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PŌ‘AI WAI OLA/WEST KAUA‘I WATERSHED ALLIANCE

BEFORE THE COMMISSION ON WATER RESOURCE MANAGEMENT

OF THE STATE OF HAWAI`I

In the Matter of: PETITION TO AMEND THE INTERIM INSTREAM FLOW STANDARDS FOR WAIMEA RIVER AND ITS HEADWATERS AND TRIBUTARIES, AND COMPLAINT AND PETITION FOR DECLARATORY ORDER AGAINST WASTE	PŌ‘AI WAI OLA/WEST KAUA‘I WATERSHED ALLIANCE’S COMBINED PETITION TO AMEND THE INTERIM INSTREAM FLOW STANDARDS FOR WAIMEA RIVER AND ITS HEADWATERS AND TRIBUTARIES, AND COMPLAINT AND PETITION FOR DECLARATORY ORDER AGAINST WASTE; EXHIBITS 1-7; CERTIFICATE OF SERVICE

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I. INTRODUCTION

Pursuant to Haw. Rev. Stat. § 174C-71(2) (2011) and Haw. Admin. R. § 13-169-40 (1988), Pōʻai Wai Ola/West Kauaʻi Watershed Alliance ("Pōʻai Wai Ola"), through their counsel Earthjustice, petition the Commission on Water Resource Management ("Commission") to amend the interim instream flow standards ("IIFSs") for Waimea River and its headwaters and tributaries, including, but not limited to Waiakoali Stream, Kawaikōī Stream, Kauaikinanā Stream, Poʻomau Stream, Kōkeʻe Stream, Waiahulu Stream, and Koaiʻe Stream (collectively, the "Waimea River system"). As explained below, the current IIFSs under Haw. Admin. R. § 13-169-45 (effective June 15, 1988) merely rubber-stamped the historical diversions of the former Kekaha Sugar Company plantation ("Kekaha Sugar") via the Kekaha and Kōkeʻe Ditches. Thus, the IIFSs neither reflect the current reduced offstream demands, nor protect the range of public trust instream uses that depend on Waimea River system flows. The constitutional public trust and the State Water Code mandate the interim restoration of flow to the Waimea River system in increased IIFSs.

Pōʻai Wai Ola also submits a complaint and petitions for a declaratory order pursuant to Haw. Rev. Stat. § 174C-13 (2011) and Haw. Admin. R. §§ 13-167-81, -82 (1988), against the waste of water diverted from the Waimea River system by the state Agribusiness Development Corporation ("ADC") and its tenant Kekaha Agriculture Association ("KAA") (collectively, "ADC/KAA"). As explained below, despite the closure of the Kekaha Sugar plantation, ADC/KAA are continuing the large-scale diversions of the Kekaha and Kōkeʻe Ditches and are committing unlawful waste, including outright dumping of diverted river water. These excess diversions must immediately cease and be incorporated into the amended IIFSs.

In this combined IIFS petition, complaint, and declaratory ruling petition, Part II initially sets forth the governing law. Part III establishes Pōʻai Wai Ola's standing to bring this legal action. Part IV provides factual background regarding the Waimea River system and offstream diversions, including the river system's natural and cultural significance, the Kekaha and Kōkeʻe Ditch Systems, and the ongoing diversions and waste. Part V summarizes the available United States Geological Survey ("USGS") stream flow data. Parts VI and VII describe the existing instream and offstream uses and the anticipated benefits of stream restoration. Finally, Part VIII sets forth the relief sought. In sum, Pōʻai Wai Ola respectfully requests this Commission to fulfill its constitutional and statutory obligations by (1) ordering the immediate cessation of any and all waste and requiring reporting and monitoring of actual uses and needs, and (2) restoring flows to the Waimea River system in amended IIFSs.

II. LEGAL FRAMEWORK

A. The Public Trust Doctrine

The Hawaiʻi Constitution, art. XI, §§ 1 & 7, incorporates the public trust in the water resources of the state and establishes the foundation for the State Water Code ("Code") and Commission. See In re Waiāhole Ditch Combined Contested Case Hr'g, 94 Hawaiʻi 97, 130-33, 9 P.3d 409, 442-45 (2000) ("Waiāhole"). The constitutional public trust embodies a dual mandate of (1) protection, which ensures "the continued availability and existence of [state] water resources for present and future generations," and (2) maximum reasonable and beneficial use, which 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.'" Id. at 139-40, 9 P.3d at 451-52.

The public trust confers on the state "an affirmative duty to take the public trust into account in the planning and allocation of water resources, and to protect public trust uses whenever feasible." Id. at 141, 9 P.3d at 453. Protected trust uses or purposes include "resource protection, with its numerous derivative public uses, benefits, and values," as well as the "exercise of Native Hawaiian and traditional and customary rights," but do not include private commercial uses. Id. at 136-37, 9 P.3d at 448-49.

The public trust mandates that "any balancing between public and private purposes must begin with a presumption in favor of public use, access, and enjoyment" and "establishes use consistent with trust purposes as the norm or 'default' condition." Id. at 142, 9 P.3d at 454. Thus, private commercial uses require a "higher level of scrutiny," and "the burden ultimately lies with those seeking or approving [private commercial uses] to justify them in light of the purposes protected by the trust." Id. As trustee and "primary guardian of public rights under the trust," the Commission "must take the initiative in considering, protecting, and advancing public rights in the resource at every stage of the planning and decisionmaking process." Id. at 143, 9 P.3d at 455.

The public trust also incorporates the precautionary principle, which maintains that scientific uncertainty "should not be a basis for postponing effective measures to prevent environmental degradation," but rather militates "in favor of choosing presumptions that also protect the resource." Id. at 154, 9 P.3d at 466. In other words, "[u]ncertainty regarding the exact level of protection necessary justifies neither the least protection feasible nor the absence of protection." Id. at 155, 9 P.3d at 467.

B. Instream Flow Standards

The Code mandates that the Commission "shall establish an instream use protection program designed to protect, enhance, and reestablish, where practicable, beneficial instream uses of water in the State." Haw. Rev. Stat. § 174C-5(3) (2011); accord id. §§ 174C-71, -71(4) (2011). "Instream flow standards are an integral part of the regulatory scheme established by the Code" and the "primary mechanism by which the Commission is to discharge its duty to protect and promote the entire range of public trust purposes dependent upon instream flows." Waiāhole, 94 Hawai'i at 147-48, 9 P.3d at 459-60 (footnote omitted).

The Commission "must designate instream flow standards as early as possible . . . particularly before it authorizes offstream diversions potentially detrimental to public instream uses and values." Id. at 148, 9 P.3d at 460. Even in cases of existing diversions, the Commission "may reclaim instream values to inevitable displacement of [the] diversions," and its "duty to establish proper instream flow standards continues." Id. at 149-50, 9 P.3d at 461-62.

"[T]he establishment of bona fide, 'permanent' instream flow standards [i]s an ultimate objective in [the Code's] mandated 'instream use protection program.'" Id. at 150, 9 P.3d at 462. Interim standards are established pending the development of permanent standards, but this "does not alter the Commission's duty to protect instream uses": interim standards "must still protect instream values to the extent practicable." Id. at 151 & n.55, 155, 9 P.3d at 463 & n.55, 467.

On June 15, 1988, the Commission adopted "status quo" IIFSs for Kaua'i streams, which did "nothing more than ratify the major diversions already existing." Id. at 150, 9 P.3d at 462; see Haw. Admin. R. § 13-169-45. The Code provides that "[a]ny person with the proper standing may petition the Commission to adopt an IIFS for streams in order to protect the public interest pending the establishment of a permanent [IFS]." Haw. Rev. Stat. § 174C-71(2)(A). The burden of justifying interim standards, however, does not fall on citizen petitioners. Waiāhole, 94 Hawai'i at 153, 9 P.3d at 465. Rather, the Commission bears the "affirmative duty under the public trust to protect and promote instream trust uses," which are favored by "presumption" and "default." Id. at 153, 142, 9 P.3d at 465, 454.

C. Prohibition Against Waste

The Code contains a specific provision against waste, obligating the Commission to "investigate and take appropriate action" against allegations of waste, including "deficient operation and upkeep" of ditches. Haw. Rev. Stat. § 174C-13; Waiāhole, 94 Hawai'i at 172, 9 P.3d at 484. The Commission has recognized, and the Hawai'i Supreme Court has affirmed, that water not actually used for reasonable-beneficial use must be left undiverted to avoid unlawful waste. See Waiāhole, 94 Hawai'i at 118, 156, 9 P.3d at 430, 468; see also Haw. Rev. Stat. § 174C-3 (2011) (requiring use in "such a quantity as is necessary for economic and efficient utilization").

D. Native Hawaiian and Traditional and Customary Rights

The Constitution and Code both provide specific protections for Native Hawaiian and traditional and customary water rights. The constitutional public trust protects such rights as a public trust purpose. Waiāhole, 94 Hawai'i at 137, 9 P.3d at 449. The state also bears the constitutional duty under art. XII, § 7 of the Hawai'i Constitution to protect Native Hawaiian rights "to the extent feasible" and, thus, "may not act without independently considering the effect of [its] actions on Hawaiian traditions and practices" and, "at a minimum," making "specific findings and conclusions" on the existence of Native Hawaiian rights, the extent of their impairment, and feasible action to protect them. Ka Pa'akai O Ka 'Aina v. Land Use Comm'n, 94 Hawai'i 31, 35, 46-47, 7 P.3d 1068, 1072, 1083-84 (2000). The Code independently "obligates the Commission to ensure that it does not 'abridge or deny'" traditional and customary rights. Waiāhole, 94 Hawai'i at 153, 9 P.3d at 465 (citing Haw. Rev. Stat. §§ 174C-101(c), -63 (2011)).

Native Hawaiian water rights include those of Hawaiian Home Lands. The Constitution, Code, and Hawaiian Homes Commission Act ("HHCA") all protect home land water rights. See

In re Wai‘ola o Moloka‘i, 103 Hawai‘i 401, 431, 83 P.3d 664, 694 (2004) (recognizing home land water entitlements as a public trust purpose); Haw. Rev. Stat. §§ 174C-101(a), -49(a), -49(e), -31(q) (2011); Hawaiian Homes Commission Act of 1920, Pub. L. No. 67-34, §§ 101(b)(4), 220(d), 42 Stat. 108 (1921); see also Haw. Admin. R. §§ 13-171-60 to -63 (1995).

III. PETITIONERS' INTERESTS IN THE NATURAL AND CULTURAL RESOURCES OF THE WAIMEA RIVER SYSTEM

Petitioners have direct, substantial interests in the natural and cultural resources of the Waimea River system that are clearly distinguishable from those of the general public. Pō‘ai Wai Ola is a community-based organization established by Waimea watershed residents, farmers, and users, including Native Hawaiian cultural practitioners, to address water issues affecting West Kaua‘i. Pō‘ai Wai Ola is dedicated to managing and conserving water resources for present and future generations and protecting the long-term sustainability and health of the Waimea River system from its mauka headwaters to makai nearshore marine areas.

Pō‘ai Wai Ola members live, work, recreate, and practice their culture in and around the Waimea River system and rely on, use, or seek to use these resources for a host of public trust uses including, but not limited to, fishing, agriculture, recreation, research and education, aesthetic enjoyment, spiritual practices, and the exercise of Native Hawaiian cultural rights and values. Further, Pō‘ai Wai Ola and its members believe that inadequate stream flow is causing heavy siltation buildup within the Waimea River, creating a flood hazard for area residents, including Pō‘ai Wai Ola's members.

The individual interests of petitioners' members, as well as the group's organizational interests, are thus directly and adversely affected by the Commission's failure to establish meaningful IIFSs that protect, enhance, and restore beneficial instream uses and values in the Waimea River system, and by the ongoing excessive offstream diversions and waste. The interests of Pōʻai Wai Ola and its members will continue to be irreparably harmed unless the relief requested is granted.

For example, many Pōʻai Wai Ola members have legally protected interests in, and/or lawfully reside or rely on, affected lands and waters in and adjacent to the Waimea River system and watershed. These include:

Jim K. Aʻana	TMK # [redacted]
John K. Aʻana	TMK # [redacted]
Albette Bajo	TMK # [redacted]
Myrna Bucasas	TMK # [redacted]
Clarence F. Ching	TMK # [redacted]
Isaac K. Hoʻokano	TMK # [redacted]
Marc Kakuda	TMK # [redacted]
Galen Kaohi	TMK # [redacted]
Aletha Goodwin Kaohi	TMK # [redacted]
Bernard & Sandra Makuaole	TMK # [redacted]
Robert K. Nawai	TMK # [redacted]
Nanette Nawai	TMK # [redacted]
Teddy & Tammy Perreira	TMK # [redacted]
Nicholas & Nancy Taniguchi	TMK # [redacted]

The following Pōʻai Wai Ola members have declared their water uses pursuant to Section 174C-26(a) (2011) of the Code:

John K. Aʻana	TMK # [redacted]
Clarence F. Ching	TMK # [redacted]
Isaac K. Hoʻokano	TMK # [redacted]
Marc Kakuda	TMK # [redacted]
Aletha Goodwin Kaohi	TMK # [redacted]
Bernard & Sandra Makuaole	TMK # [redacted]
Nanette Nawai	TMK # [redacted]

IV. FACTUAL BACKGROUND

A. Natural and Cultural Significance of the Waimea River System

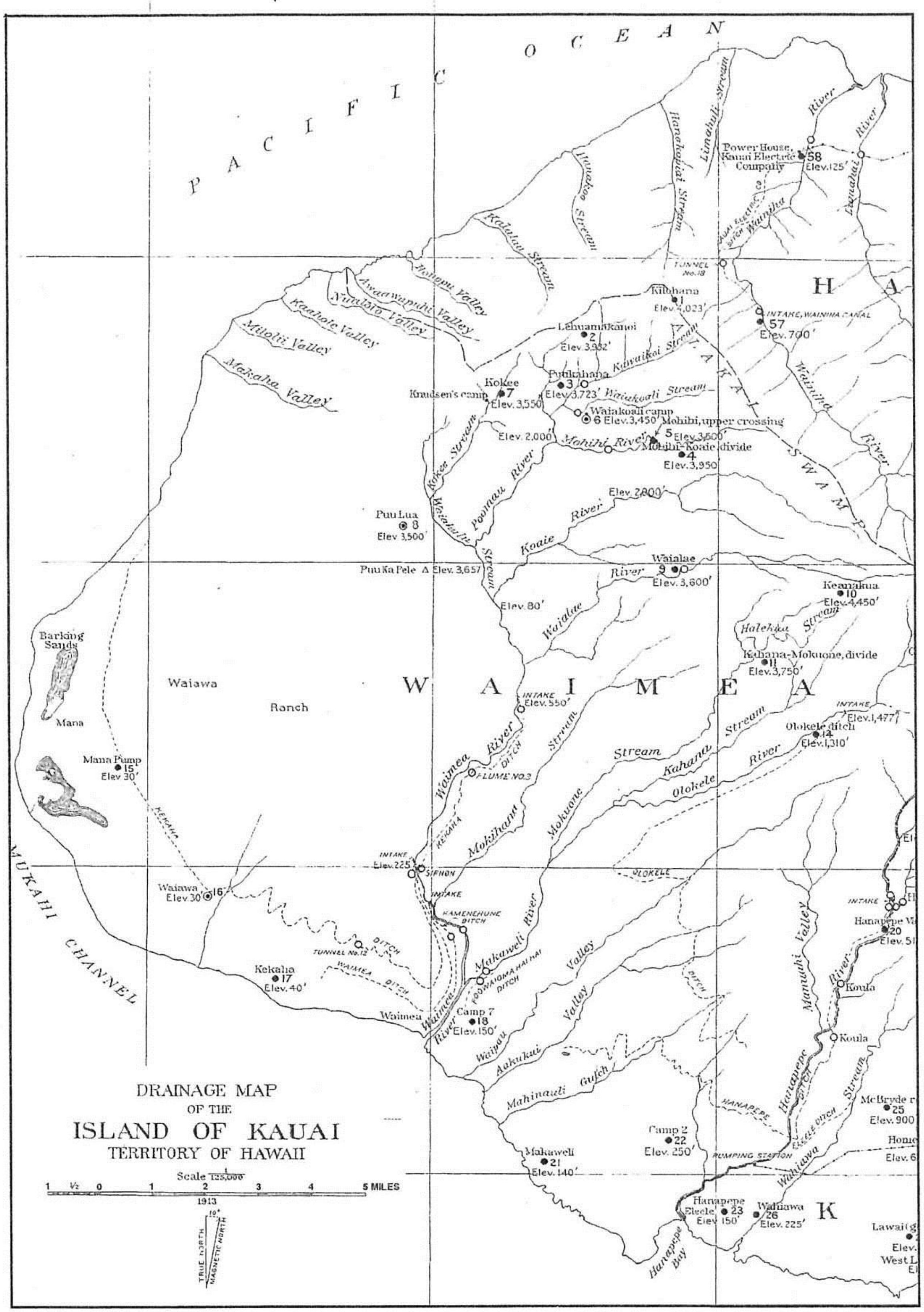
1. The Waimea River System

The Waimea River watershed encompasses 85.9 square miles in west Kauaʻi, with a maximum elevation of 5,243 feet. James E. Parham et al., Atlas of Hawaiian Watersheds &

Their Aquatic Resources 485 (2008) ("Watershed Atlas") (attached as Exh. 1). It contains 38 streams totaling 276.4 miles in length, as well as 8 waterfalls. Id. at 486; Comm'n on Water Res. Mgmt. et al., Hawai'i Stream Assessment 120 (1990) ("HSA") (attached as Exh. 2).

Waimea Canyon, renowned as the "Grand Canyon of the Pacific," is the "longest, deepest, and most complex of a number of valleys" radiating from Kaua'i's central mountain, Mount Wai'ale'ale. E.S. Craighill Handy, Elizabeth Green Handy & Mary Kawena Pukui, Native Planters in Old Hawaii: Their Life, Lore and Environment 393, 395 (1991) ("Native Planters") (attached as Exh. 3). Waimea River, the watershed's crown jewel, has "carved out a course for itself" more than 2,800 feet in depth below the canyon's rim. Id. at 394.

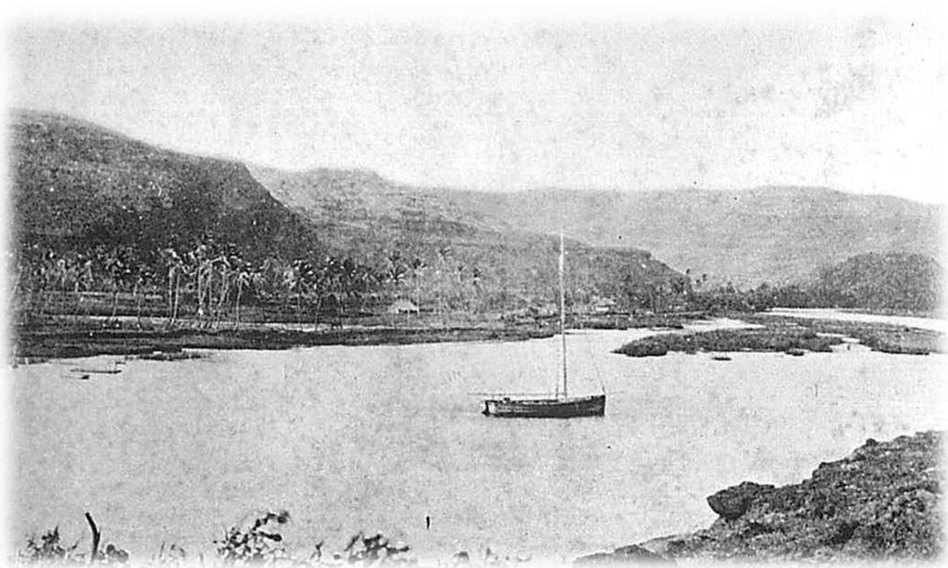
The Waimea River system is one of the largest rivers on Kaua'i and in the state, with the highest average annual flow of all Hawai'i streams. HSA at 55. The river travels generally north to south, collecting surface flows from various northern headwaters and tributaries that drain down from the Alaka'i Swamp, and from lower eastern tributaries, before flowing into Waimea Bay. Native Planters at 394-96. The major northern tributaries include: (1) Po'omau Stream (meaning "many heads"), which combines numerous streams including Kauaikinanā, Kawaikōī, and Waiakoali Streams; (2) Waiahulu Stream, which combines Kōke'e Stream and others; (3) Koai'e Stream; and (4) Wai'alae Stream. The major lower tributaries from the east include Mokihana Stream and Makaweli River. See also Part V, infra (summarizing USGS gaging data).



1913 drainage map, West Kauai. (USGS.)

2. Native Hawaiian Historical and Cultural Connection to the Waimea River System

In ancient times, the Waimea River watershed -- from the fertile Waimea Delta to the upland Po'omau headwater region -- was home to thriving Native Hawaiian communities. Native Planters at 393-409. Waimea was the site of Captain Cook's first anchorage in Hawai'i, in 1778, the first recorded contact between Hawaiians and Europeans. Mary Kawena Pukui, Samuel H. Elbert & Esther T. Mo'okini, Place Names of Hawai'i 225 (1974 ed.). Captain Cook's crew reported dozens of grass-thatched dwellings along the shore west of the river mouth, as well as other houses dispersed inland along the river. Native Planters at 408. Early explorers were most impressed with Waimea Delta's vast expanses of wetland kalo (taro) cultivation. Id. at 270. In 1784, Captain Cook noted that its "inhabitants far surpass all the neighbouring islanders in the management of their plantations." Id. at 406 (quoting James Cook, A Voyage to the Pacific Ocean . . . 1776-1780 (1784)). The delta produced the largest taro that Captain Cook had ever seen in Polynesia. Id.



