single-family residents).

[241] *See* Hawaiʻi Energy, Conservation and Efficiency Program, http://www.hawaiienergy.com/.

[242] *See generally* Comm'n on Water Resource Mgmt., State of Haw., *Protoype Water Conservation Plan for the Department of Land and Natural Resources* B-7 (2005), *available at* http://hawaii.gov/dlnr/cwrm/planning/pwcp2005.pdf.

[243] *See, e.g.*, News Release, Honolulu Bd. of Water Supply, Ultra-Low Flow Toilet Rebate Program to end on December 31st (Sept. 7, 2010), *available at* http://www.boardofwatersupply.com/files/9.7.10-Toilet_Rebate.pdf.

[244] *See Lessons for London*, *supra* note 203, at 136; *see also Using & Saving Water Rebate Program*, Dep't of Sustainability and Env't, State Gov't of Victoria, http://www.water.vic.gov.au/saving/home/rebates/products.

[245] *Using & Saving Water*, Dep't of Sustainability and Env't, State Gov't of Victoria, http://www.water.vic.gov.au/saving.

[246] *See* Southern Nevada Water Authority Rebate Coupon Program, http://www.snwa.com/apps/coupon_program/index.cfml; Southern Nevada Water Authority Water Smart Contractor Program, http://www.snwa.com/apps/watersmart_contractor/index.cfml.

[247] *See* C. Fishman, *The Big Thirst: The Secret Life and Turbulent Future of Water* 63-65 (2011) (describing the substantial cost savings associated with retrofitting a commercial laundry service in Las Vegas, aided by a $150,000 rebate from the Southern Nevada Water Authority).

[248] *See, e.g.*, Haw. Admin. R. §§ 13-168-12 , 13-169-51(c), 13-171-12(c) (establishing the permit application fee for well construction and pump installation, stream channel alteration, and water use permit, respectively).

[249] *See id.* § 13-171-12(d).

[250] *See id.* § 13-190-20(d) (requiring a separate application for each regulated reservoir or dam).

[251] *See id.* § 13-190.1-50 to -52 (proposed Sept. 08, 2010), *available at* http://hawaii.gov/dlnr/eng/rules/Proposed-Chap-190-1r-HAR-9-10-10.doc.

[252] *See id.* §§ 11-54-9.1.02(e), 11-55-04(d), 11-55-34.08(i) (establishing filing fees of $500 to $1000 for various applications).

[253] Pub. Utilities Comm'n, State of Cal., *Implementing a Public Goods Charge for Water* 1 ("*Cal. Public Goods Charge Study*") (2010), *available at* http://www.waterplan.water.ca.gov/docs/cwpu2009/0310final/v4c02a19_cwp2009.pdf.

[254] *See Rates and Charges*, Honolulu Bd. of Water Supply, http://www.hbws.org/cssweb/display.cfm?sid=1175.

[255] *See Cal. Public Goods Charge Study, supra* note 253, at 1, 4, 8.

[256] *See Koʻolau Loa WMP, supra* note 24, at OV-13.

"The impacts of global climate change in the Hawaiian Islands can potentially devastate our considerable natural resources."

"Climate change causes alterations in temperature and precipitation patterns, and Hawaii's water resources are almost exclusively dependent on rainfall."

"Prudent water resource planning should consider the long-term impacts of global climate change and how this could affect Hawaii's water supplies …."

—State of Hawaiʻi Commission on Water Resource Management, 2008.

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Water Resources and Climate Change Adaptation in Hawai‘i:

Adaptive Tools in the Current Law and Policy Framework

Water resources are a critical component of every society. In Hawai‘i, climate trends observed today are a threat to the security of tomorrow's water resources. Adaptation measures are necessary to increase resilience to such threats. Thus, prudent planning will ensure that Hawai‘i has policies and procedures in place to account for climate trends, variability, and uncertainty. Water resource management must be: (i) forward-looking enough to identify and avoid water crisis; (ii) flexible enough to solve climate change challenges when they appear on the horizon; (iii) integrated enough to address climate impacts on every part of the water cycle; and (iv) iterative enough to achieve all three of those goals in a timely manner. This paper identifies those four characteristics embedded within Hawai‘i's existing water law and policy regime and proposes twelve tools to improve climate adaptation for the benefit of Hawai‘i's water resources.

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