Waimea River delta in 1860 (Stormy Cozad, Images of America: Kauai 16 (2008))

One of Hawai'i's most famous ancient 'auwai (aqueducts), Kīkīaola, also known as Menehune or Pe'ekaua'i Ditch, fed the lo'i kalo (wetland taro fields) throughout the delta.

Native Planters at 62, 406-09. Attribution of the ‘auwai’s construction to “Menehune” indicates that development of the surrounding community occurred very early in Hawaiian history. Id. at 270. Carrying water around a cliff twenty-four feet above the river level, the Native Hawaiian engineering feat spanned several miles. Id.

In addition, all along Waimea River’s inland reaches and tributaries, kua‘āina or “backlanders” established “large and very nearly self-sufficient” communities. Id. at 397-400. Backland lo‘i produced several rare and unique varieties of taro, including Ha‘o-kea, “a fast-maturing taro variety adapted to cold stream water and shallow soil,” and Ha-kalo-a-‘Ola, named after an ancient ali‘i (chief), which grows in highly inaccessible areas. Id. at 397. The “widespread favorite” mōhihi sweet potato varieties likely originated along the upland Mōhihi Stream, where it is “well adapted to just such soil and climatic conditions.” Id. An extensive native forest blanketed the upland region of Waimea and produced many plants and trees traditionally used for subsistence and cultural practices, several of which are associated with stream flow. Id. at 400-02.

Lo‘i terracing followed along the main Waimea River as far as eight to ten miles inland, wherever lands were tillable. Id. at 396. Lo‘i and ‘auwai extended even further into upper tributaries such as Wai‘alae and Koai‘e Streams. Id. In Waimea Canyon, there was an estimated twenty-five linear miles along the watercourses on which irrigated cultivation was practicable. Id. at 397. “It is characteristic of this . . . area that every foot of land that could be leveled by terracing above the floodwater stage, and to which a ditch could bring stream water, was utilized for taro *lo‘i*.” Id.

Native stream life was abundant in the Waimea waterways and sustained the populace. Id. at 275, 398. “Ka i‘a ho‘opā ‘ili kanaka o Waimea. The fish of Waimea that touch the skins of people.” Mary Kawena Pukui, ‘Ōlelo No‘eau, #1339 (1983). When it was the season for hinana (‘o‘opu spawn) at Waimea, they were so numerous that one could not go into the water without rubbing against them. Id.[1] Waimea River’s upland headwater streams “abounded in shrimps (*‘ōpae*) and the prized fresh-water fish, the *‘o‘opu* (guppy).” Native Planters at 398.

Women catching hinana at mouth of Waimea River, c.1910
(Kamehameha Schools Archives)

3. Recognition of the Waimea River System’s Public Trust Values

In the HSA, the Commission “identif[ied] streams appropriate for protection.” Id. at xix. The HSA recognized the Waimea River system as a place of high cultural significance, exhibiting four of five National Register of Historic Places criteria. Id. at 218. Native Planters similarly valued Waimea as one of the most important areas on Kaua‘i. Id. at 425.

The HSA recognized the Waimea River system’s riparian, cultural, and recreational resources as “outstanding.” Id. at 263. The system’s riparian and recreational resources received “blue ribbon” ranking, meaning that they stood out as the “few very best” in the state. Id. at 272. The United States Fish & Wildlife Service ranked the Waimea watershed’s instream aquatic

[1] In fact, the ‘o‘opu of Kaua‘i were famous throughout the Islands. Margaret Titcomb & Mary Kawena Pukui, Native Use of Fish in Hawaii (1952).

values as "High," and the Nature Conservancy designated it a "Priority Aquatic Site." Watershed Atlas at 492.

Out of the 376 perennial streams throughout the islands, the HSA designated only forty-four "Candidate Streams for Protection." Id. at 272 It included the Waimea River system on that select list, as one of only thirteen Kauaʻi rivers and streams with that distinction. Id. at 272-73.

B. Plantation Diversions from the Waimea River System

The flourishing, self-sufficient Waimea community described above changed dramatically with the arrival of the sugar industry. The extensive loʻi kalo from mauka to makai went fallow as "most of the water [was] taken higher up by the Kekaha Plantation ditch." Native Planters at 402.

In the late 1870s, Kekaha Sugar began planting sugar cane on fifty acres in the then-vast marshlands in Kekaha and Mānā, which it leased from the Hawaiian government. Carol Wilcox, Sugar Water 92 (1996) (attached as Exh. 4); Deborah Saito & Susan Campbell, Hawaiian Sugar Planters' Association Plantation Archives, Register of the Kekaha Sugar Company, 1880-1946 1 (1986) ("KSC Register"), available at http://www2.hawaii.edu/~speccoll/m_plantations.html. In 1923, Kekaha Sugar expanded its lease to cultivate 2,000 additional acres in the mauka highland region. Sugar Water at 96. By the 1930s, Kekaha Sugar was leasing over 7,000 acres of agricultural land from the government. KSC Register at 2. Kekaha Sugar converted the Kekaha-Mānā marsh by filling in low areas and operating two large draining pumping stations at Kawaiele and Nohili. Dep't of Land & Natural Res., Kekaha Sugar Infrastructure Study, Job.

No. 1-KL-A, Report No. R-114 at D-1 (2000) ("Kekaha Infrastructure Study") (attached as Exh. 5).[2]

In the early 1900s, having impaired its initial groundwater wells from overuse, Kekaha Sugar turned to develop Waimea River surface water. Sugar Water at 92. Kekaha Sugar completed construction of the Kekaha Ditch in 1907. Id. at 93.[3] In 1923, Kekaha Sugar expanded the system's length from 20 to 28 miles, its capacity from 45 to 50 mgd, and its average flow from 30 to 35 mgd. Id. at 93, 96. The Kekaha Ditch diverted flows in the middle reaches of canyon and transported the water to the makai lands in the Kekaha-Mānā Plain.

From 1923 to 1926, Kekaha Sugar constructed the Kōke'e Ditch. Id. at 96. The system comprised 21 miles of open channel flows and tunnels, a capacity of 55 mgd, and an average flow under Kekaha Sugar of around 13-15 mgd. Kekaha Infrastructure Study at I-6; Sugar Water at 96. The Kōke'e Ditch diverted various headwater tributaries in the northern, high-elevation region and delivered the water to the plantation's mauka lands to the west of the river.[4]

In 1969, Kekaha Sugar entered into a general lease with the state Board of Land and Natural Resources for 27,834 acres, 7,381 of which were indicated as suitable for sugar cultivation. General Lease No. S-4222. The lease included: (1) the right to use 14,558 acres of Hawaiian Home Lands and the balance of more than 13,000 acres of public land; and (2) the right to store, take and use all surface water flowing from Waimea River and the irrigation ditch

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[2] The Kawaiele station has about 100 million gallons per day ("mgd") total pumping capacity, while the Nohili station has about 34 mgd pumping capacity. Id. at D-6. These drainage pumps continue to operate today in order to keep much of the makai plains from reverting back to wetlands. Id. at D-2.

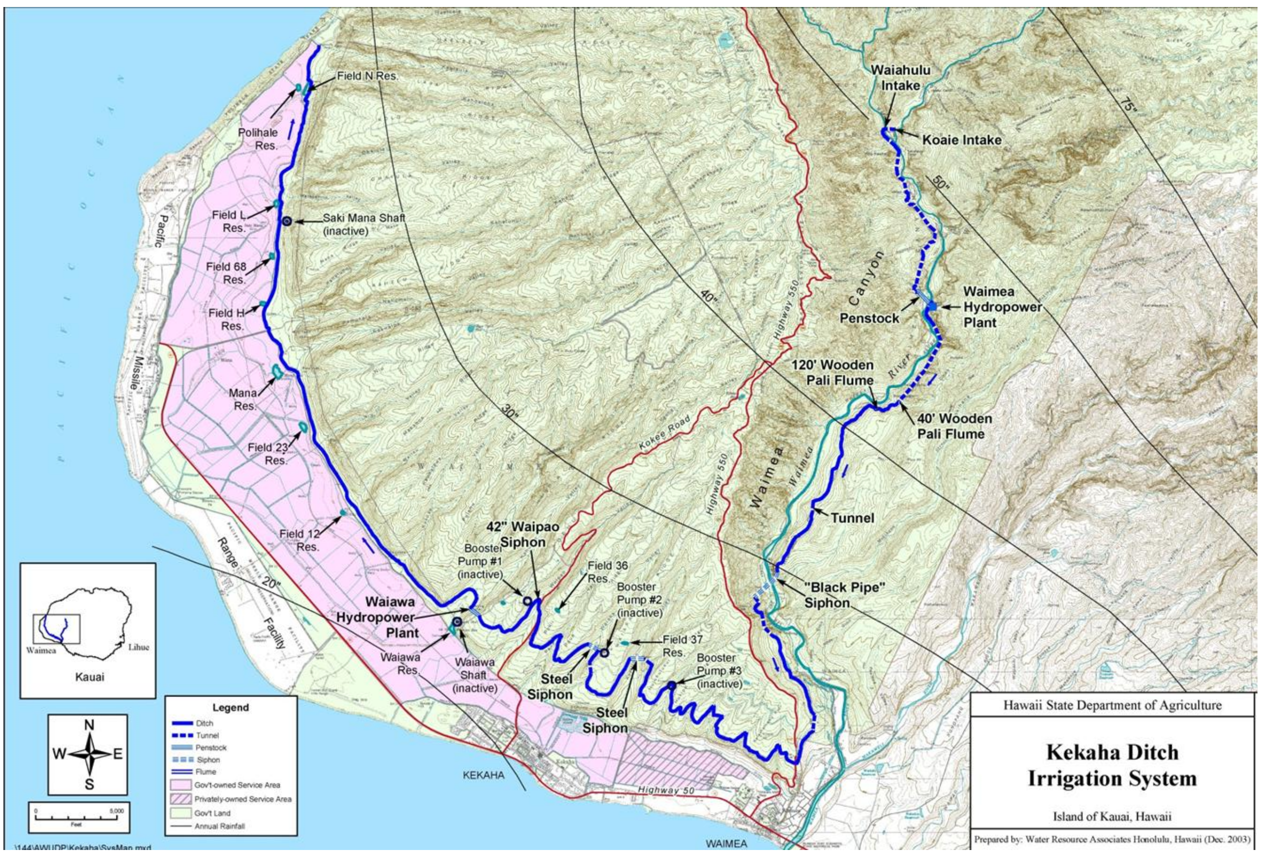
[3] The ditch was originally referred to as the Waimea Ditch, and was sometimes referred to as the Waimea-Kekaha Ditch. It is now commonly known as the Kekaha Ditch. Sugar Water at 93.

[4] Another, smaller ditch called the Waimea Ditch (also sometimes called Kīkīaola Ditch) historically diverted around five mgd for the several hundred-acre Waimea Sugar Mill Co. plantation located near Waimea town, but has been out of service since 1990 due to damage from a landslide. Kekaha Infrastructure Study at I-1.

systems as well as ground water from existing wells and shafts. Alan Murakami, "The Hawaiian Homes Commission Act," in Native Hawaiian Rights Handbook 58 (Melody K. MacKenzie ed. 1991) ("Native Hawaiian Rights Handbook"). Kekaha Sugar used diverted river flows along with ground water wells and drainage recycling pumps in the Kekaha-Mānā plain. See Kekaha Infrastructure Study at I-1.

C. Overview of Kekaha and Kōke'e Ditch Systems.

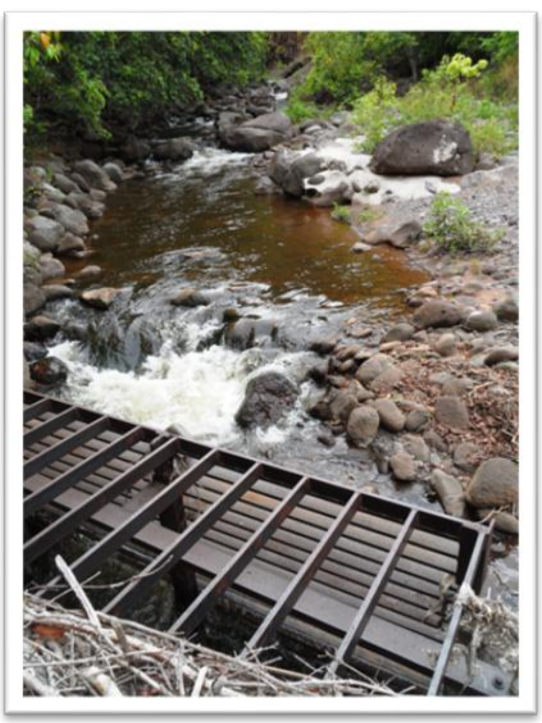
1. Kekaha Ditch



The Kekaha Ditch, the older, larger, and more downstream ditch, begins at an elevation of around 800 feet, about 1,000 feet upstream from the confluence of the Waimea River and one of its main tributaries, Koai'e Stream.

Koai‘e Stream upstream of diversion

A dam on Koai‘e Stream diverts nearly all of the stream’s regular flow into a tunnel intake, leaving the stream channel below the dam nearly dry. At most only a small amount of leftover flow makes it past the intake and into a small side outlet in the dam.



Koai‘e diversion, looking upstream

Koai‘e diversion, looking from top of dam

Below Koaiʻe Dam (outlet at left)

The tunnel from Koaiʻe Stream then directs the stream flows to an exit point immediately upstream of the Waiahulu Dam on the Waimea River.[5] That dam then diverts into the Kekaha Ditch nearly all of the combined diverted flows of Koaiʻe Stream and the Waimea River, again leaving the downstream channel nearly dry, with only a small amount of leftover flow spilling through a small notch in the dam.

[5] Waiahulu Stream is the name of the tributary that combines with Poʻomau Stream to form the main stem of the Waimea River. The Kekaha Ditch diversion below the Waiahulu-Poʻomau confluence is called the Waiahulu Dam.

Waimea River upstream of Waiahulu Dam

Waiahulu Dam diversion grate and boarded-up outlet

Waiahulu Dam (boarded-up outlet in middle left)

Waiahulu Dam, view from east

Below Waiahulu Dam

The Kekaha Ditch then carries the diverted flows downstream along the canyon to a point at about 700 feet elevation, where it drops the water downhill through a pipe to a small hydroelectric power plant known as the Mauka Powerhouse. Another dam, called the "Mauka Powerhouse Dam," spans the river at that location and diverts additional flows into the Kekaha Ditch.[6]

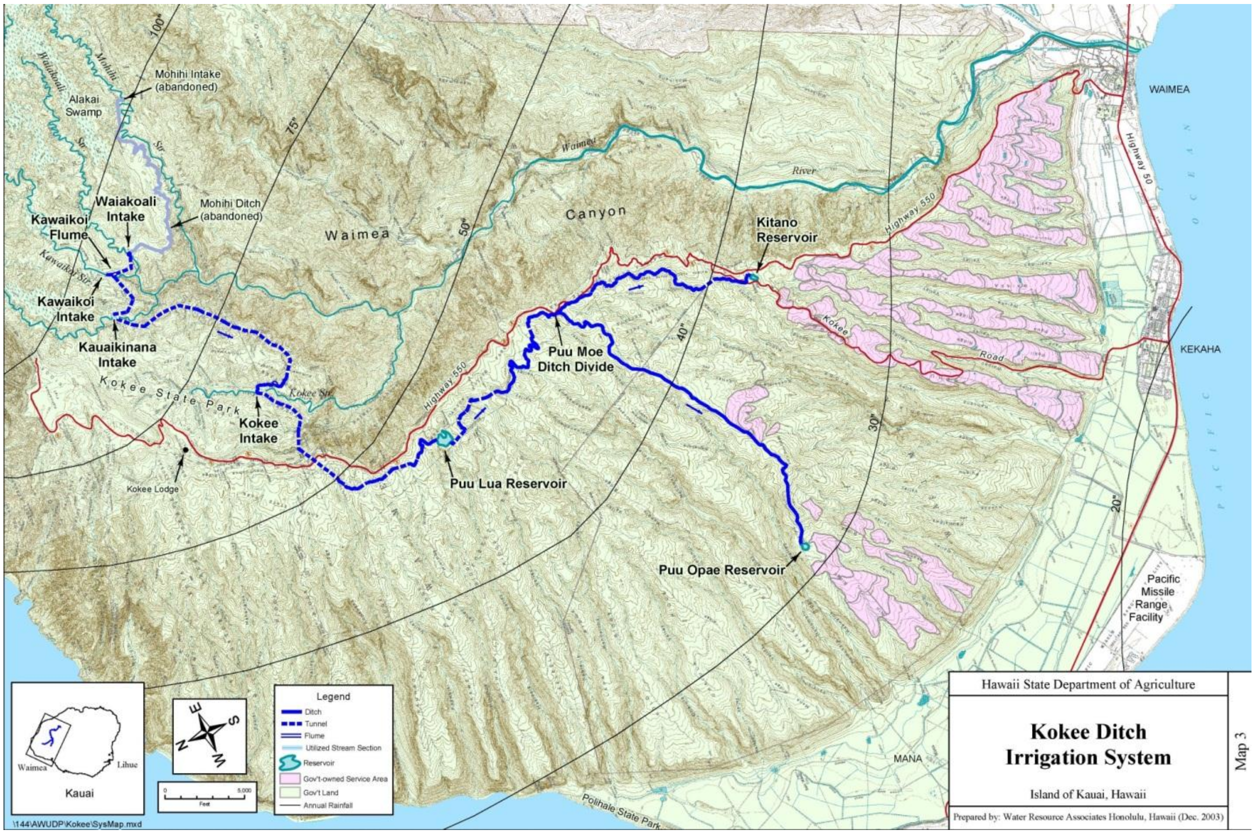
Mauka Powerhouse Dam

After the Mauka Powerhouse, the ditch winds along the river before turning westward above Waimea town and running the length of the Kekaha-Mānā Plain. Kekaha Infrastructure Study at I-4.

The Kekaha Ditch currently supplies water to the Menehune Ditch, the water supply for taro farmers, kuleana owners, and residents in lower Waimea Valley. The Menehune Ditch historically drew flows directly from Waimea River, but decades ago the Kekaha Sugar plantation redirected this connection and instead began to supply the ditch through a pipe coming down the valley wall from the Kekaha Ditch.

[6] Kekaha Sugar's water use declarations also included a "Kukui Trail #1" diversion at the 790-foot elevation, at which point stream flow is "intermittent." See Kekaha Sugar Co., Registration of Stream Diversion Works and Declaration of Water Use (Kukui Trail #1 for Kekaha Ditch) (filed May 25, 1988).

2. Kōke‘e Ditch



The Kōke‘e Ditch initially runs from east to west as it diverts surface water from at least four streams in the Waimea River system’s high-elevation (around 3,400 to 3,500 feet) headwater region. The former Kekaha Sugar plantation reported as many as fifteen stream diversions feeding the Kōke‘e Ditch, but it appears that not all of these remain active today. See Comm’n on Water Res. Mgmt., Declarations of Water Use, Vol. I 148 (1992) (“Water Use Declarations”).

The first main diversion is a dam that spans the width of Waiakoali Stream and takes all of its flow except for when the stream rises enough to overtop the concrete wall structure.

Waiakoali diversion

Similarly, a dam on Kawaikōī Stream diverts most of the stream flow, except for the amount that can overtop the concrete structure.

Kawaikōī diversion

Another dam on Kauaikinanā Stream diverts most of the stream flow, except for an amount that is allowed to spill through a notch in the concrete structure.

Kauaikinanā diversion

After these diversions,[7] the Kōkeʻe Ditch turns south and feeds into Puʻu Lua Reservoir. Kekaha Infrastructure Study at I-3. After Puʻu Lua Reservoir, at the Puʻu Moe Ditch Divide, the ditch splits into two branches: one continues further south to Kitano Reservoir, and the other turns southwest to Puʻu ʻŌpae Reservoir.

[7] The Kōkeʻe Ditch System map above also shows diversions of Mōhihi Stream that have been "abandoned" and an intake on Kōkeʻe Stream that appears to be active.

3. Downstream of the Diversions

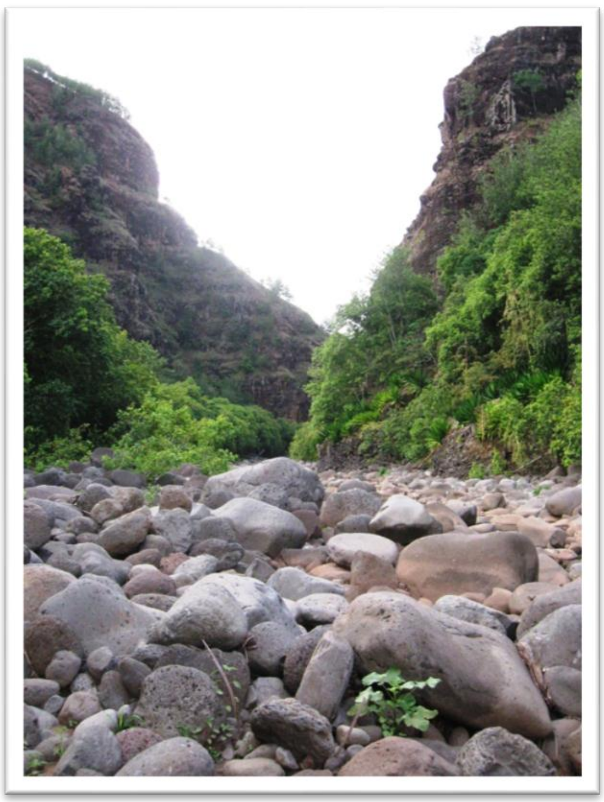
The following photographs, taken earlier this month, illustrate the impacts of diversions on the Waimea River system. In Waimea River, immediately below the Waiahulu Dam, which diverts flows for the Kekaha Ditch, ʻoʻopu could be seen stranded in the stagnant, algae-filled pool, which also contained alien toads:

Immediately below the Waiahulu Dam on Waimea River

As the river continues downstream, the leftover flows are slack, and the river bed is filled with alien green algae, pond scum, and sediment.

Below the confluence of Waimea River (left of the hill) and Koaiʻe Stream (right of the hill)

Continuing further down Waimea River



Further down Waimea River

When the river finally reaches the lower Waimea Valley, shallow flows cover only a portion of the river bed, which is buried in brown silt:

The lower Waimea River bed, upstream of the confluence with Makaweli River

D. The End of Sugar and Continued Diversions and Waste

The historical operator and end user of the Kekaha and Kōke‘e Ditches, the Kekaha Sugar plantation, ceased operations in 2001. ADC, Strategic Plan 4 (2008). In contrast to the sugar plantation operations, the current agricultural tenants under ADC/KAA cultivate only a fraction of Kekaha Sugar's former lands, in far less land- and water-intensive crops. Yet, the glaring discrepancy between the ongoing diversions and the radically reduced water demands indicates that the diverted river flows are not being put to maximum reasonable-beneficial use, but rather are being wasted, contrary to law. Indeed, Pō‘ai Wai Ola documents below several examples of dumping of water from the ditch systems. Further, much of the ditch infrastructure is inefficient and unlined, which causes an unknown amount of waste. ADC/ KAA, however, do not provide the Commission or public with any information on actual water uses and losses, concealing the full extent of the waste.

1. Kekaha Sugar's Closure and Decline in Water Demands

From 1946 to 1996, the average flow in the Kekaha Ditch was 1,015 million gallons per month ("mgm"), or around 33.4 mgd. Kekaha Infrastructure Study at I-5, I-9. The average flow in the Kōke'e Ditch during that same time period was 438 million mgm, or around 14.4 mgd. Id. at I-7, I-11.

In 1992, Kekaha Sugar reported cultivating about 11,750 acres of its total 27,834 leased acres, mostly in sugar cane, but also some diversified agriculture. Water Use Declarations at 148. In 2000, Kekaha Sugar was cultivating 7,758 acres, mostly in sugar cane: 2,668 acres in the mauka highlands and 5,090 acres in the makai plain. Kekaha Infrastructure Study at I-1. Others were using an estimated total of around 9 mgd of Kekaha Ditch water in 2000; these included two land development companies (Kikiaola and Knudsen, 4.5 mgd combined), two corn companies (Pioneer and Navortis, 1.5 mgd combined), and Menehune Ditch users (2.5 mgd). Id. at I-5. During this time, despite the apparent reduction in cultivated acreage, the Kekaha and Kōke'e Ditches' diverted flows did not appreciably change. For nearly 12 years between 1988 and 1999, the average ditch flows in the Kekaha and Kōke'e Ditches were around 32 and 13 mgd, respectively. See id. at I-9, -11.

After Kekaha Sugar's closure, ADC formally assumed management of 12,592 total acres of the former plantation lands in 2003. See Executive Order No. 4007 (Sept. 16, 2003). On April 1, 2007, ADC entered into a Memorandum of Agreement with the agricultural tenants' association, KAA, delegating to it the management of the ditch and drainage infrastructure. See Restated and Amended Memorandum of Agreement Between State of Hawaii Agribusiness Development Corporation and Kekaha Agriculture Association (Aug. 29, 2008) ("ADC/KAA MOA").

Today, sugar is long gone. In its place, several seed companies are conducting experimental field test operations on the makai lands, while only a couple of small water users are located on the mauka lands.

ADC/KAA currently do not provide any reporting of actual water uses -- even though their MOA requires that KAA members "record and report monthly water use from the surface water diversions in accordance with [Haw. Admin. R. §] 13-168-7." ADC/KAA MOA at 17. Nonetheless, the unambiguous and plainly visible reality is that only a fraction of the former plantation lands are currently being cultivated, in far less water-intensive crops than the notoriously thirsty sugar cane crop.[8] Seed field test operations, for example, involve crops like corn that use less water than sugar cane, and also require isolation distances between plantings, resulting in large fallow areas.[9] The operations on the Kekaha-Mānā Plain are no exception; in contrast to dense sugar cane plantings, large swaths of land on the plain have no visible plantings at all:

[8] According to a state Department of Agriculture ("DOA") study of former Kekaha Sugar lands, sugar cane needs approximately three times more water than the average tropical farm product. Dep't of Agric., An Economic Assessment of the Former Kekaha Sugar Company Land and Infrastructure: Its Current and Potential Economic Capability 11-12 (2005). See also Waiāhole, 94 Hawai'i at 163, 9 P.3d at 475 (pointing out the differences in water duties between sugar and diversified agriculture).

[9] See Waiāhole, 94 Hawai'i at 164, 9 P.3d at 476 (reviewing land and water use of seed corn operation and limiting water use to actual need).

Isolated field test planting on the Kekaha-Mānā Plain

View of the Kekaha-Mānā Plain (note large unplanted areas)

As for the mauka lands irrigated by the Kōkeʻe Ditch, the entire region is almost completely idle, except for a small orchard operation of about 125 acres and a Hawaiian homesteader's pastoral land of a few hundred acres.

2. Ongoing Diversions, Waste, and Dumping

Despite this dramatic decline in cultivation and actual water demands due to Kekaha Sugar's closure, ADC/KAA continue to divert Waimea River flows in amounts comparable to the sugar plantation. According to ADC's ditch flow reports to this Commission from 2010 through May 2013, Kekaha Ditch took an average of 31.3 mgd, and Kōkeʻe Ditch took an average of 7.6 mgd.[10] See Commission's ADC Ditch Flow Reports (attached as Exh. 7).

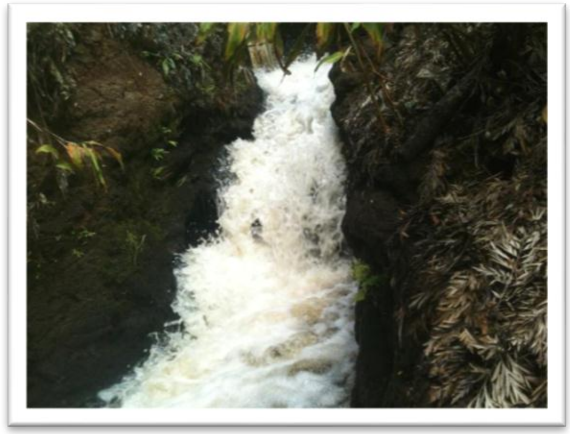
Nearly eight years ago, the DOA acknowledged the decline in water demands because of Kekaha Sugar's closure and recognized not only the potential need to downsize ditch capacity, but also potential "alternative uses" such as "stream restoration." Dep't of Agric., Agricultural Water Use and Development Plan 57 (2004) ("DOA AWUDP") (attached as Exh. 6). While some reduction in reported ditch flows appears to have occurred over the years, there has not been a change in ditch operations or design commensurate to the collapse of water demand from the demise of sugar cultivation.

On their face, the discrepancies between the ongoing diversions and the vastly less land- and water-intensive operations establish that the diverted Waimea River system flows are being wasted. Pōʻai Wai Ola, in fact, is aware of the following examples of outright dumping of diverted water.

[10] These reported data include several months of anomalously low ditch flows. For example, Kōkeʻe Ditch flows were only 0.04 mgd in October and November 2012 and only 1-2 mgd in August of 2011 and 2012.

From the Kōke‘e Ditch, water is continually being dumped down the Kauhao gulch, at a point before the ditch reaches the Pu‘u Lua Reservoir:

Kōke‘e Ditch water being dumped from sluice gate…



down otherwise empty Kauhao gulch

Until earlier this year, Kōke‘e Ditch water was also being continually dumped at a spot on the side of Waimea Canyon Road, where it flowed under the road and down the side of the canyon, many miles downstream from where it was originally diverted:

Kōke‘e Ditch water dumped…

down the side of the canyon

(note green strip along downhill path)

More recently, this dumping has been modified to be less conspicuous, with the ditch water dumped into a newly constructed trench in an empty field, where the water flows away from the Waimea River and in a makai direction, to nowhere:

Redirected dumping from Kōke‘e Ditch

As for the Kekaha Ditch, a visit to the Kekaha-Mānā Plain revealed dumping from an irrigation ditch directly into a low-elevation drainage canal flowing to the ocean:

Kekaha Ditch water being dumped…

into a drainage ditch flowing to ocean

As the plain is filled with such drainage canals (see supra note 2 and accompanying text), the full extent of such wasteful practices remains to be seen.

Moreover, much of the Kōke‘e and Kekaha systems consists of unlined, earthen ditches and reservoirs, resulting in significant waste. In 2005, the DOA recognized the need to address seepage losses and line the reservoirs of the Kōkeʻe system. DOA AWUDP at 55-57. The state Department of Land and Natural Resources ("DLNR") similarly recommended examining system losses in its Kekaha Infrastructure Study. Id. at I-8. The ongoing diversions of the Waimea River system in excess of actual demands and uses compounds this waste via system losses, as the excess diverted water needlessly fills the unlined ditches and reservoirs.

V. USGS STREAM FLOW DATA

Since 1908, USGS has operated an array of approximately twenty-seven stream gages throughout the Waimea River system.[11] While these gages have operated over various timeframes, they collectively provide an extensive body of stream flow data, far more than are available for many other watersheds statewide.

A number of gages provide insights regarding the Waimea River system's flows and the Kōkeʻe and Kekaha Ditches' diversions. The following reviews some of the highlights.

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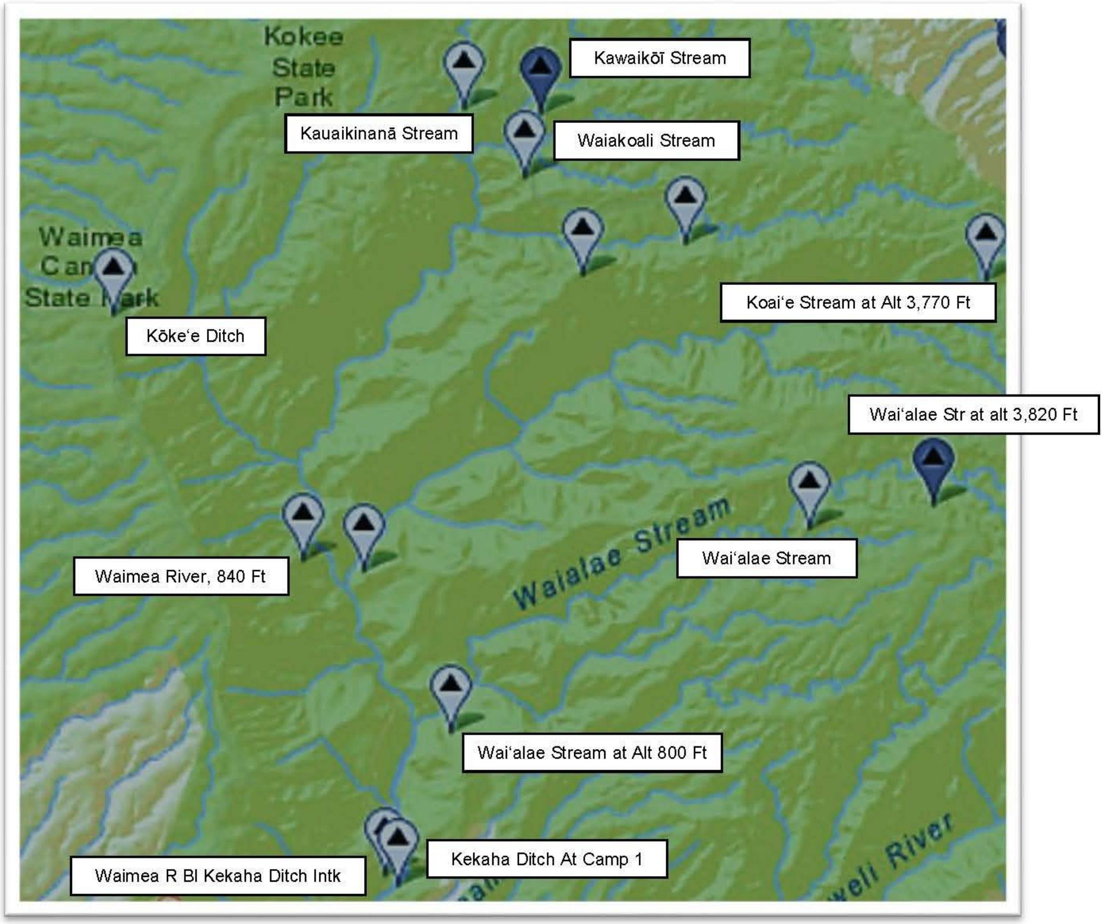
[11] The USGS gaging data are now readily available and accessible online and, thus, are not attached in hard copy here. See USGS, National Water Information System, http://maps.waterdata.usgs.gov/mapper (showing data range, gage location, and gage elevation); USGS, StreamStats, http://streamstatsags.cr.usgs.gov/gages/viewer15.htm?stabbr=gages (showing stream flow data).

Highlights of USGS Data



Location	Gage No.	Elevation (feet)	Data Range	Q_{50} (mgd)	Q_{70} (mgd)	Q_{90} (mgd)
Kauaikinanā Stream	16012000	3,440	1919-25	1.29	0.71	0.40
Kawaikōī Stream	16010000	3,420	1909-2013	8.40	4.98	2.78
Waiakoali Stream	16011000	3,490	1909-25	2.00	1.29	0.71
Kōke'e Ditch	16014000	3,310	1926-83	12.28	7.76	4.07
Waimea River at Alt 840 Ft	16016000	840	1916-68	12.28	10.34	8.40
Koai'e Stream at Alt 3,770 Ft	16017000	3,770	1919-68	5.30	3.23	1.81
Wai'alae Str at alt 3,820 ft	16019000	3,820	1920-2013	4.20	2.59	1.29
Wai'alae Stream	16020000	3,500	1910-16	7.11	4.46	2.46
Wai'alae Stream at Alt 800 Ft	16021000	800	1917-21	9.70	6.46	4.40
Kekaha Ditch At Camp 1	16022000	520	1908-68	36.20	29.73	23.92
Waimea R Bl Kekaha Dtch Intk	16028000	490	1921-68	0.97	0.20	0.01

* Map and stream flow data available at http://maps.waterdata.usgs.gov/mapper/. Elevation and data range information available at http://streamstatsags.cr.usgs.gov/gages/viewer15.htm?stabbr=gages.

As explained in Part IV above, the Kōke‘e Ditch includes diversions from Kauaikinanā, Kawaikōī, and Waiakoali Streams. Stream gage data is available for all three streams. Prior to completion of the Koke‘e Ditch, the “Kauaikinanā Stream” gage (No. 16012000, 1919-25)[12] recorded Q_{50}, Q_{70}, and Q_{90} flows[13] of 1.29 mgd, 0.71 mgd, and 0.40 mgd,[14] respectively. The “Kawaikōī Stream” gage (No. 16010000, 1909-2013) recorded Q_{50}, Q_{70}, and Q_{90} flows of 8.40 mgd, 4.98 mgd, and 2.78 mgd, respectively. The “Waiakoali Stream” gage (No. 16011000, 1909-25) recorded Q_{50}, Q_{70}, and Q_{90} flows of 2.00 mgd, 1.29 mgd, and 0.71 mgd, respectively. While the gages’ periods of record are not identical, they overlap. A rough sum of the available data amounts to Q_{50}, Q_{70}, and Q_{90} flows of 11.69 mgd, 6.98 mgd, and 3.89 mgd, respectively.

The “Kōke‘e Ditch” gage (No. 16014000, 1926-83), recorded the ditch flow diverted from multiple northern headwater tributaries. The gage recorded Q_{50}, Q_{70}, and Q_{90} flows of 12.28 mgd, 7.76 mgd, and 4.07 mgd, respectively.

After the Kōke‘e Ditch diversions, the northern headwater tributaries converge into Waiahulu and Po‘omau Streams. Po‘omau Stream then flows into Waiahulu Stream to form the main stem of the Waimea River. The “Waimea River at Alt 840 Ft” gage (No. 16016000, 1916-68) is located about one mile downstream of the Waiahulu-Po‘omau convergence, close above the Kekaha Ditch diversion on the upper Waimea River. The gage recorded Q_{50}, Q_{70}, and Q_{90} flows of 12.28 mgd, 10.34 mgd, and 8.40 mgd, respectively.

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[12] The gages are referenced by USGS gage number, followed by the gage’s period of record.

[13] “Q” flow figures indicate the amount of flow that is met or exceeded for a stated percentage of time. For example, a Q_{50} of 10 mgd means that 50 percent of the time, water flow at the gage location is at least 10 mgd.

[14] USGS reports flow data in cubic feet per second (“cfs”), which is converted to mgd using USGS’s conversion factor of 1.547 mgd to 1.000 cfs.

As explained in Part IV above, the Kekaha Ditch's first two diversions take flows from both Koaiʻe Stream and the Waimea River below the Waiahulu-Poʻomau convergence. Limited data is available for Koaiʻe Stream. The only continuous gage on that stream, the "Koaiʻe Stream at Alt 3,770 Ft" gage (No. 16017000, 1919-68), is located in its high-elevation headwaters near the Alakaʻi Swamp. That gage recorded Q_{50}, Q_{70}, and Q_{90} flows of 5.30 mgd, 3.23 mgd, and 1.81 mgd, respectively.[15]

More than a mile below the point at which Koaiʻe Stream joins the Waimea River, Waiʻalae Stream enters the Waimea River. Stream gage data is available for the upper, middle, and lower reaches of Waiʻalae Stream. The "Waiʻalae Stream at Alt 800 Ft" gage (No. 16021000, 1917-21), located at the base of Waiʻalae Stream just before it enters Waimea River, recorded Q_{50}, Q_{70}, and Q_{90} flows of 9.70 mgd, 6.46 mgd, and 4.40 mgd, respectively.

Below Waiʻalae Stream's confluence with the Waimea River, the Kekaha Ditch's diversion at the Mauka Powerhouse again diverts the Waimea River. At that point, the river flows comprise whatever flows remain after the upper Waimea River and Koaiʻe diversions and the flows added by the Waiʻalae Stream tributary. The "Kekaha Ditch At Camp 1" gage (No. 16022000, 1908-68) appears to have recorded the total Kekaha Ditch diversions. The gage recorded Q_{50}, Q_{70}, and Q_{90} flows of 36.20 mgd, 29.73 mgd, and 23.92 mgd, respectively.

The "Waimea R Bl Kekaha Dtch Intk" gage (No. 16028000, 1921-68) is located immediately below the Kekaha Ditch diversion at the Mauka Powerhouse. The gage recorded Q_{50}, Q_{70}, and Q_{90} flows of 0.97 mgd, 0.20 mgd, and 0.01 mgd, respectively. Comparing the Kekaha Ditch gage with the Waimea River gage below the Kekaha Ditch indicates that from 50

[15] The USGS also operated a peak flood gage on Koaiʻe Stream (No. 1601800, 1916-71) around the location of the diversion on that stream and its convergence with Waimea River.

to 90 percent of the time, Kekaha Ditch diverted nearly all (97 to almost 100 percent) of the river flows that crossed its path.

VI. EXISTING INSTREAM AND OFFSTREAM WATER USES

The Waimea River system is the lifeblood for a host of protected instream public trust uses. These uses persist as best they can in the face of ongoing diversions by the Kekaha and Kōke‘e Ditches. Meanwhile, as explained above, ADC/KAA maintain inflated and wasteful offstream diversions despite the closure of the Kekaha Sugar plantation and extensive reduction in offstream uses and demands.

A. Instream Uses

Historic and ongoing diversions have impaired Waimea River's ability to support instream uses. The Code defines instream use as "beneficial uses of stream water for significant purposes, which are located in the stream and which are achieved by leaving the water in the stream." Haw. Rev. Stat. § 174C-3. The definition provides several examples such as: the maintenance of fish and wildlife habitats; outdoor recreational activities; maintenance of ecosystems such as estuaries, wetlands, and stream vegetation; aesthetic values such as waterfalls and scenic waterways; maintenance of water quality; and the protection of traditional and customary Native Hawaiian rights. Id. Restoration of flow in amended IIFSs for the Waimea River system is necessary to protect and restore the full range and quality of these instream uses.

Maintenance of Fish and Wildlife Habitats: Native stream and nearshore life depends on natural mauka to makai stream flow. As DLNR's Division of Aquatic Resources ("DAR") emphasizes, the "single most important requirement" for protecting native stream life in Hawai‘i is ensuring the natural patterns of water flow between streams and the ocean.[16] The amphidromous life cycles of native stream life, alternating between the stream and the ocean, underscore this paramount importance of maintaining mauka to makai stream flow. HSA at 133.

The HSA observed in the Waimea River system three of its four native indicator species for habitat quality: ‘o‘opu nakea (Awaous stamineus), ‘o‘opu nōpili (Sicyopterus stimpsoni), and hīhīwai (Neritina granosa). Id. at 152. The HSA initially ranked the Waimea River system's aquatic resources as outstanding, but lowered the rank to moderate because of "degradation of habitat." Id. at 151-52.

The Waimea River watershed also contains the highest number of threatened and endangered bird (9) and rare plant (17) species on Kaua‘i. HSA at 182-83. Stream-associated endangered birds such as the koloa maoli (Hawaiian duck) and the ‘alae ‘ula (Hawaiian moorhen) are found in the watershed. In addition, several of the watershed's native plant species used for traditional and customary practices are associated with stream flows, including the pāpala kēpau, māmaki, olomea, and ōpuhe trees.

Long-time kama‘āina community members attest to a steady decline in the abundance of native amphidromous stream life in the Waimea River system as the ditch diversions persist in dewatering it over the long term, compounding the stresses on the river habitat. Preliminary scientific evaluations of the river similarly observed markedly diminished stream life and habitat compared to undiverted, healthy streams. Native indicator species such as ‘o‘opu are found in low percentages compared to alien pest fishes and are also found outside of their normal ranges in the river, all of which indicate the native ecological system is breaking down. Moreover, the lower river habitats are covered with sediment, the extended result of persistently low flows that

[16] Robert Nishimoto, Div. of Aquatic Res., Hawaiian Streams: The Mauka to Makai Connection, http://www.hawaii.gov/dlnr/dar/hawn_streams.htm.

are insufficient to flush the river bed. The chronic low flows downstream of ditch diversions have an undeniable impact on the native stream life and ecosystem.

Outdoor Recreational Activities: "Water-related recreation is a part of life in Hawai'i." HSA at 232. Waimea was one of only four Kaua'i rivers and streams recognized for their "statewide outstanding," "blue ribbon" recreation resources. Id. at 248-49, 272. The HSA recognized the Waimea River system's opportunities for camping, hiking, fishing, swimming, hunting and boating, as well as parks and scenic views. Id. at 243, 249. Waimea Bay and Recreational Pier at the mouth of the river are a popular community fishing area and a DLNR-designated Marine Fisheries Management Area. See Haw. Admin. R. ch. 13-50 (1981). The large-scale plantation ditch diversions, however, diminish these recreational values. HSA at 244 (acknowledging that recreational values "tend to be correlated with high flow rates").

Long-time kama'āina community members attest that their ability to recreate in the river has deteriorated or vanished as the weak river flows continue and cause more and more silt to fill the river bed. See photograph in Part VI.C.3. In the 1920s, the river was deep enough for recreational riverboats to travel upstream as far as the "point" at the Waimea-Makaweli fork. In the early 1960s, Waimea children would build boats from recycled materials, some up to eight feet long, and sail them across the Waimea River in what one resident called the "tin boat wars." Moke Kupihea, The Seven Dawns of the Aumakua: The Ancestral Spirit Tradition of Hawaii 151-52 (2004) ("Seven Dawns"). As recent as the 1980s to 1990s, community members would frequent a popular swimming hole under the swinging bridge near the Waimea-Makaweli fork. The water was around fifteen feet deep at the time, deep enough for people to dive in from the bridge. Today, the swimming hole is buried, and only a thin layer of water covers the silt-laden river bed.

Standing where there used to be a 15-foot deep swimming hole, into which people could dive from the bridge

By substantially reducing flow in the Waimea River system, the ditch diversions are antithetical to public instream recreational uses.

Maintenance of Ecosystems, Such as Estuaries, Wetlands, and Stream Vegetation: Healthy stream flows in the Waimea River system are also necessary to maintain its various interconnected ecosystems, such as estuaries, wetlands, and stream vegetation. The Waimea River system sustains more than 0.5 square miles of palustrine (marsh) wetland, as identified by the United States Fish & Wildlife Service. HSA at 182-83. It also supports twenty percent native forest along its banks, which contains the highest number of rare plants species (17) of any river or stream on Kaua‘i. Id. The estuary provides habitat for fresh water and marine life. These ecological features, which are dependent on river flow, support the quality of the river system and its ability to support other instream uses and values. HSA at 169.

Scenic Beauty and Water Quality: River flow is also synonymous with scenic beauty and water quality. The HSA recognized the Waimea River system for its scenic views. Id. at 248-49. The "Grand Canyon of the Pacific," however, is an empty shell without the river that made it. The diversions not only degrade the river's aesthetic values, but also directly affect its water quality by reducing the water available to assimilate and transport pollutants. The state

Department of Health has designated the Waimea River as water quality impaired under the federal Clean Water Act for turbidity and phosphorous, and the river estuary as impaired for turbidity.[17] The pictures of the dewatered river filled with algae and sediment speak for themselves regarding the aesthetic and water quality impacts. See Part IV.C.3, supra.

Protection of Traditional and Customary Native Hawaiian Rights: Native Hawaiians actively practice many traditional and customary Native Hawaiian rights that are dependent on the Waimea River system. These rights, however, are being abridged by the former plantation ditches' excessive diversions of water.

Native Hawaiians are limited in their rights to gather stream life such as ʻoʻopu, ʻōpae, and hīhiwai. As explained above, the Waimea River system was legendary for the abundance of its native stream life, including ʻoʻopu. See Part IV.A.2, supra. These resources, however, have markedly declined with the continued long-term diversion of the river and cannot support the traditionally practiced and currently desired levels of gathering.

The Waimea River system traditionally supported extensive kalo cultivation from the delta and far into the valley, which the plantation diversions widely diminished. In the lower valley, community members continue to exercise traditional and customary water rights in growing kalo and other domestic crops. These uses receive their needed and entitled water from the Menehune Ditch, which, through the actions of the former plantation, is currently connected to the Kekaha Ditch. When ADC transferred control of irrigation infrastructure to KAA, the parties provided assurances that kalo farmers in Waimea Valley and Department of Hawaiian Home Lands ("DHHL") homesteaders who depend on the ditch systems will continue to have the right to take water. ADC/KAA MOA at 6. These uses are constitutionally protected public

[17] See U.S. Envtl. Prot. Agency, Hawaii 303(d) Listed Waters for Reporting Year 2006, http://iaspub.epa.gov/tmdl_waters10/attains_impaired_waters.impaired_waters_list?p_state=HI&p_cycle=2006 (list of impaired waters).

trust purposes as well, and must be preserved and promoted together with other Native Hawaiian rights and public trust uses dependent on instream flows.

Other Native Hawaiian, riparian, and kuleana rightholders downstream of the ditch diversions could access surface water directly from Waimea River, but are limited by the diminished flows. See Haw. Rev. Stat. § 174C-3 (instream use includes "conveyance of irrigation and domestic water supplies to downstream points of diversion"). For example, the Kaohi ʻohana owns two acres of kuleana land (TMK # (4)1-5-3-26) along the Waimea River below the Kekaha Ditch diversions and would like to restore and enjoy this ʻāina, but the dewatered river limits their ability to do so. They and others downstream of the diversions are entitled to share in this public trust resource.

Healthy river flows are also vital to the perpetuation of Native Hawaiian spiritual practices and values. The shallow and warm water that the diversions currently leave in the Waimea River system are not conducive to Native Hawaiian spiritual practices such as ritual blessings. Further, wai is the kino lau (physical embodiment) of the Hawaiian deity Kāne, and its waste offends traditional Hawaiian values.

The Waimea River system is legendary in Hawaiian tradition and central to the community's cultural identity. For example, the legendary Pohakulani ("the stone of a high chief")[18] lies in the riverbed near the swinging bridge and marks the location of a sacred leina a ka ʻuhane (point where the deceased depart for the spirit realm). Seven Dawns at 120-21. Due

[18] Pohakulani was the ill-fated son of renowned Waimea king Ola. According to the legend, Ola bargained with the king of the Menehune to build an ʻauwai to enable more kalo cultivation for Ola's kingdom. In return, the Menehune king required that Ola supply all the ʻōpae his people could eat and ensure that no one venture outdoors at night, as the Menehune would only work in secrecy. Each night, Ola supplied 2,000 large calabashes full of ʻōpae. All went well until the final night of construction, when Ola's children snuck outside to catch a glimpse of the Menehune at work. As punishment, the two were turned into stone right where they stood -- the sister where she hid on the hillside and the brother in the river. Seven Dawns at 65-66.

to the diminished river flows from longstanding ditch diversions, accumulating muck has completely buried this sacred stone. The ongoing degradation of the Waimea River system causes deep injury to Native Hawaiian spiritual and cultural values.

Standing above the location of the sacred Pohakulani, now buried under silt

B. Offstream Uses

1. ADC/KAA's Diversions and Waste

Part IV.D, supra, details ADC/KAA's ongoing diversions and waste and the lack of public accountability on ADC/KAA's actual water uses and demands.

2. Hawaiian Home Land Water Rights

DHHL holds 15,061 acres of the Waimea mauka uplands in trust for its beneficiaries.[19] Most these lands were historically leased to the Kekaha Sugar plantation and irrigated by the Kōke'e Ditch. Meanwhile, the few homesteaders on the land suffered a long history of

[19] See Dep't of Hawaiian Homelands, West Kaua'i Regional Plan 11 (2011) ("DHHL West Kaua'i Plan").

inadequate water resources.[20] Currently, only one homesteader is leasing several hundred acres of land for pasture.

DHHL, together with its beneficiaries, plan to expand use of these lands for agricultural and pastoral homesteads and other community uses, including farming, ranching, and aquaculture. See DHHL West Kauaʻi Plan. The Waimea-Kekaha community has resurgent interest and desire to make these lands agriculturally productive, including for kalo.[21] To make the home lands productive will require ditch irrigation water.

As discussed in Part II.D, supra, the law establishes the priority rights of Hawaiian Home Lands. ADC is legally barred from amending or modifying water rights under "article XI, section 7, of the Constitution . . . , or the [HHCA]." Haw. Rev. Stat. § 163D-4(9)(A)(i) (2011). Pōʻai Wai Ola supports a reasonable and pono (just) balance between parallel public trust uses for the Waimea-Kekaha Hawaiian home lands, and the protection and restoration of Waimea River system's instream uses. See Waiāhole, 94 Hawaiʻi at 142 n.43, 9 P.3d at 454 n.43 (Commission must protect all trust purposes to the extent feasible).

VII. ANTICIPATED BENEFITS OF STREAM RESTORATION

Ola I Ka Wai: Water Is Life. Restoring flows to the Waimea River system will protect and promote the range of public trust instream uses discussed above. Whereas the plantation ditch diversions impair these uses by depriving them of their natural, sole source of water, restoration of diverted flows will undo these harms.

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[20] See Native Hawaiian Rights Handbook at 58. In fact, because of ongoing problems with obtaining water, four of five original homesteaders at Puʻu ʻŌpae abandoned their leases. See id. (describing the self-help efforts of homesteaders unable to obtain sufficient water, and Kekaha Sugar's attempts to stop them).

[21] See Dep't of Hawaiian Homelands, Item No. G-2: Authorize the Chairman to Take Action to Secure the Control and Use of Water in Waimea, Kauaʻi Through State Administrative Action 3-4 (Jan. 15, 2013).

Pōʻai Wai Ola anticipates that increased instream flow will have a direct, positive impact on the river ecosystem from mauka to makai. Both the Commission and the Hawaiʻi Supreme Court have recognized the "positive effect" of stream restoration:

> [G]enerally, the higher the volume of instream flow and the closer the streamflow approaches its natural pre-diversion levels, the greater the support for biological processes in the stream and its ecosystem. Thus, in general, it is expected that additional flows to the streams would increase the native biota habitat.

Waiāhole, 94 Hawaiʻi at 146, 9 P.3d at 458 (citations and quotation marks omitted); see also id. at 158, 9 P.3d at 470 (recognizing that "[h]igh base flow is important to the estuary ecosystem as well as the stream itself"). In the HSA, the Commission observed that "[e]xtensive water development is incompatible with outstanding aquatic resources" and "found a positive correlation between good aquatic resources and larger streams and lack of stream modification." Id. at 139, xxi.

Actual experience and studies confirm the ecological benefits of instream flow restoration. In the Waiāhole case, for example, these benefits were not only expected, but also "immediate" and observed. 94 Hawaiʻi at 112, 146, 9 P.3d at 424, 458. Peer-reviewed scientific literature has established a direct correlation between stream flow volume and native species productivity.[22]

Restored river flows will benefit other public trust instream uses. Enhancing instream flows toward their natural levels will support the entire river ecosystem from mauka to makai, including interconnected wetlands, estuaries, and riparian areas. Recreational opportunities will increase as river flow rises and scours accumulated sediment. Aesthetic values will also improve

[22] See, e.g., Benbow et al., "The use of two modified Breder traps to quantitatively study amphidromous upstream migration," Hydrobiologia 527: 139-51 (2004); Way et al., "Reproductive biology of the endemic goby, Lentipes concolor, from Makamakaʻole Stream, Maui and Waikolu Stream, Molokaʻi," Environmental Biology of Fishes 51: 53-68 (1998).

from the current stagnant, polluted conditions. Traditional and customary Native Hawaiian rights will benefit from greater downstream flows and revived native stream resources.

Settled law establishes that leaving flow in the river is categorically not waste, that public trust instream uses are the presumptive priority and default, and that commercial offstream diverters bear the burden to justify their diversions. Id. at 136-37, 142-43, 9 P.3d at 448-49, 454-55. The benefits of restoring the Waimea River system's flows are not only evident from the river's currently degraded conditions and supported by experience and science, but presumed and mandated under law.

VIII. THE COMMISSION MUST EXPEDITIOUSLY ORDER THE CESSATION OF WASTE AND AMEND THE INTERIM INSTREAM FLOW STANDARDS TO RESTORE FLOWS IN THE WAIMEA RIVER SYSTEM.

Given the Commission's public trust mandate, the negative impacts of ongoing diversions, and the prima facie indications of excess diversions and waste, Pōʻai Wai Ola respectfully requests the Commission to take expeditious action and order the immediate cessation of waste and interim return of the Waimea River system's flows under amended IIFSs. The Code charges the Commission to investigate and take action against waste. Haw. Rev. Stat. 174C-13; Waiāhole, 94 Hawaiʻi at 172, 9 P.3d at 484.[23] Both the Commission and the Hawaiʻi Supreme Court have recognized that "the policy against waste dictates that any water above the minimum flows and not otherwise needed for use remain in the streams in any event." Waiāhole, 94 Hawaiʻi at 156, 9 P.3d at 468. Thus, as it did in the Waiāhole case, the Commission must compel, under threat of penalties if necessary, that any and all diverted flows being wasted (i.e., not being put to actual, reasonable-beneficial use) remain in their streams of

[23] Additionally, the Commission has general jurisdiction over "any disputes regarding water resource protection" and may "fashion conditions, limitations, and remedies, and otherwise exercise such other powers as may be necessary and proper in aid of its jurisdiction consistent with law." Haw. Rev. Stat. § 174C-10 (2011); Haw. Admin. R. § 13-167-3(4), (5) (1988).

origin. See id. at 112, 9 P.3d at 424 (Commission issued an order to show cause regarding waste).[24] This also includes compelling ADC/KAA to reduce to the extent feasible the ongoing waste via system losses. See id. at 172, 9 P.3d at 484 (Commission has authority to take action on "allegation that the ditch is wasting water due to deficient operation and upkeep").

As noted above, ADC/KAA do not provide the Commission or public with any information on actual water uses and losses, despite their commitment in their MOA to document such information. As part of its mandated investigation, the Commission should require essential monitoring and reporting, including average daily water usage by end user, breakdowns of acreages and crops cultivated, reservoir volumes or stages, and system losses. This minimum information is critical to ensure public accountability over ADC and KAA's diversions of public trust river flows.

Moreover, the flows immediately returned to the Waimea River system to prevent waste must be incorporated into amended IIFSs. "Interim standards must respond to interim circumstances." Id. at 151, 9 P.3d at 463. "[A]t least for the time being," the IIFSs should reflect the amount of instream flow that reflects current, actual reasonable-beneficial offstream use and the absence of waste. Id. at 157, 9 P.3d at 469. If necessary, the Commission may further amend the IIFSs as it obtains more detailed information and analysis of instream and offstream uses.

The Code mandates a 180-day deadline for IIFS petitions. Haw. Rev. Stat. § 174C-71(2)(E); Haw. Admin. R. § 13-169-41 (1988). This provides ample time for the Commission to investigate and take action on the matters set forth herein, at least for purposes of establishing initial IIFSs pending any further investigation and amendments. The delays that have occurred in other IIFS cases are inefficient and highly prejudicial to community petitioners and must not

[24] See Haw. Rev. Stat. § 174C-15(b) (2011) (providing for fines for violations).

be repeated in this case. Pō‘ai Wai Ola respectfully requests decisive, effective, and timely relief on their IIFS amendment request within the deadlines mandated by law.

IX. CONCLUSION

Waimea River is a natural and cultural treasure, and the state Constitution and Code mandate its protection and restoration for present and future generations. For the reasons set forth herein, Pō‘ai Wai Ola respectfully requests that this Commission grant the relief sought and (1) order the immediate cessation of any and all waste and require reporting and monitoring of actual offstream uses and needs, and (2) restore flows to the Waimea River system in amended IIFSs.

DATED: Honolulu, Hawai‘i, July 24, 2013.

EARTHJUSTICE
David L. Henkin
Isaac H. Moriwake
223 South King Street, Suite 400
Honolulu, Hawai‘i 96813

By: ______________________
ISAAC H. MORIWAKE
Attorneys for Petitioner/Complainant
PŌ‘AI WAI OLA/WEST KAUA‘I
WATERSHED ALLIANCE

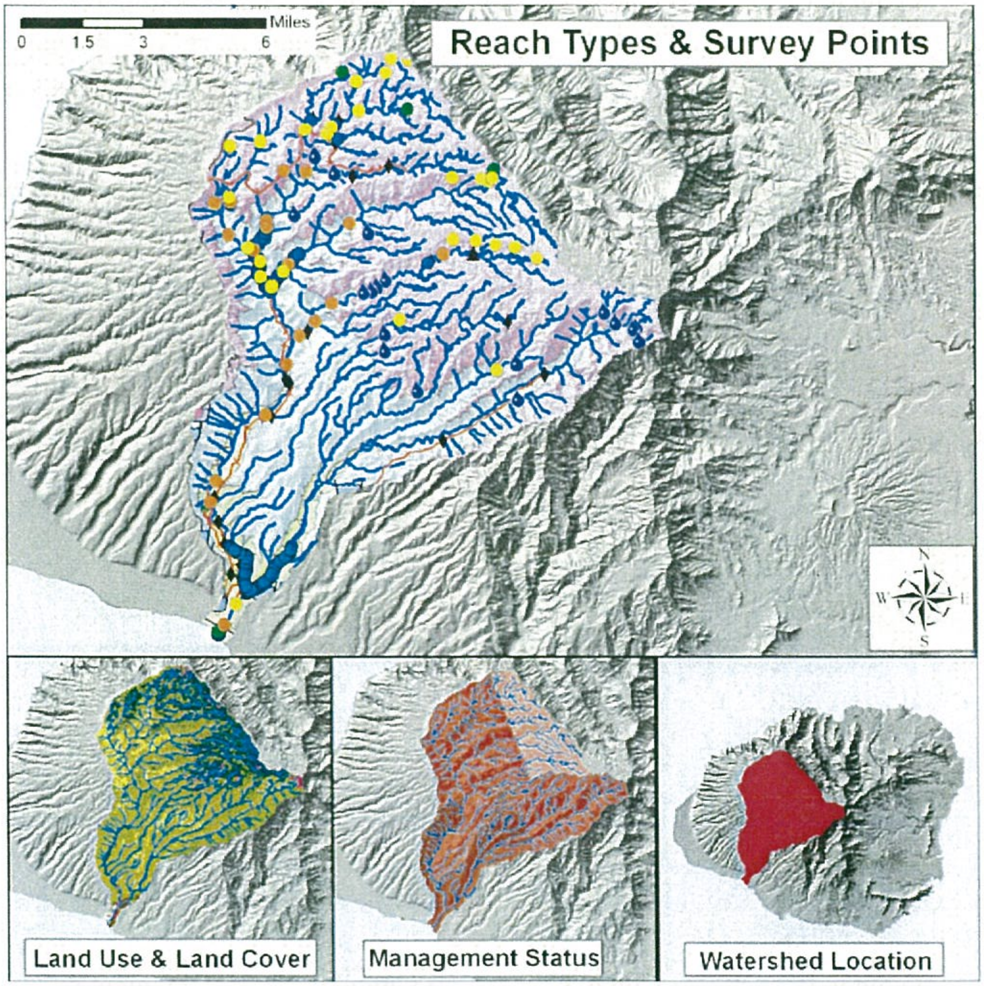
BEFORE THE COMMISSION ON WATER RESOURCE MANAGEMENT

OF THE STATE OF HAWAI`I

In the Matter of:	)	EXHIBITS 1-7
	)	
PETITION TO AMEND THE INTERIM	)	
INSTREAM FLOW STANDARDS FOR	)	
WAIMEA RIVER AND ITS HEADWATERS	)	
AND TRIBUTARIES, AND COMPLAINT	)	
AND PETITION FOR DECLARATORY	)	
ORDER AGAINST WASTE	)	
	)	
	)	

EXHIBITS 1-7

Waimea River, Kauaʻi



WATERSHED FEATURES

Waimea River watershed occurs on the island of Kaua'i. The Hawaiian meaning of the name is "reddish water (as from erosion)". The area of the watershed is 85.9 square mi (222.6 square km), with maximum elevation of 5243 ft (1598 m). The watershed's DAR cluster code is 8, meaning that the watershed is very large, and steep in the upper watershed.. The percent of the watershed in the different land use districts is as follows: 12.9% agricultural, 86.6% conservation, 0.1% rural, and 0.4% urban.

Land Stewardship: Percentage of the land in the watershed managed or controlled by the corresponding agency or entity. Note that this is not necessarily ownership.

Military	Federal	State	OHA	County	Nature Conservancy	Other Private
0.0	0.0	78.7	5.4	0.0	0.0	15.9

EXHIBIT 1

Land Management Status: Percentage of the watershed in the categories of biodiversity protection and management created by the Hawaii GAP program.

Permanent Biodiversity Protection	Managed for Multiple Uses	Protected but Unmanaged	Unprotected
0.0	17.0	61.7	21.3

Land Use: Areas of the various categories of land use. These data are based on NOAA C-CAP remote sensing project.

	Percent	Square mi	Square km
High Intensity Developed	0.1	0.06	0.17
Low Intensity Developed	0.3	0.29	0.75
Cultivated	0.6	0.49	1.26
Grassland	0.8	0.71	1.84
Scrub/Shrub	71.6	61.55	159.42
Evergreen Forest	13.8	11.83	30.64
Palustrine Forested	7.2	6.18	16.01
Palustrine Scrub/Shrub	1.4	1.22	3.16
Palustrine Emergent	0.5	0.45	1.17
Estuarine Forested	0.0	0.00	0.00
Bare Land	3.6	3.08	7.97
Unconsolidated Shoreline	0.0	0.00	0.00
Water	0.1	0.08	0.21
Unclassified	0.0	0.00	0.00

STREAM FEATURES

Waimea River is a perennial stream. Total stream length is 276.4 mi (444.9 km). The terminal stream order is 5.

Reach Type Percentages: The percentage of the stream's channel length in each of the reach type categories.

Estuary	Lower	Middle	Upper	Headwaters
0.2	0.0	10.1	35.6	54.1

The following stream(s) occur in the watershed:

ʻĀwini	ʻElekeniʻiki	ʻElekeninui	Haleʻaha	Halekua
Halemanu	Halepaʻakai	Hipalau	Kahana	Kauaikinanā
Kawai Iki	Kawaikōī	Koaiʻe	Koholoina	Kōkeʻe
Kunini	Loli	Makaweli	Maluapopoki	Mōhihi
Mokihana	Mokuone	Nāwaimaka	Nīhoa	Noe
Olokele	ʻŌmaʻo	Oneopaewa	Peamoa	Poʻomau
Wahane	Waiahulu	Waiakōali	Waiʻalae	Waiānuenue
Waiau	Waimea	Waineki		

BIOTIC SAMPLING EFFORT

Biotic samples were gathered in the following year(s):

1895	1897	1919	1920	1940	1963	1977
1978	1979	1990	1991	1992	1994	1995
1997	2000	2002	2005			

Distribution of Biotic Sampling: The number of survey locations that were sampled in the various reach types.

Survey type	Estuary	Lower	Middle	Upper	Headwaters
Damselfly Surveys	0	1	0	9	40
DAR General Surveys	0	0	0	0	5
DAR Larval Trapping	0	219	0	0	0
DAR Point Quadrat	0	153	1	106	0
HDFG	1	0	5	12	3
Published Report	1	0	0	0	3

BIOTA INFORMATION

Species List

Native Species

Crustaceans	*Atyoida bisulcata*
	Macrobrachium grandimanus
Fish	*Awaous guamensis*
	Eleotris sandwicensis
	Gobiid sp.
	Kuhlia xenura
	Lentipes concolor
	Mugil cephalus
	Mugilid sp.
	Polydactylus sexfilis
	Sicyopterus stimpsoni
	Stenogobius hawaiiensis
Snails	*Neritina granosa*
	Neritina vespertina
Worms	*Oligochaete sp.*

Native Species

Insects	*Anax strenuus*
	Campsicnemus nigricollis
	Campsicnemus sp.
	Dolichopodid sp.
	Ephydrid sp.
	Eurynogaster mediocris
	Eurynogaster minor
	Forcipomyia hardyi
	Forcipomyia sp.
	Hyposmocoma sp
	Limonia hawaiiensis
	Limonia jacobus
	Limonia sp.
	Limonia stygipennis
	Megalagrion adytum
	Megalagrion calliphya
	Megalagrion eudytum
	Megalagrion heterogamias
	Megalagrion mauka
	Megalagrion oresitrophum
	Megalagrion paludicola
	Megalagrion sp.
	Megalagrion vagabundum
	Microvelia vagans
	Nesogonia blackburni

Paraliancalus metallicus
Procanace bifurcata
Procanace nigroviridis
Procanace quadrisetosa
Procanace sp.
Procanace wirthi
Rhantus pacificus
Saldula exulans
Saldula oahuense
Saldula procellaris
Scatella cilipes
Scatella hawaiiensis
Scatella kauaiensis
Sigmatineurum napali
Telmatogeton hirtus
Telmatogeton sp.
Tipulid sp.

Introduced Species

Amphibians	*Bufo marinus*	
	Rana rugosa	
Crustaceans	*Macrobrachium lar*	
	Procambarus clarkii	
Fish	*Clarias fuscus*	
	Gambusia affinis	
	Misgurnus anguillicaudatus	
	Oncorhynchus mykiss	
	Oreochromis mossambicus	
	Poecilia reticulata	
	Poecilia sphenops	
	Poeciliid sp.	
	Tilapia sp.	
	Xiphophorus helleri	
Snails	Lymnaeid sp.	
	Melania sp.	

Introduced Species

Insects	*Anopheles subpictus*
	Cheumatopsyche pettiti
	Chironomid larvae
	Cricotopus bicinctus
	Deielia fasciata
	Dolichopus exsul
	Enallagma civile
	Ischnura posita
	Ischnura ramburi
	Limonia advena
	Ochthera circularis
	Syntormon flexible
	Toxorhynchites amboinensis

Species Size Data: Species size (inches) observed in DAR Point Quadrat Surveys.

Scientific Name	Status	Minimum Size	Maximum Size	Average Size
Bufo marinus	Introduced	0.125	0.25	0.2
Rana rugosa	Introduced	3	3	3.0
Macrobrachium grandimanus	Endemic	1	3	1.7
Macrobrachium lar	Introduced	1.25	5	2.9
Eleotris sandwicensis	Endemic	2	4.5	2.8
Kuhlia xenura	Endemic	2	4.5	3.2
Sicyopterus stimpsoni	Endemic	0.75	6	2.7
Stenogobius hawaiiensis	Endemic	0.75	4	1.8

Awaous guamensis	Indigenous	0.75	9	3.1
Gobiid sp.	Indigenous	0.5	1.5	0.9
Mugil cephalus	Indigenous	1	12	4.3
Mugilid sp.	Indigenous	2	12	2.6
Poecilia reticulata	Introduced	0.25	1	0.3
Poecilia sphenops	Introduced	2	2.5	2.4
Poeciliid sp.	Introduced	0.25	1	0.4
Tilapia sp.	Introduced	0.25	8	0.4
Xiphophorus helleri	Introduced	0.75	3	2.0
Neritina vespertina	Endemic	1	1.25	1.1

Average Density: The densities (#/square yard) for species observed in DAR Point Quadrat Surveys averaged over all sample dates in each reach type.

Scientific Name	Status	Estuary	Low	Mid	Upper	Headwaters
Eleotris sandwicensis	Endemic		0.05			
Kuhlia xenura	Endemic		0.19			
Macrobrachium grandimanus	Endemic		0.06			
Neritina granosa	Endemic		0.01			
Neritina vespertina	Endemic		0.03			
Sicyopterus stimpsoni	Endemic		0.54		0.14	
Stenogobius hawaiiensis	Endemic		2.1			
Awaous guamensis	Indigenous		2.13	8	2.85	
Gobiid sp.	Indigenous		3.21			
Mugil cephalus	Indigenous		1.02			
Mugilid sp.	Indigenous		0.82			
Bufo marinus	Introduced		0.31			
Macrobrachium lar	Introduced		0.22			
Melania sp.	Introduced		0.01			
Poecilia reticulata	Introduced		0.57			
Poecilia sphenops	Introduced		0.05			
Poeciliid sp.	Introduced		0.79			
Rana rugosa	Introduced		0.01			
Tilapia sp.	Introduced		3.34			
Xiphophorus helleri	Introduced		0.14			

Species Distributions: Presence (P) of species in different stream reaches.

Scientific Name	Status	Estuary	Lower	Middle	Upper	Headwaters
Atyoida bisulcata	Endemic	P	P	P	P	P
Macrobrachium grandimanus	Endemic		P			
Eleotris sandwicensis	Endemic		P	P		
Kuhlia xenura	Endemic		P			
Lentipes concolor	Endemic		P			
Sicyopterus stimpsoni	Endemic		P	P	P	

Stenogobius hawaiiensis	Endemic		P	P		
Anax strenuus	Endemic					P
Campsicnemus nigricollis	Endemic					P
Eurynogaster mediocris	Endemic					P
Eurynogaster minor	Endemic					P
Forcipomyia hardyi	Endemic					P
Hyposmocoma sp	Endemic					P
Limonia hawaiiensis	Endemic					P
Limonia jacobus	Endemic					P
Limonia stygipennis	Endemic					P
Megalagrion adytum	Endemic					P
Megalagrion calliphya	Endemic					P
Megalagrion eudytum	Endemic					P
Megalagrion heterogamias	Endemic				P	P
Megalagrion mauka	Endemic					P
Megalagrion oresitrophum	Endemic					P
Megalagrion paludicola	Endemic					P
Megalagrion sp.	Endemic			P	P	P
Megalagrion vagabundum	Endemic				P	P
Microvelia vagans	Endemic					P
Nesogonia blackburni	Endemic					P
Paraliancalus metallicus	Endemic					P
Procanace bifurcata	Endemic					P
Procanace nigroviridis	Endemic					P
Procanace quadrisetosa	Endemic					P
Procanace wirthi	Endemic					P
Rhantus pacificus	Endemic					P
Saldula exulans	Endemic					P
Saldula oahuense	Endemic					P
Saldula procellaris	Endemic					P
Scatella cilipes	Endemic					P
Scatella hawaiiensis	Endemic					P
Scatella kauaiensis	Endemic					P
Sigmatineurum napali	Endemic					P
Neritina granosa	Endemic		P			
Neritina vespertina	Endemic		P			
Awaous guamensis	Indigenous		P	P	P	
Gobiid sp.	Indigenous	P	P	P	P	P
Mugil cephalus	Indigenous		P			
Mugilid sp.	Indigenous		P			
Polydactylus sexfilis	Indigenous		P			
Campsicnemus sp.	Indigenous					P

Forcipomyia sp.	Indigenous					P
Limonia sp.	Indigenous					P
Procanace sp.	Indigenous					P
Telmatogeton sp.	Indigenous			P	P	P
Bufo marinus	Introduced		P			
Rana rugosa	Introduced		P			P
Macrobrachium lar	Introduced		P			
Procambarus clarkii	Introduced					P
Clarias fuscus	Introduced					P
Gambusia affinis	Introduced			P		
Misgurnus anguillicaudatus	Introduced					P
Oncorhynchus mykiss	Introduced					P
Oreochromis mossambicus	Introduced			P		
Poecilia reticulata	Introduced	P	P			
Poecilia sphenops	Introduced		P			
Poeciliid sp.	Introduced		P			
Tilapia sp.	Introduced	P	P	P		
Xiphophorus helleri	Introduced	P	P	P		P
Anopheles subpictus	Introduced					P
Cheumatopsyche pettiti	Introduced					P
Chironomid larvae	Introduced	P		P	P	P
Cricotopus bicinctus	Introduced					P
Deielia fasciata	Introduced					P
Dolichopus exsul	Introduced					P
Enallagma civile	Introduced		P			P
Ischnura posita	Introduced				P	P
Ischnura ramburi	Introduced				P	P
Limonia advena	Introduced					P
Ochthera circularis	Introduced					P
Syntormon flexible	Introduced					P
Toxorhynchites amboinensis	Introduced					P
Lymnaeid sp.	Introduced			P	P	
Melania sp.	Introduced	P	P	P		
Dolichopodid sp.	Undetermined					P
Ephydrid sp.	Undetermined					P
Tipulid sp.	Undetermined					P
Oligochaete sp.	Undetermined					P

HISTORIC RANKINGS

Historic Rankings: These are rankings of streams from historical studies. "Yes" means the stream was considered worthy of protection by that method. Some methods include non-biotic data in their determination. See Atlas Key for details.

Multi-Attribute Prioritization of Streams - Potential Heritage Streams (1998): No

Hawaii Stream Assessment Rank (1990): Moderate

U.S. Fish and Wildlife Service High Quality Stream (1988): Yes

The Nature Conservancy- Priority Aquatic Sites (1985): Yes

National Park Service - Nationwide Rivers Inventory (1982): No

Current DAR Decision Rule Status: The following criteria are used by DAR to consider the biotic importance of streams. "Yes" means that watershed has that quality.

Native Insect Diversity > 19 spp.	Native Macrofauna Diversity > 5 spp.	Absence of Priority 1 Introduced
Yes	Yes	No
Abundance of Any Native Species	**Presence of Candidate Endangered Species**	**Endangered Newcomb's Snail Habitat**
No	No	No

CURRENT WATERSHED AND STREAM RATINGS

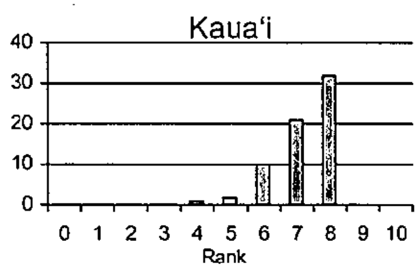
The current watershed and stream ratings are based on the data contained in the DAR Aquatic Surveys Database. The ratings provide the score for the individual watershed or stream, the distribution of ratings for that island, and the distribution of ratings statewide. This allows a better understanding of the meaning of a particular ranking and how it compares to other streams. The ratings are standardized to range from 0 to 10 (0 is lowest and 10 is highest rating) for each variable and the totals are also standardized so that the rating is not the average of each component rating. These ratings are subject to change as more data are entered into the DAR Aquatic Surveys Database and can be automatically recalculated as the data improve. In addition to the ratings, we have also provided an estimate of the confidence level of the ratings. This is called rating strength. The higher the rating strength the more likely the data and rankings represent the actual condition of the watershed, stream, and aquatic biota.

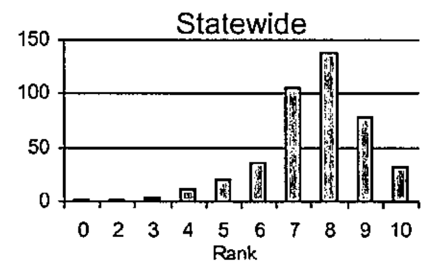
WATERSHED RATING: Waimea River, Kaua'i

Land Cover Rating: Rating is based on a scoring sytem where in general forested lands score positively and developed lands score negatively.

Watershed Rating

8

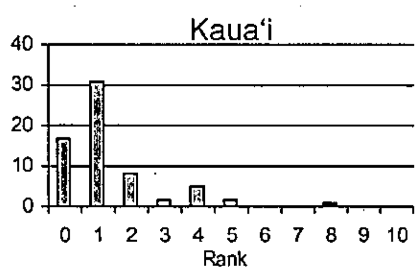


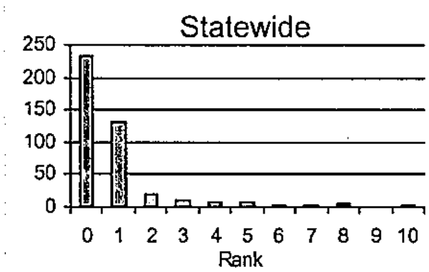


Shallow Waters Rating: Rating is based on a combination of the extent of estuarine and shallow marine areas associated with the watershed and stream.

Watershed Rating

4

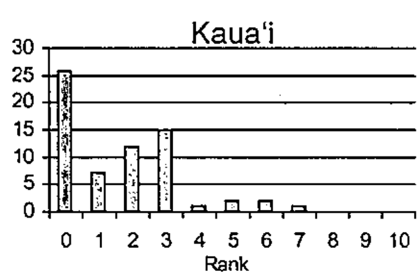


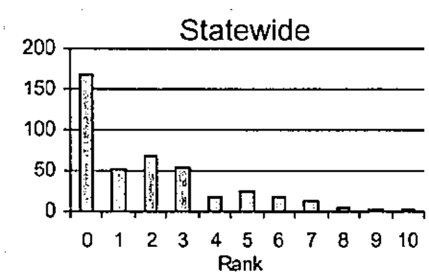


Stewardship Rating: Rating is based on a scoring system where higher levels of land and biodiversity protection within the watershed score positively.

Watershed Rating

3



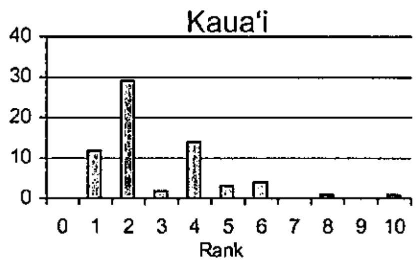


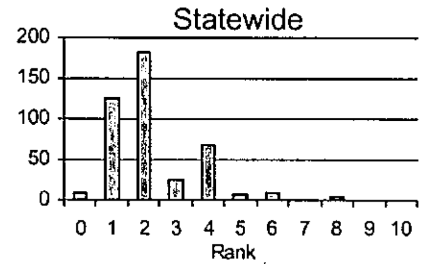
WATERSHED RATING (Cont): Waimea River, Kaua'i

Size Rating: Rating is based on the watershed area and total stream length. Larger watersheds and streams score more positively.

Watershed Rating

10

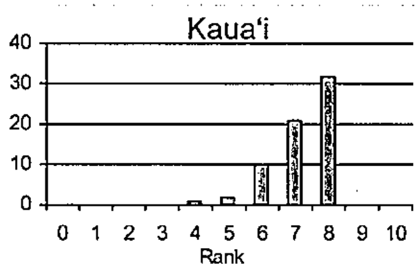


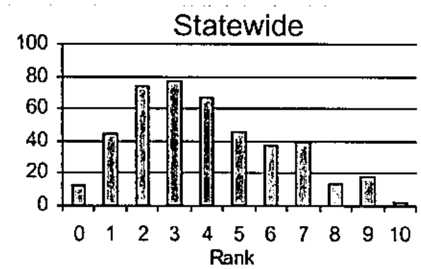


Wetness Rating: Rating is based on the average annual rainfall within the watershed. Higher rainfall totals score more positively.

Watershed Rating

4

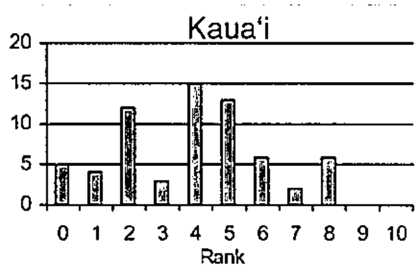


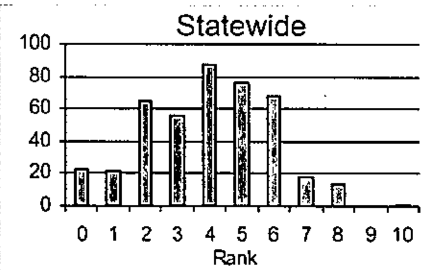


Reach Diversity Rating: Rating is based on the types and amounts of different stream reaches available in the watershed. More area in different reach types score more positively.

Watershed Rating

6

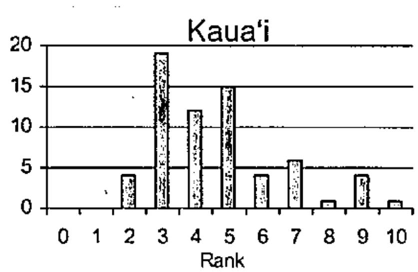


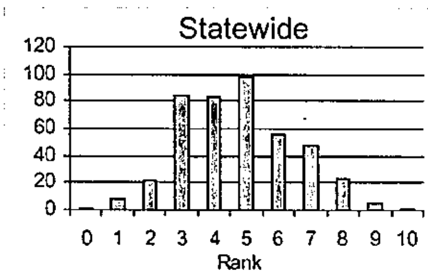


Total Watershed Rating: Rating is based on combination of Land Cover Rating, Shallow Waters Rating, Stewardship Rating, Size Rating, Wetness Rating, and Reach Diversity Rating.

Watershed Rating

9



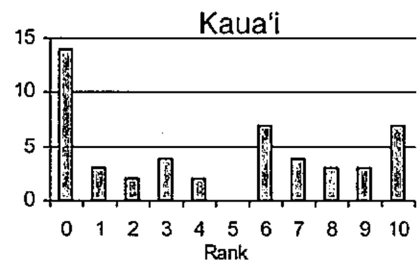


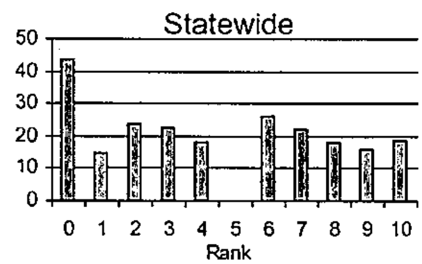
BIOLOGICAL RATING: Waimea River, Kaua'i

Native Species Rating: Rating is based on the number of native species observed in the watershed.

Stream Rating

10

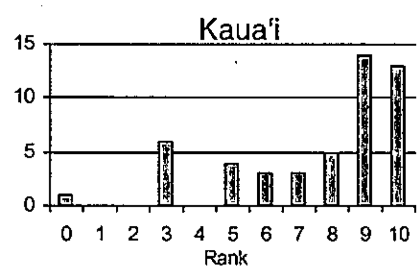


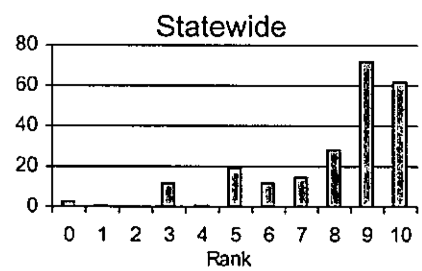


Introduced Genera Rating: Rating is based on the number of introduced genera observed in the watershed.

Stream Rating

3

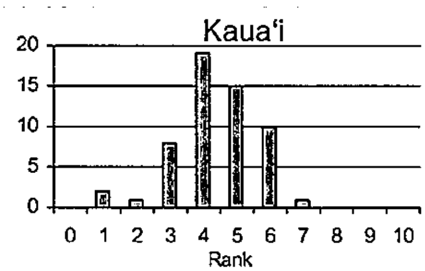


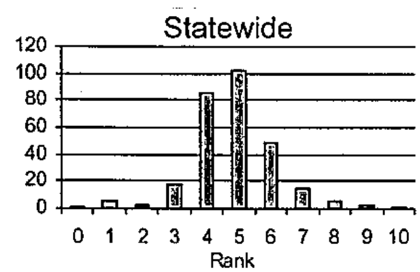


All Species' Score Rating: Rating is based on the Hawaii Stream Assessment scoring system where native species score positively and introduced species score negatively.

Stream Rating

7

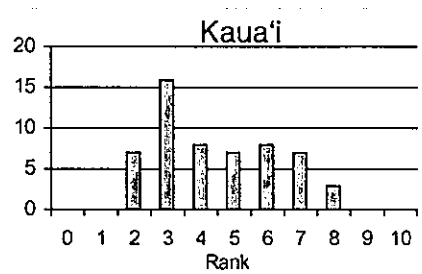


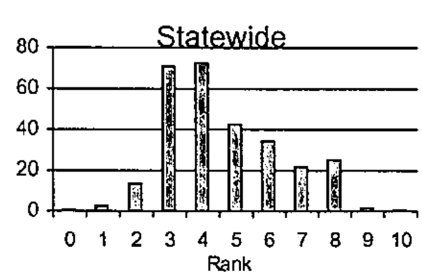


Total Biological Rating: Rating is the combination of the Native Species Rating, Introduced Genera Rating, and the All Species' Score Rating.

Stream Rating

6



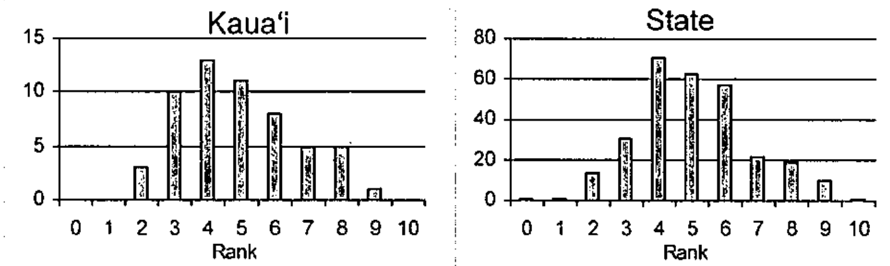


OVERALL RATING: Waimea River, Kauaʻi

Overall Rating: Rating is a combination of the Total Watershed Rating and the Total Biological Rating.

Watershed Rating

8

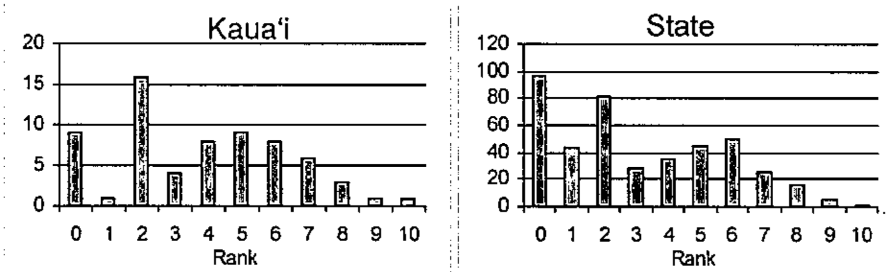


RATING STRENGTH: Waimea River, Kauaʻi

Rating Strength: Represents an estimate of the overall study effort in the stream and is a combination of the number of studies, number of different reaches surveyed, and the number of different survey types.

Information Rating

8



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Hawaii Stream Assessment

A Preliminary Appraisal of Hawaii's Stream Resources

Report R84

Prepared for

COMMISSION ON WATER RESOURCE MANAGEMENT
State of Hawaii

By

HAWAII COOPERATIVE PARK SERVICE UNIT
Western Region Natural Resources and Research Division
National Park Service

Honolulu, Hawaii

December 1990

EXHIBIT 2

Summary

The State Commission on Water Resource Management (CWRM) recognized the need for a broad-based collection of existing information on Hawaii's rivers and streams to help it make water protection and management decisions. The CWRM initiated the Hawaii Stream Assessment (HSA) through a cooperative agreement with the National Park Service's (NPS) State and Local Rivers and Trails Conservation Assistance Program. This program was established in response to the National Wild and Scenic Rivers Act, which encourages the NPS to assist states to consider needs and opportunities for establishing state and local wild, and scenic, and recreational river areas (Public Law 90-542, Section 11(a)).

The primary task of the HSA was to identify streams appropriate for protection. It makes no attempt to assess existing or potential offstream use. The HSA presents the conservation point of view.

The Hawaii Stream Assessment is to be used as a reference. The products are a physical inventory of Hawaii's 376 perennial streams and working maps; an assessment of resources associated with these streams; and a database.

The HSA will help policy-makers, resource managers, developers, scientists and the interested public to:

- Locate published information for a particular stream;
- Identify and prioritize areas where information is needed;
- Understand stream resources within a statewide context;
- Make management decisions based on data;
- Develop general stream resource protection guidelines;
- Identify specific streams appropriate for protection and enhancement.

This inventory and assessment is of a general nature, is incomplete, and does not take the place of any specific review and study normally required during the review process.

Study Process

The HSA consolidated considerable published information from diverse sources, data in government and private agency files, and, in some cases, information from knowledgeable people on Hawaii's streams and associated resources. The approach was modeled on a process developed by the NPS and used in more than 20 other states, but with certain modifications to meet Hawaii's unique needs. These modifications included 1) Streams were inventoried as complete units, as opposed to segments, and 2) Perennial was defined to include streams perennial in only part of their course.

Modifications

Water supply. Some beneficial offstream use of streams is addressed, in particular large agricultural companies identified their use of 125 streams and county water suppliers 34 streams for municipal water. A full inventory and assessment must wait for the completion of the water use certification process.

Dams and diversions. The HSA inventory of dams and diversions was of limited scope. While a list of approximately 100 of Hawaii's streams with dams or diversions along their course are presented, the water use certification will be the definitive source of information.

Hydroelectric power. Existing, proposed and potential hydroelectric power projects have been inventoried. There are currently 18 operating hydroelectric plants that supply 1.5% of Hawaii's electrical energy. Eight more projects have been proposed.

Channelization. Approximately 20% of Hawaii's streams, and almost all of Oahu's streams, have been lined or straightened or otherwise channelized according to data collected from several government agencies and reports.

Special Areas

This category includes areas identified as having natural or cultural resources of particular value. These include estuaries, embayments, wetlands, recovery habitats, special management areas, natural area reserves, wildlife refuges and sanctuaries, private preserves, national natural landmarks, historic sites, research and educational sites, parks, and waterfalls.

Resource Inventory and Assessment

Aquatic Resources

Hawaii's streams support a small but unique aquatic fauna most of which have a life cycle involving both the stream and the sea. Of the 176 streams with biological information, seventy were ranked as outstanding based on the presence of certain native species thought to be indicators of high quality habitat. While it is important to note that studies are more often undertaken in larger, high quality streams, HSA found a positive correlation between good aquatic resources and larger streams and a lack of stream modification.

Riparian Resources

While many riparian values may not be directly stream-related, the quality of the riparian environment directly determines the quality of the stream and the nearshore waters. Native species, native forests, waterbird habitat and wetlands were inventoried and assessed due to a lack of watershed information. Thirty streams were ranked outstanding.

Cultural Resources

Archaeological resources, historic sites and current taro cultivation were inventoried. Only archaeological resources were assessed due to a lack of consistent and reliable data. The committee identified 94 streams as sensitive or highly sensitive to development and

Table 9 Stream Size

(Limited to streams with gaging records)

CODE	HSA code; island-hydrographic unit-stream(system)	Stream sizes based on average or median discharge.	
STREAM	Stream name at mouth	Large streams	Median flows greater than or equal to 50 cfs or average flows equal or greater than to 80 cfs.
# GAGE	Number of gages on a stream	Medium streams	Median flows between 10 and 15 cfs or average flows between 20 and 80 cfs.
AVERAGE	Average of yearly mean flow (cfs)	Small streams	Median flows less than or equal to 10 cfs or average flows less than or equal to 20 cfs.
MEDIAN	Flow equalled or exceeded 50% of time		

Note: When a stream has more than one gaging station, the largest average and median flows were used. In some cases, tributary flows were combined to arrive at main stem estimates. See Table 8.

CODE	STREAM	# GAGE	AVERAGE	MEDIAN
Large				
2-1-14	Wainiha R.	3	138.00	79.0
2-1-15	Lumahai R.	1	117.00	67.0
2-1-19	Hanalei R.	8	212.00	130.0
2-2-08s	Wailua S.	8	238.56	110.0
2-3-07	Hanapepe	6	84.70	32.0
2-4-04s	Waimea S.	21	253.00	63.0
6-2-07	Waihee	1	82	?
6-2-09	Iao	1	65	43.0
8-1-44	Wailoa/Waipio	4	75	51.0
8-2-56	Honolii	2	125.00	38.0
8-2-60	Wailuku R.	6	84	59.0
Medium				
2-1-18	Waioli	1	31.60	20.0
2-1-25	Kalihiwai R.	1	47.70	32.0
2-2-01	Anahola	2	34.20	15.0
2-2-04	Kapaa	6	21.50	5.9
2-2-15	Huleia	4	28.00	10.0
3-1-16	Punaluu	4	17.70	12.0
3-1-18	Kahana	3	36.00	23.0
3-2-04	Waiahole	2		42.0
3-2-07s	Kahaluu S.	12	16.00	18.5
3-2-10	Kaneohe	6	14.00	11.0
3-4-04	Kalauao	3	24.40	25.0
3-4-06	Waiawa	2	32.60	7.3
3-4-10	Waikele	6	37.60	25.0
3-6-06s	Kiikii S.	13	32.00	14.9
3-6-07s	Paukauila	3	24.30	4.5
4-1-03	Waikolu	3	15.70	12.0
4-1-09	Pelekunu	9	40.70	8.3
4-1-15	Wailau	2	34.20	20.0
4-1-19	Kawainui	1	21.20	10.0
4-1-21	Halawa	1	29.20	14.0
6-1-11	Honokohau	2	39.40	24.0
6-3-14	Kailua	5	29.60	9.8
6-3-15	Nailiilihaele	2	35.50	17.0
6-4-01	Oopuola	3	38.40	2.5
6-4-04	Waikamoi	8	28.20	9.3
6-4-06	Puohokamoa	5	33.10	14.0
6-4-09	Honomanu	2	24.90	6.2
6-4-15	W. Wailuaiki	1	35.20	11.0
6-4-16	E. Wailuaiki	1	31.40	
6-4-17	Kopiliula	1	29.20	9.1
6-4-22	Hanawi	2	41.90	21.0
6-5-13	Oheo Gl	2	57.30	5.4
8-1-16	Honokane Nui	1		21.0
8-2-16	Pohakupuka	1	27.10	7.7
8-2-37	Kapehu	2	50.90	
8-2-39	Alia	1		12.0

Table 15

Hawaii's Waterfalls

(Best known falls are boldfaced)

Kauai

Hanakoa Falls (Hanakoa 2-1-07)
Hinalele Falls (Wainiha 2-1-14)
Puwainui Falls (Wainiha 2-1-14)
Keanaawi Falls (Hanalei 2-1-19)
Hoopouli Falls (Anini 2-1-21)
Waihunehune Falls (Kalihiwai 2-1-25)
Kilauea Falls (Kilauea 2-1-28)
Waianuenue Falls (Wailua System 2-2-08s)
Kapakanui Falls (Wailua System 2-2-08s)
Wailua Falls (Wailua System 2-2-08s)
Mana Waipuna Falls (Wailua System 2-2-08s)
Koholalele Falls (Wailua System 2-2-08s)
Opaekaa Falls (Wailua System 2-2-08s)
Halii Falls (Wailua System 2-2-08s)
Uhauiole Falls (Wailua System 2-2-08s)
Kapakaiki Falls (Wailua System 2-2-08s)
Ooiki Falls (Hanapepe 2-3-07)
Kahili Falls (Hanapepe 2-3-07)
Waipoo Falls (Waimea System 2-4-04s)
Mohihi Falls (Waimea System 2-4-04s)
Hihinui Falls (Waimea System 2-4-04s)
Oopulele Falls (Waimea System 2-4-04s)
Awini Falls (Waimea System 2-4-04s)
Moeloa Falls (Waimea System 2-4-04s)
Waialae Falls (Waimea System 2-4-04s)
Waikaka Falls (Waimea System 2-2-04s)

Oahu

Sacred Falls (Kaluanui 3-1-13)
Manoa Falls (Ala Wai System 3-3-07s)
Kahuawai Falls (Nuuanu 3-3-09)
Waipuhia (Nuuanu 3-3-09) (upside down falls)
Waihee (a.k.a. Waimea) Falls (Waimea 3-6-10)

Molokai

Haloku Falls (Haloku 4-1-11)
Oloupena Falls (Oloupena 4-1-12)
Wailele Falls (Wailele 4-1-14)
Kahiwa Falls (Kahiwa 4-1-18)
Hipuapua Falls (Halawa 4-1-21)
Moaula Falls (Halawa 4-1-21)
Mooloa Falls (Kamalo 4-2-14)
Haha Falls (Kamalo 4-2-14)
Hina Falls (Kamalo 4-2-14)

Aquatic Resources

Hawaiian streams support a small but unique aquatic fauna, including freshwater fish, mollusks, crustaceans, and insects. Although the diversity of native species in Hawaii's streams is low, most of those species are found only in the Hawaiian islands.

A number of these unique native stream animals have a life cycle involving both the stream and the sea. This type of life history, in which an animal lives its entire adult life in fresh water and its early larval period in the ocean, is called amphidromy.

The common perception among aquatic biologists is that Hawaii's native stream fauna is limited in abundance and distribution, however these characteristics are not well documented. Better understanding of the life history and habitat requirements of the native aquatic fauna is needed in order to manage the natural resources for their survival.

An inventory and assessment of Hawaii's native aquatic resources were needed to inform and assist managers of those resources. An advisory committee of aquatic biologists and resource managers was formed to obtain expert input on the design and development of such an inventory and assessment. The Aquatic Resources Committee was responsible for overseeing the inventory of the available information and the assessment of streams.

Although the habitat requirements of certain stream animals are not fully understood, the committee assumed that their presence indicated that conditions necessary for their survival were also present. Since at least some of the native species traverse or use the entire length of the stream in their life history, conditions on any part of the stream may affect these species. Therefore, the entire stream was considered important as a single unit and assessment of streams by segments was considered inappropriate.

An important first step for this inventory was a search of all available published literature, unpublished reports and field notes. The Board of Land and Natural Resources contracted with The Nature Conservancy's Hawaii Heritage Program to compile all the literature available on biological resources of Hawaiian streams. Personal observations were obtained from the committee and active aquatic biologists. A complete list of sources consulted is provided.

Available biological information for individual streams was entered on standardized data sheets, (Table 20) and then were entered into the HSA database.

The committee established assessment criteria to identify streams containing ecosystems with potentially high quality aquatic resources. They identified four key native species considered to be indicators of the health of the native aquatic ecosystem. The

Table 17 Aquatic Species Groups

Native Species Group One (NG1)

Scientific name	Hawaiian name	Type
Awaous stamineus	'O'opu nakea	Goby
Lentipes concolor	'O'opu hiukole 'O'opu alamo'o	Goby
Neritina granosa	Hihiwai	Snail
Sicyopterus stimpsoni	'O'opu nopili	Goby

Native Species Group Two (NG2)

Scientific name	Hawaiian name	Type
Atyoida bisulcata	'O'pae kala'ole	Shrimp
Eleotris sandwicensis	'O'opu okuhe 'O'opu akupa 'O'apu oau 'O'apu owau	Eleotrid
Kuhlia sandvicensis	Aholehole	Kuhliid
Macrobrachium grandimanus	'O'pae 'oeha'a	Prawn
Mugil cephalus	'Ama'ama	Mullet
Stenogobius genivittatus	'O'opu naniha	Goby
Theodoxus vespertinus	Hapawai	Snail

Introduced Species Group One (IG1)*

Scientific name	Common name
Cichlasoma nigrofasciatum	Convict cichlid
Clarias fuscus	Chinese catfish
Corbicula fluminea	Clam
Gambusia affinis	Mosquito fish
Macrobrachium rosenbergii	Malaysian prawn
Micropterus dolomieu	Smallmouth bass
Poecilia spp.	Guppy (Limia, Topminnow)
Tilapia (*Sarotherodon, Oreochromis*) spp.	Tilapia
Xiphophorous spp.	Swordtail

* *Macrobrachium lar* is excluded because it is believed to be present in nearly all Hawaiian streams

Introduced Species Group Two (IG2)

All those species not listed in IG1; considered innocuous or accidental.

Native Species Group 2 (NG2): The other seven native species considered more common comprised Native Species Group Two (NG2). These included two stream and two marine fishes, one shrimp, one prawn, and one snail. Presence of these species was considered to be typical of a healthy native stream ecosystem.

Introduced Species: The committee divided the introduced (non-native) species into two groups depending on their potential threat to native species.

Introduced Species Group One (IG1): This group included noxious, non-native stream animals that may prey upon and/or out-compete with native species. *Macrobrachium lar*. (Tahitian prawn), was not included in this group even though it may pose a threat to native stream animals because it is believed to be present in almost all Hawaiian streams. Thus, no stream is "pristine" and the presence of *Macrobrachium lar* cannot be used for comparing stream quality.

Introduced Species Group Two (IG2): This consists of the non-native species considered to be innocuous to Hawaiian streams.

Data Sheets: Available biological information compiled for each stream was summarized in a three-page data sheet (Table 20). These data sheets included the presence and abundance of both native and introduced species. When available, physical information was included. The total numbers of native species observed were then summarized by group (NG1 and NG2) and were this way used to rate the abundance and diversity of native species in the stream.

The second page of the data sheet contained information on presence and abundance of introduced species.

The Factor Summary Table on the third page of the data sheet noted the total number of native and introduced species, along with ratings for diversity, spawning and recruitment, habitat quality, dams, diversions and channelizations (Table 20).

Assessment

To assess and compare the biological quality of individual streams, the Aquatic Resources committee developed a ranking system based primarily on the presence and abundance of the four native species believed to be indicators of potentially outstanding habitat.

Little information is available on aquatic habitat. Because of the data available, almost the only criteria that seemed to be applicable broadly across most streams, were biological, i.e. based on presence and abundance of the various species. In large measure, this accounts for the specific criteria chosen for Outstanding (and other) categories.

Concern about the scarcity of *Lentipes concolor* seemed to make any stream where it is at least common a potentially very important resource, i.e. Outstanding.

Observation of egg mass or gravid females constitued evidence of spawning. While it is likely that frequent spawning by NG1 gobies occurs in many streams, not enough about their biology is known to say. Until or unless it becomes clear that there are many such

The Aquatic Resource Committee reviewed the initial rankings. In a few cases, where appropriate, it changed the rank based on personal observations as well as habitat quality.

Results

Inventory

Biological information was obtained for 178 streams, 45 percent of Hawaii's total of 376 streams. All except 18 of these studies were conducted on continuous streams. Of the total number of streams studied, 63 (K16, O28, Mo2, Ma12, Hi5) were surveyed since 1984, and 122 since 1974 (K36, O29, Mo5, Ma27, Hi25). NG1 species were found to be present in 111 of these streams. Only 6 streams had any records of spawning and only 16 of spawning and/or recruitment, possibly because these events are extremely difficult to observe.

The records of dams, diversions and channelization in the aquatic resources report were taken exclusively from the biological reports, although better sources for this information exist. The Hawaii Stream Assessment has more complete information about these modifications from other sources. Much of the literature suggested that the presence of these modifications may negatively affect native aquatic habitat. Modification information is included in the database for further correlation work. (Tables 7, 10)

Assessment

Of the 178 streams with biological information, 74 fulfilled the criteria for Outstanding. Breaking that down according to specific criteria, the results are as follows: *Lentipes concolor* was common in 44 streams. NG1 were abundant or very abundant in 47 streams (K12, O5, Mo4, Ma15, Hi11), and spawning of NG1 fish was observed in 6 streams. All four NG1 species were recorded in 20 streams. (K10, O0, Mo2, Ma 6, Hi2). Criteria B, which took diversity and habitat into account, was met by 12 streams.

Discussion

Continuous perennial streams are the principal habitat for native stream species. Extensive water development is incompatible with outstanding aquatic resources. The maps and data suggest that outstanding aquatic resources tend to be concentrated in the less developed areas, particularly the north shores of Kauai, Molokai and a small section of Oahu, and several areas on Maui. Survey coverage summarized in this report is geographically more complete for Oahu, Kauai and Maui than for Molokai and Hawaii.

While the concern about the viability of native aquatic species is high, scientific information to guide management efforts is limited. The Aquatic Resources committee endorses Robert Kinzie's expression of concern related to stream management:

> A serious deterrent to the formulation of rational management practices for native amphidromous species is the lack of knowledge of their population biology, larval life history, and genetic structure. Two possible extreme scenarios illustrate the problems involved. In the first instance, while a species may

18 Aquatic Resources

[illegible] HSA code; island-hydrographic unit-stream (system)

[illegible]KM Stream name at mouth

[illegible]K Aquatic Ranking determined by the HSA Aquatic Resources Committee

- L Outstanding
- M Moderate
- O Outstanding
- S Substantial
- U Unknown
- W Without

Alamoo
- Y oopu alamoo. Lentipes concolor, has been observed.

Nakea
- Y oopu nakea. Awaous stamineus, has been observed.

Nopili
- Y oopu nopili. Sicyopterus stimpsoni, has been observed.

Hihiwai
- Y Hihiwai. Neritina granosa, has been observed.

\# NG2 Number of NG2 species observed

\# IG1 Number of introduced species (IG1)

Year Last Year Last surveyed

\# Surv Number of surveys

Last Surv Year of most recent survey

* Rank changed from O on basis of degradation of habitat subsequent to studies

** Rank raised on basis of evaluation of habitat and data

*** Rank lowered from M on basis of habitat degradation

CODE	STREAM	RANK	Alamoo	Nakea	Nopili	Hihiwai	#NG2	#IG1	#Surv	Last Surv
Kauai										
2-1-01	Awaawapuhi	O	Y	Y	Y	Y	1		1	84
2-1-04	Kalalau	O	Y	Y	Y	Y	2		7	89
2-1-05	Pohakuao	O	Y				1		2	80
2-1-07	Hanakoa	O	Y	Y	Y		1	1	3	89
2-1-08	Waiahuakua	O	Y				1		2	80
2-1-09	Hoolulu	L					1		2	80
2-1-10	Hanakapiai	O	Y	Y	Y	Y	2	1	12	89
2-1-11	Maunapuluo	O	Y	Y	Y	Y	1		4	89
2-1-12	Limahuli	O	Y	Y	Y		2		5	89
2-1-13	Manoa	S	Y	Y	Y		1		1	89
2-1-14	Wainiha R.	O	Y	Y	Y	Y	6	3	11	89
2-1-15	Lumahai R.	O	Y	Y	Y	Y	7	1	10	89
2-1-16	Waikoko	W							1	78
2-1-17	Waipa	S		Y			3	1	2	66
2-1-18	Waioli	S		Y	Y		3	1	1	66
2-1-19	Hanalei R.	O	Y	Y	Y	Y	6	5	7	86
2-1-20	Waileia	M		Y					1	89
2-1-21	Anini	M		Y			6	3	5	89
2-1-25	Kalihiwai R.	O		Y	Y	Y	6	2	5	79
2-1-26	Puukumu	M		Y			1	1	3	89
2-1-28	Kilauea	M		Y		Y	7	5	5	89
2-1-29	Kulihaili	S		Y	Y	Y	5	1	1	79
2-1-30	E. Waiakalua	S		Y	Y		3		1	79
2-1-31	Pilaa	L					1		1	79

CODE	STREAM	RANK	Ala-moo	Nakea	Nopili	Hihi-wai	#NG2	#IG1	#Surv	Last Surv
2-1-32	W. Waipake	W							1	79
2-1-33	E. Waipake	S				Y	6		1	79
2-1-34	Moloaa	L					4	4	1	79
2-2-01	Anahola	O	Y	Y	Y	Y	4	3	4	89
2-2-02	Kumukumu	L					1	1	1	78
2-2-04	Kapaa	O	Y	Y			5	4	4	90
2-2-06	Waikaea Canal	U							1	79
2-2-08s	Wailua S.	M		Y	Y	Y	6	7	10	90
2-2-12	Hanamaulu	L					1	3	2	66
2-2-15	Huleia	O		Y			6	7	4	90
2-3-02	Waikomo	M		Y			2	4	2	90
2-3-04	Lawai	M		Y	Y		3	2	1	78
2-3-07	Hanapepe	M		Y	Y		4	3	3	78
2-4-03	Waipao	U							1	78
2-4-04s	Waimea S.*	M		Y	Y	Y	7	3	5	90
2-5-15	Milolii	O	Y	Y	Y	Y	2		2	84
2-5-16	Nualolo	O	Y	Y	Y	Y	3		2	84
				Oahu						
3-1-07	Kahawainui	L					1		1	84
3-1-09	Koloa Gl.	O		Y	Y	Y	1		3	90
3-1-10	Kaipapau	L					1		1	84
3-1-11	Maakua	L					1		2	84
3-1-13	Kaluanui	O	Y	Y	Y	Y	5	4	8	90
3-1-16	Punaluu	O		Y	Y	Y	5	4	7	89
3-1-18	Kahana**	O		Y	Y		7	6	13	90
3-1-19	Kaaawa	O		Y			1	2	1	84
3-1-20	Makaua	O		Y			1		1	84
3-2-01	Hakipuu	M		Y			2	3	3	84
3-2-02	Waikane	M		Y			5	3	4	84
3-2-04	Waiahole	M		Y			5	4	10	84
3-2-05	Kaalaea	M		Y			5	4	4	84
3-2-07s	Kahaluu S.*	M		Y			6	5	11	84
3-2-08	Heeia	M		Y			7	5	7	84
3-2-09	Keaahala	M		Y			4	4	5	84
3-2-10	Kaneohe*	M		Y			6	6	15	89
3-2-11	Kawa***	U						5	5	84
3-2-13	Kawainui/ Maunawili***	L		Y			1	5	8	84
3-2-14	Kaelepulu Canal	W						3	1	84
3-2-15	Waimanalo	M		Y			2	3	1	84
3-3-07s	Ala Wai S.	M		Y			7	6	6	89
3-3-09	Nuuanu	L					4	4	3	89

Riparian Resources

Streams are dependent on and affected by the physical and biological entities that surround them and compose their watersheds. No statewide inventory or assessment of Hawaiian watersheds has been conducted, even though their deterioration has been a concern since the turn of the century (Hall 1904, Judd 1931). This inventory has, therefore, concentrated on known stream-associated resources (e.g., rare, threatened and endangered species and communities, protected areas, wetlands, native forests) because of their intrinsic value and because their presence or absence provides an indication of the status of the watershed. This indirect approach to assessing watershed quality is very limited and identifies an important area where research is needed.

Riparian resources have been defined in U.S. mainland stream assessments to include everything within a strip extending either a quarter of a mile or 1,000 feet on each side of a stream or river. But an arbitrary fixed distance from the stream was considered inappropriate to define riparian resources in Hawaii. A Hawaiian stream may pass through narrow gorges, plunge down cliffs in excess of 2,000 feet and/or meander through broad flood plains during its short course to the ocean. Therefore, natural resources are considered riparian in this assessment if they:

- could affect the quality of the stream;
- could be affected by changes in stream management;
- were adjacent to and possibly dependent on the stream.

Many riparian resources in Hawaii have been addressed in a broad array of publications. The most comprehensive report, the U.S. Fish and Wildlife Service's (USFWS) Forest Bird Survey (Scott et al. 1986), includes distribution maps of various resources. Several databases have been compiled: wetland plants (USFWS 1989); wetland physical data (U.H. Environmental Center 1989); and rare plant distribution (The Nature Conservancy of Hawaii's ongoing Heritage Program). Government agency files and maps, particularly those of the USFWS and the state Division of Forestry and Wildlife, provided information on rare plants, weeds, vegetation type, etc. Data from all of these sources have been abstracted and incorporated into the inventory and assessment compiled by this project.

All of the categories of riparian resources inventoried for the assessment are biological/ecological. The committee considered for a time the inclusion of notable geologic features such as the exposures of pillow lavas at the base of Wailua Falls on the South Fork of the Wailua River and at the Menehune Ditch next to the Waimea River, both on Kauai. However, the committee decided that, on the one hand, the association of such features with the streams was insufficient to warrant their inclusion in the inventory and,

Table 28 Riparian Resources

CODE	HSA code; island-hydrographic unit-stream (system)	PLT RAR	Number of Rare Plants
NAME	Stream name at mouth		

DETRMTL

- **PLT** Detrimental Plants
  - C California Grass; H Hau; M Mangrove
- **ANL** Detrimental Animals
  - A Axis Deer; B Black-tailed deer; G Goats; M Mouflan; P Pigs; S Sheep

%NAT Percent Native forest

RH Presence of Recovery Habitat

BRD T&E Number of Threatened and Endangered Birds

PLT RAR Number of Rare Plants

WETLAND

- **E** Wetlands identified by Environmental Center or Elliott and Hall
- **FWS** Wetland identified by the USFWS
  - W Palustrine Wetland
  - W + Over 1/2 square mile of Palustrine wetland

PROTECT

- **PT 1** Streams partially protected due to the presence of a NARS, NPS or preserve.
- **TL Y** Streams protected from the headwaters to the sea

CODE	NAME	DETRMTL		%NAT	RH	BRD T&E	PLT RAR	WETLAND		PROTECT	
		PLT	ANL					E	FWS	TL	PT
Kauai											
2-1-01	Awaawapuhi	H	PGB	30			3				
2-1-02	Honopu		G	0		1					
2-1-03	Nakeikionaiwi		G	0							
2-1-04	Kalalau	H	PG	10			7		W		
2-1-05	Pohakuao		G	0			1				
2-1-06	Waiolaa		G	0							
2-1-07	Hanakoa		PGB	10			1				1
2-1-08	Waiahuakua		G	0			2			Y	1
2-1-09	Hoolulu		G	0			4			Y	1
2-1-10	Hanakapiai	H	PGB	40			3		W		1
2-1-11	Maunapuluo		G	0							
2-1-12	Limahuli	H	G	10			6		W +		
2-1-13	Manoa		P	0			1				
2-1-14	Wainiha R.	HC	P	30		6			W +		
2-1-15	Lumahai R.	HC	P	20	2	5		E	W +		
2-1-16	Waikoko		P	0							
2-1-17	Waipa	H	P	0	2	4			W +		
2-1-18	Waioli	HC	P	30		4			W +		
2-1-19	Hanalei R.	HC	P	30	2	5		E	W +		1
2-1-20	Waileia	H	P	0	2			E			
2-1-21	Anini	H	P	0							
2-1-25	Kalihiwai R.	H	P	20		5		E	W		

CODE	NAME	DETRMTL		%NAT	RH	BRD T&E	PLT RAR	WETLAND		PROTECT	
		PLT	ANL					E	FWS	TL	PT
2-1-26	Puukumu		P	0		3			W+		
2-1-27	Unnamed		P	0							
2-1-28	Kilauea	H	P	20		3		E	W+		
2-1-29	Kulihaili		P	0							
2-1-30	E. Waiakalua		P	0		3			W		
2-1-31	Pilaa		P	0							
2-1-32	W. Waipake		P	0							
2-1-33	E. Waipake		P	0							
2-1-34	Moloaa	H	P	0		3			W		
2-1-35	Papaa		P	0		3			W		
2-1-36	Aliomanu		P	0					W		
2-2-01	Anahola	H	P	10		5		E	W		
2-2-02	Kumukumu	H	P	10		1					
2-2-04	Kapaa	H	P	20		5			W		
2-2-05	Moikeha Canal		P	0		3			W		
2-2-06	Waikaea Canal	H	P	0		4			W+		
2-2-08s	Wailua R. System	H	P	10	2	5			W+		
2-2-10	Kawailoa		P	0		1					
2-2-12	Hanamaulu	H	P	10		4			W		
2-2-13	Nawiliwili	HC	P	10		3			W		
2-2-14	Puali	HC	P	10		3			W		
2-2-15	Huleia	HC	P	10	2	4		E	W+		1
2-3-01	Kipu Kai		P	0		4		E			
2-3-02	Waikomo	H	P	10	2	3			W		
2-3-04	Lawai	HC	P	20		3			W		
2-3-06	Wahiawa	HC	P	30		3	3		W		
2-3-07	Hanapepe	HC	P	30		4	1		W+		
2-4-01	Mahinauli	HC	P	20		3			W		
2-4-02	Aakukui	HC	P	10		3			W		
2-4-03	Waipao	HC	P	30		3			W		
2-4-04s	Waimea R. System	HC	PGB	20		9	17		W+		
2-5-06	Kinekine Ditch			0	2	3					
2-5-07	Kaawaloa		PB	0	2	3					
2-5-08	Nahomalu		PB	10	2	3					
2-5-09	Kaulaula		PB	30					W		
2-5-10	Haeleele		PB	30			2		W		
2-5-13	Kauhao		PB	40		1					
2-5-15	Milolii	H	PB	60		1	6				
2-5-16	Nualolo	H	PB	50		1	4		W		1

Kipapa	Kipapa
Honouliuli	Honouliuli
Makaha	Makaha
Hawaii	
Kealakaha	Kealakaha
Mamalahoa/Hakalau	Hakalau
Mamalahoa/Honolii	Honolii
Mamalahoa/Pukihae	Pukihae
Keawe Street/Wailuku	Wailuku

Table 32 Streams used for Taro Cultivation

Greater than 50 acres

Waioli (2-1-18)
Hanalei (2-1-19)
Waihee (6-2-07)
Waiehu (6-2-08)
Piinaau (6-4-11)
Wailoa/Waipio (8-1-44)

10 to 50 acres of taro

Hanapepe, (2-3-07)
Waimea (2-4-04)
Punaluu (3-1-16)
Waiahole (3-2-04)
Kaalaea (3-2-05)
Kahuluu System (3-2-07s)
Honokohau (6-1-11)
Iao (6-2-09)
Honopou (6-3-08)
Hoolawa (6-3-09)
Hanehoi (6-3-11)
Waiokamilo (6-4-13)
Opelu (6-5-15)
Niulii (8-1-13)
Ninole (8-2-21)
Kahakuloa (6-2-03)

Up to 10 acres of taro

Limahuli (2-1-12)
Wainiha (2-1-14)
Waipa (2-1-17)
Anini (2-1-21)
Kilauea (2-1-28)
Anahola (2-2-01)
Wailua S. (2-2-08s)

Table 33 Cultural Resources

CODE HSA code; island-hydrographic unit-stream

STREAM Stream name at mouth

ARCHAEOLOGICAL

SURV COVR Extent of survey coverage

- C Complete
- P Partial
- L Very limited
- N None

PRE-DICT Abilities to predict what historic sites might be in unsurveyed areas.

- H Substantial information exist to assist prediction
- L Little or no information exists to assist prediction
- M All others

 # SITES Rough estimates of total number of archaeological sites

DENSITY

- H Continuous sites
- M Scattered clusters of sites
- L Very few sites

VALLEY Significance of valley as district using National Register of Historic Places Criteria

- A Pre-contact or early contact
- B Associated with important people or dieties
- C Excellent examples of site type
- D Contains important information
- E Contains culturally noteworthy sites

SENSI-TIVE Overall sensitivity of a valley based on density of archaeological sites and land disturbance.

- V Very high
- H High
- M Moderate
- L Low

OTHER

HIST SITE A historic or potentially historic resource has been associated with this stream (usually a bridge).

TARO Taro cultivation has been associated with this stream.

CODE	STREAM	ARCHAEOLOGICAL						OTHER	
		SURV COVR	PRE-DICT	# SITES	DEN-SITY	VALL-EY	SENSI-TIVE	HIST SITE	TARO
Kauai									
2-1-01	Awaawapuhi	P	M	9	H	ACDE	H		
2-1-02	Honopu	C	M	8	H	ACDE	H		
2-1-03	Nakeikionaiwi	N	M		H	ACDE	H		
2-1-04	Kalalau	P	H	26	H	ACDE	H		
2-1-05	Pohakuao	P	M	6	M	CD	H		
2-1-06	Waiolaa	P	M	6	H	CD	H		
2-1-07	Hanakoa	C	H	9	H	ACDE	H		
2-1-08	Waiahuakua	P	L	2	M	CD	H		
2-1-09	Hoolulu	N	L				H		
2-1-10	Hanakapiai	P	H	21	H	ACDE	H		
2-1-11	Maunapuluo	P	H	17	H	ACDE	H		
2-1-12	Limahuli	P	L	4	M	CDE	H		Y
2-1-13	Manoa	L	L	1	M	CD	H		
2-1-14	Wainiha R.	L	L	4	M	CD	H		Y
2-1-15	Lumahai R.	L	L	10	M	CD	H		
2-1-16	Waikoko	N	L						Y
2-1-17	Waipa	L	L	6	H	ACDE	H	Y	Y
2-1-18	Waioli	L	L	3	M	ACDE		Y	Y

CODE	STREAM	ARCHAEOLOGICAL						OTHER	
		SURV COVR	PRE-DICT	# SITES	DEN-SITY	VALL-EY	SENSI-TIVE	HIST SITE	TARO
2-1-19	Hanalei R.	P	M	15	H	ACDE	H	Y	Y
2-1-20	Waileia	P	M	2	L	AD	M		
2-1-21	Anini	L	L	2	M	D			Y
2-1-25	Kalihiwai R.	L	L	2	L	ACDE	M		
2-1-26	Puukumu							Y	
2-1-27	Unnamed	N	L		L				
2-1-28	Kilauea	L	L	1	L	ACDE			Y
2-1-29	Kulihaili	N	L		L		L		
2-1-30	E. Waiakalua	L	L	3	H	ACDE	H		
2-1-31	Pilaa	L	L	2	L	ACD	M		
2-1-32	W. Waipake	L	L	5	L	ACD	M		
2-1-33	E. Waipake	N	L		M				
2-1-34	Moloaa	N	L		L			Y	
2-1-35	Papaa	L	L	3	M	ACD	H		
2-1-36	Aliomanu	N	L		L				
2-2-01	Anahola	L	L	5	M	ACD	M		Y
2-2-02	Kumukumu	N	L		L				
2-2-04	Kapaa	L	L	2	L	CDE	M		
2-2-05	Moikeha Canal	N	L		L				
2-2-06	Waikaea Canal	L	L	2	M	CDE	M		
2-2-08s	Wailua S.	C	H	6	H	ABCDE	H		Y
2-2-10	Kawailoa	N	L		L				
2-2-12	Hanamaulu	L	L	1	L	D	L	Y	
2-2-13	Nawiliwili	N	L		L		L	Y	Y
2-2-14	Puali	L	L	1	L	BCDE	L		Y
2-2-15	Huleia	L	L	1	L	AD	L	Y	Y
2-3-01	Kipu Kai	N	L		L		L		
2-3-02	Waikomo	P	M	16	H	CDE	H	Y	
2-3-04	Lawai	L	L	6	H	CDE	H	Y	
2-3-06	Wahiawa	P	M	6	M	CDE	H	Y	
2-3-07	Hanapepe	P	M	8	M	CDE	H	Y	Y
2-4-01	Mahinauli	N	L						
2-4-02	Aakukui	N	L						
2-4-03	Waipao	N	L						
2-4-04s	Waimea S.	P	M	8	M	ACDE	H	Y	Y
2-5-06	Kinekine Ditch	N	L						
2-5-07	Kaawaloa	N	L						
2-5-08	Nahomalu	L	L	1	M	CDE	H		
2-5-09	Kaulaula	L	L	1	M	AD	H		
2-5-10	Haeleele	L	L	4	M	AD	H		
2-5-13	Kauhao	L	L	1	M	AD	H		
2-5-15	Milolii	C	H	24	H	ACDE	H		
2-5-16	Nualolo	C	H	25	H		H		

Recreational Resources

Water-related recreation is a part of life in Hawaii. Although beaches draw more users, stream-related recreation is also significant. It includes water-based activities such as boating and swimming, land-based activities such as hiking and camping, and less energetic ventures such as nature study or sightseeing. This is the first attempt to inventory and assess stream-related recreation in Hawaii.

A state Recreational Resources Committee was formed to design the recreation inventory and assessment. Members identified boating, camping, fishing, hiking, hunting, nature study areas, scenic views, public parks and swimming as the elements to be included in the inventory. They next identified two basic sources of information: 1) government documents and other published information such as guide books and maps; and 2) residents who were familiar with local recreational opportunities.

Regional committees were then established on each island and given responsibility for compiling an inventory for their respective islands, based on current uses and facilities. Members included representatives from state and local governments, hunting clubs, longtime residents, recreational user groups, and other members of the public who responded to a call for participation issued by HSA.

Island by island recreational inventories were then developed, using a modified U.S. Forest Service Recreation Opportunity Spectrum, or ROS classification. Assessment factors used to rank the streams were diversity of experiences, quality of the experiences, specific unique characteristics, and unique combinations of attributes. The regional committees ranked all streams for their islands as Outstanding, Substantial, Moderate and Limited/Unknown. Based on the list of 70 regionally outstanding streams, the state committee, using regional input, identified 18 outstanding streams statewide. Five of these are on Kauai, two on Oahu, three on Molokai, three on Maui and five on Hawaii. Several of these "streams" are actually large stream systems.

The results of this inventory and assessment are somewhat subjective in that they are related to the composition of the committees and their collective experiences. In addition, the inclusion of an experience in this study does not necessarily mean that it is one the general public can take advantage of. Rather it means only that it was identified by some user. Finally, this report should not be considered a complete and final inventory of stream-related recreational resources.

Assessment

Regional Assessment Results

The following table shows the number of streams ranked in each category by island.

Table 36. Distribution of Regional Assessment Ranks

	Outstanding	Substantial	Moderate	Ltd/Unknown	Total
Kauai	17	19	15	10	= 61
Oahu	7	30	15	5	= 57
Molokai	7	11	11	7	= 36
Maui	22	36	14	18	= 90
Hawaii	17	50	49	16	= 132
Total	= 70	= 146	= 104	= 56	= 376

State Assessment Results

The 70 Regionally Outstanding streams are shown on Map Set 7.

Table 37. Statewide Outstanding Streams for Recreation

Kauai

2-1-10 Hanakapiai
2-1-18 Waioli
2-1-19 Hanalei
2-2-08s Wailua System
2-4-04s Waimea System

Oahu

3-1-18 Kahana
3-6-06s Kiikii System

Molokai

4-1-15 Wailau
4-1-21 Halawa
4-2-04 Waialua

Maui

6-2-07 Waihee
6-2-09 Iao
6-5-13 Oheo

Hawaii

8-1-16 Honokane Nui
8-1-35 Waimanu
8-1-45 Lalakea
8-2-33 Kolekole
8-2-60 Wailuku

Discussion

Much land use planning is done island by island rather than statewide so that the regional assessment of streams is very important. It includes streams that are not only currently outstanding but also those that have the potential to be outstanding. Streams ranked regionally outstanding for recreation warrant consideration by local parks departments for recreational development and should receive extra scrutiny when non-recreational developments are proposed.

Streams that received votes from more than two regional committees are clearly significant. However, name familiarity may indirectly be a factor in the identification of these streams. Many of the streams that have associated state or national parks or wildlife refuges are on the list, as are those that have been the topic of public controversy. Parks and refuges are clearly identified and promoted for their facilities, educational opportunities and, indirectly, for the access they provide. Streams that have been in the public eye may be brought to the attention of the recreational user who then plans a visit.

The statewide outstanding streams are those considered the most outstanding by residents of that island. These streams deserve special protection and consideration for recreational development. Many of these streams are now associated with parks and those that aren't should be considered for park development, after giving due consideration to their aquatic and riparian resources.

Streams ranked highly for recreation tend to be correlated with high flow rates, and to a lesser extent with stream length. All of the largest 25 streams were ranked either Outstanding or Substantial. Only three of the 50 largest streams for which gaging data is available were ranked Moderate: Waikele, Oahu; Hapuaena, Maui; and Nailiilihaele, Maui. All except six streams of the 50 that are 10 miles or longer (based on the U.S. Army Corps of Engineers Headwaters survey), were ranked outstanding or substantial on the regional ranking scale.

Boating and natural experiences are rare throughout the islands. Streams with these resources tend to be included in the list of outstanding and important streams.

Hunting was initially considered stream-related, but later that relationship was questioned. Hunting may occur along a stream, but the quality of the experience is not directly affected by the stream. It is rather related more to the abundance of animals, physical access, and other factors. In addition, hunting is often incompatible with other stream-related recreational activities.

Limitations to Inventory

The methodology used to create this inventory is by its nature subjective and dependent on the individual members of the committee and their experiences. The regional committee chairs were nominated by the state committee from among their personal and professional acquaintances. Then, these regional chairs chose their own members using state committee guidelines. Others were identified through HSA press releases. The committees, as a result, differed in composition, expertise and size. A different committee may or may not have arrived at the same results.

Table 38 Recreational Resources

CODE	HSA code; Island-hydrographic unit-stream (system)	PLUS	Number of high quality experiences. * Number could not be calculated for stream systems.
STREAM	Stream name at mouth	REG	Rank assigned to the stream by the regional committee

OPPORTUNITIES

C	camping	H	Hiking
F	Fishing	S	Swimming
B	Boating	U	Hunting
N	Nature Study	V	Scenic Views
P	Parks		

REG rankings: 1 Outstanding, 2 Substantial, 3 Moderate, 4 Limited, P Potential

REG — Rank assigned to the stream by the regional committee

EXP — Number of experiences (opportunities categorized by Recreational opportunity spectrum. * Number could not be calculated for stream systems.

STATE — Statewide Outstanding streams
1 Outstanding

CODE	STREAM	OPPORTUNITIES	EXP	PLUS	REG	STATE
Kauai						
2-1-01	Awaawapuhi	HFSPUV	8	1	2	
2-1-02	Honopu	SPUV	5	0	2	
2-1-03	Nakeikionaiwi	CHFSPUV	10	3	1	
2-1-04	Kalalau	CHFSPUV	9	9	1	
2-1-05	Pohakuao	HSPUV	6	1	2	
2-1-06	Waiolaa	HSPUV	6	0	2	
2-1-07	Hanakoa	CHFSPUV	8	6	1	
2-1-08	Waiahuakua	HPUV	6	4	2	
2-1-09	Hoolulu	HPUV	6	4	2	
2-1-10	Hanakapiai	CHFSPV	8	5	1	1
2-1-11	Maunapuluo	HPV	4	0	3	
2-1-12	Limahuli	HSNV	7	2	2	
2-1-13	Manoa	CPUV	5	0	2	
2-1-14	Wainiha R.	CHFSBUV	8	3	1P	
2-1-15	Lumahai R.	CHFSBUV	7	2	2P	
2-1-16	Waikoko	V	1	0	3	
2-1-17	Waipa		0	0	4	
2-1-18	Waioli	HFSBUV	9	3	1P	1
2-1-19	Hanalei R.	CHFSBPUNV	15	8	1P	1
2-1-20	Waileia		0	0	4	
2-1-21	Anini		0	0	4	
2-1-25	Kalihiwai R.	CHFSBUV	8	2	2	
2-1-26	Puukumu	V	1	1	2	
2-1-27	Unnamed		0	0	4	
2-1-28	Kilauea	CHFSBUV	10	8	1P	
2-1-29	Kulihaili		0	0	4	
2-1-30	East Waiakalua	F	1	1	2	
2-1-31	Pilaa	F	1	1	2	
2-1-32	West Waipake	F	1	1	2	
2-1-33	East Waipake	CHFU	4	3	2	
2-1-34	Moloaa	U	1	0	3	

CODE	STREAM	OPPORTUNITIES	EXP	PLUS	REG	STATE
2-1-35	Papaa		0	0	4	
2-1-36	Aliomanu		0	0	4	
2-2-01	Anahola	FSBUV	7	0	2	
2-2-02	Kumukumu		0	0	4	
2-2-04	Kapaa	HFSBUV	8	1	1	
2-2-05	Moikeha Canal	FS	2	0	3	
2-2-06	Waikaea Canal	FSBP	4	0	2	
2-2-08s	Wailua System	CHFSBPUV	0	0	1	1
2-2-10	Kawailoa	F	1	0	3	
2-2-12	Hanamaulu	CFBPV	5	0	2	
2-2-13	Nawiliwili	SPNV	4	0	3	
2-2-14	Puali	CFP	3	0	3	
2-2-15	Huleia	HFSBPUV	10	3	1	
2-3-01	Kipu Kai	CHUV	6	6	2	
2-3-02	Waikomo	HPUV	4	0	3	
2-3-04	Lawai	HFSUNV	9	4	2	
2-3-06	Wahiawa	HFSUV	7	5	1	
2-3-07	Hanapepe	HFSBUV	14	8	1P	
2-4-01	Mahinauli	U	1	0	3	
2-4-02	Aakukui	U	1	0	3	
2-4-03	Waipao	U	1	0	3	
~~2-4-04s~~	~~Waimea System~~	CHFSUUBPV	*	*	1	1
2-5-06	Kinekine Ditch		0	0	4	
2-5-07	Kaawaloa		0	0	4	
2-5-08	Nahomalu	U	1	1	3	
2-5-09	Kaulaula	U	1	1	3	
2-5-10	Haeleele	U	1	1	3	
2-5-13	Kauhao	U	1	1	3	
2-5-15	Milolii	CHFSPUV	9	2	2	
2-5-16	Nualolo	CHFSPUV	9	5	1	

Oahu

CODE	STREAM	OPPORTUNITIES	EXP	PLUS	REG	STATE
3-1-03	Paumalu		0	0	2	
3-1-04	Kawela		0	0	4	
3-1-05	Oio	U	1	0	3	
3-1-06	Malaekahana	HU	2	0	3	
3-1-07	Kahawainui	CFSPU	6	0	2	
3-1-08	Wailele Gl.		0	0	4	
3-1-09	Koloa Gl.	CHSPUV	6	3	1	
3-1-10	Kaipapau	SU	2	0	2P	
3-1-11	Maakua	CHFSPV	6	2	1	
3-1-13	Kaluanui	CHFSPUV	11	4	1	
3-1-16	Punaluu	CHFSPU	8	0	2	
3-1-18	Kahana	CHFSBPUNV	14	10	1	1
3-1-19	Kaaawa	FPU	3	0	2	
3-1-20	Makaua	HV	2	0	3	
3-1-21	Unnamed		0	0	4	
3-2-01	Hakipuu		0	0	4	

Table 40 Resource Assessment Summary

CODE	HSA Code; island-hydrographic unit-stream (system)
STREAM	Stream name at mouth

Resource Ranks

Aquatic, Riparian, Cultural, Recreational resource ranks. Streams with unknown resources are not ranked.

- O Outstanding
- S Substantial
- M Moderate
- L Limited

CODE	NAME	AQU	RIP	CUL	REC
Kauai					
2-1-01	Awaawapuhi	O		O	S
2-1-02	Honopu			O	S
2-1-03	Nakeikionaiwi			O	O
2-1-04	Kalalau	O	S	O	O
2-1-05	Pohakuao	O		O	S
2-1-06	Waiolaa			O	S
2-1-07	Hanakoa	O		O	O
2-1-08	Waiahuakua	O		O	S
2-1-09	Hoolulu	L	S	O	S
2-1-10	Hanakapiai	O	S	O	O
2-1-11	Maunapuluo	O		O	M
2-1-12	Limahuli	O	S	O	S
2-1-13	Manoa	S		O	S
2-1-14	Wainiha R.	O	S	O	O
2-1-15	Lumahai R.	O	O	O	S
2-1-16	Waikoko	L			M
2-1-17	Waipa	S	O	O	
2-1-18	Waioli	S	S		O
2-1-19	Hanalei R.	O	O	O	O
2-1-20	Waileia	M	S	S	
2-1-21	Anini	M			
2-1-25	Kalihiwai R.	O	S	S	S
2-1-26	Puukumu	M			S
2-1-27	Unnamed				
2-1-28	Kilauea	M	S		O
2-1-29	Kulihaili	S		L	
2-1-30	E. Waiakalua	S		O	S
2-1-31	Pilaa	L		S	S
2-1-32	W. Waipake	L		S	S
2-1-33	E. Waipake	S			S
2-1-34	Moloaa	L			M
2-1-35	Papaa			O	
2-1-36	Aliomanu				
2-2-01	Anahola	O	S	S	S
2-2-02	Kumukumu	L			
2-2-04	Kapaa	O	S	S	O
2-2-05	Moikeha Canal				M
2-2-06	Waikaea Canal		S	S	S
2-2-08s	Wailua S.	M	O	O	O
2-2-10	Kawailoa				M
2-2-12	Hanamaulu	L	S	L	S
2-2-13	Nawiliwili			L	M
2-2-14	Puali			L	M
2-2-15	Huleia	O	O	L	O
2-3-01	Kipu Kai		S	L	S
2-3-02	Waikomo	M	S	O	M
2-3-04	Lawai	M		O	S
2-3-06	Wahiawa		S	O	O
2-3-07	Hanapepe	M	O	O	O
2-4-01	Mahinauli				M
2-4-02	Aakukui				M
2-4-03	Waipao				M
2-4-04s	Waimea S.	M	O	O	O
2-5-06	Kinekine Ditch				
2-5-07	Kaawaloa				
2-5-08	Nahomalu		S	O	M
2-5-09	Kaulaula			O	M
2-5-10	Haeleele			O	M
2-5-13	Kauhao			O	M
2-5-15	Milolii	O	S	O	S
2-5-16	Nualolo	O	O	O	O
Oahu					
3-1-03	Paumalu			S	S
3-1-04	Kawela				
3-1-05	Oio			S	M
3-1-06	Malaekahana				M
3-1-07	Kahawainui	L		S	S
3-1-08	Wailele Gl.				

Table 1 Candidate Streams for Protection

(Approach 2 Results: Streams that met either the diversity or blue ribbon criteria)

Code HSA Stream Code Island-Hydrographic Unit-Stream
Stream Stream Name

Diversity of resources: To meet diversity criteria a stream must be outstanding in 3 or more resource areas

- Aq Aquatic
- Cu Cultural
- Rc Recreation
- Rp Riparian

Blue Ribbon Resources: The few very best resources

- Aq Aquatic: Met 3 out of 5 criteria for outstanding
- Cu Cultural: Very high sensitivity, high density, predictability and sensitivity, or over 50 acres of taro cultivation.
- Rc Recreation: Statewide outstanding streams
- Rp Riparian: Met score of 7.

CODE	STREAM	DIVERSITY	BLUE RIBBON
Kauai			
2-1-04	Kalalau	AqCuRc	AqCu
2-1-07	Hanakoa	AqCuRc	
2-1-10	Hanakapiai	AqCuRc	AqCuRc
2-1-11	Maunapuloa	AqCu	AqCu
2-1-14	Wainiha	AqCuRc	Aq
2-1-15	Lumahai	AqRpCu	AqRp
2-1-18	Waioli	Rc	Rc
2-1-19	Hanalei	AqRpCuRc	AqRpCuRc
2-2-08s	Wailua S.	RpCuRc	RpCuRc
2-2-15	Huleia	AqRpRc	Rp
2-3-07	Hanapepe	RpCuRc	
2-4-04s	Waimea S.	RpCuRc	RpRc
2-5-16	Nualolo	AqRpCuRc	Rp
Oahu			
3-1-18	Kahana	AqRpCuRc	CuRc
3-2-13	Maunawili	RpCuRc	Cu
3-4-02	Halawa	Cu	Cu
3-5-05	Kaupuni		Cu
3-6-04	Makaleha		Rp
3-6-06s	Kiikii S.		Rc
Molokai			
4-1-01	Waihanau	Cu	Cu
4-1-03	Waikolu	AqRc	Aq
4-1-09	Pelekunu	AqRpCuRc	AqCu
4-1-15	Wailau	AqCuRc	CuRc
4-1-21	Halawa	AqCuRc	AqCuRc
4-2-04	Waialua	CuRc	Rc
Maui			
6-2-07	Waihee	AqCuRc	CuRc
6-2-08	Waiehu		Cu
6-2-09	Iao	Rc	Rc
6-2-10	Waikapu		Rp
6-4-11	Piinaau	AqRpRc	AqCu
6-4-18	Waiohue Gl.	RcAq	Aq
6-4-22	Hanawi	AqRpRc	AqRp
6-5-13	Oheo Gl.	AqRpRc	AqRc
6-5-24	Manawainui	AqCuRc	
Hawaii			
8-1-11	Halawa	Cu	Cu
8-1-15	Pololu	RpCuRc	RpCu
8-1-16	Honokane Nui	CuRc	Rc
8-1-35	Waimanu	RpCuRc	RpCuRc
8-1-44	Wailoa/Waipio	AqRpCuRc	RpCu
8-1-45	Lalakea	AqCu	CuRc
8-2-33	Kolekole	AqRc	Rc
8-2-56	Honolii	AqRpRc	Aq
8-2-60	Wailuku	RpRc	Rc
8-5-03	Waikoloa	Cu	Cu

Map 8

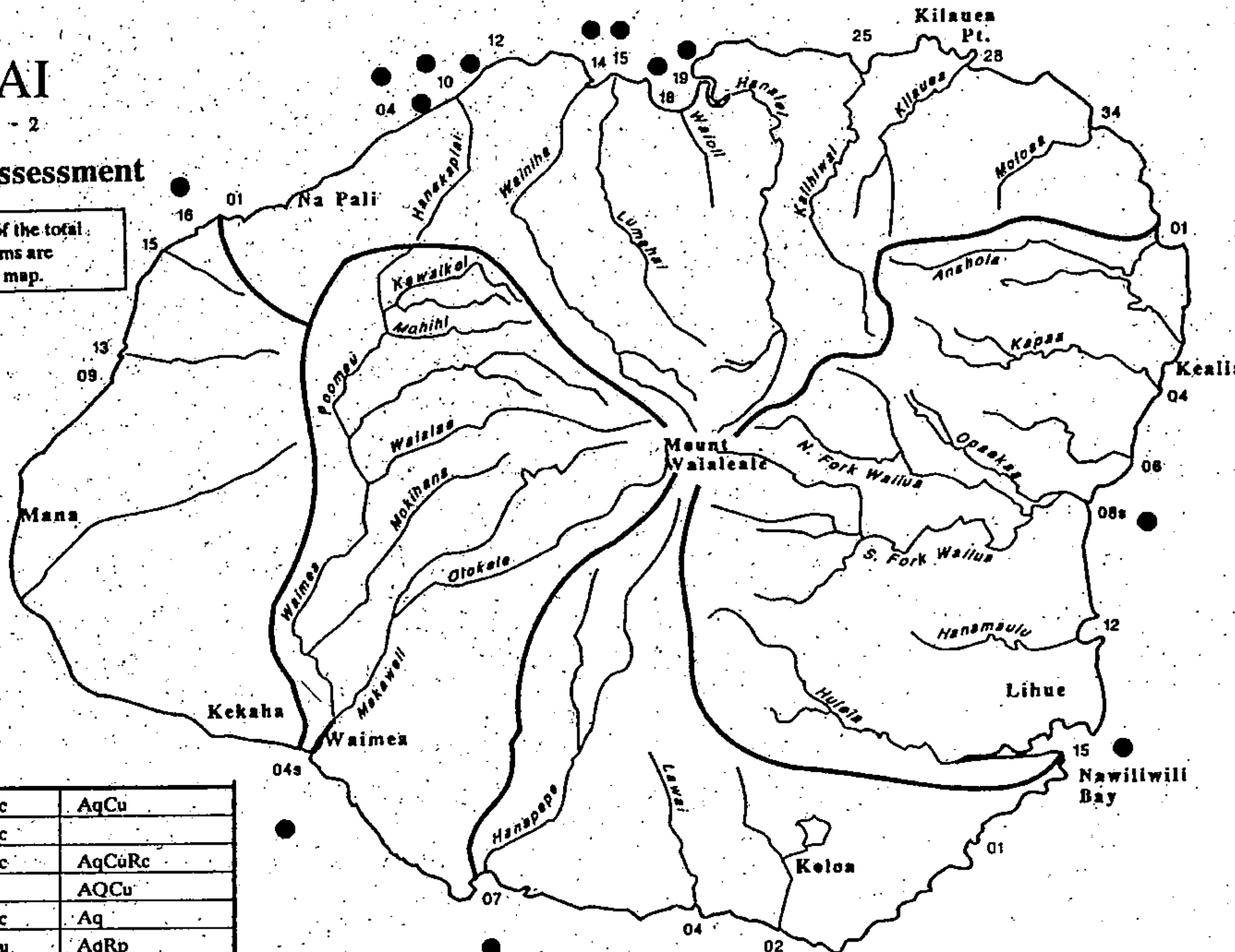
Candidate Streams for Protection

KAUAI

Island Code - 2

Hawaii Stream Assessment

Note:	Only a portion of the total number of streams are depicted on this map.



2-1-04	Kalalau	AqCuRc	AqCu
2-1-07	Hanakoa	AqCuRc	
2-1-10	Hanakapiai	AqCuRc	AqCuRc
2-1-11	Maunapuloa	AqCu	AQCu
2-1-14	Wainiha	AqCuRc	Aq
2-1-15	Lumahai	AqRpCu	AqRp
2-1-18	Waioli	Rc	Rc
2-1-19	Hanalei	AqRpCuRc	AqRpCuRc
2-2-08s	Wailua S.	RpCuRc	RpCuRc
2-2-15	Huleia	AqRpRc	Rp
2-3-07	Hanapepe	RpCuRc	
2-4-04s	Waimea S.	RpCuRc	RpRc
2-5-16	Nualolo	AqRpCuRc	Rp

Native Planters in Old Hawaii
Their Life, Lore, and Environment

E.S. CRAIGHILL HANDY and ELIZABETH GREEN HANDY

With the Collaboration of

MARY KAWENA PUKUI

BERNICE P. BISHOP MUSEUM BULLETIN 233

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EXHIBIT 3

which was only mildly brackish, was used for drinking water only. The elders were very strict about anything being thrown into any one of these springs.

Structure of Aqueducts

The typical irrigation ditches, large and small, were simply trenches made in the soil, from the dam in the stream to the *lo'i* area. One large ditch carried water for a number of *lo'i* tended by different planters. The *lo'i* adjoined the ditch and there were openings in the side of the ditch to let water into the *lo'i*. These were stopped with a stone or clod of grass and dirt when the water was cut off from a particular *lo'i* or group of *lo'i*.

Where water had to be carried around or along a hillside, on which terraces rose like steps on a steep gradient, the embankment beneath the ditch was often faced with stone part or all the way up. The base of the stone facing was made with large stones carefully fitted, and with smaller stones above. The stones are for the most part stream boulders. The walls slant outward at the base, and beneath the ditch level there is an earth fill. Such ditches are typical of Kalalau Valley on the island of Kauai.

Bennett in 1929 studied two ditches on Kauai that carried water around cliffs. There is one example far up in the Waimea Canyon, where water was carried for about 400 feet around a cliff face that juts out above the Koaie Stream. The stonework, as he describes it (W. C. Bennett, 1931, Site 38, p. 110), is in this case "well laid but not fitted," and rises in some places to a height of 20 feet, in others less, according to necessity, the space between the wall and the cliff face being filled in with earth and smaller stones. The top of the wall is finished with special care, with "large flat stones set on an inward slant toward the cliff," each stone overlapping "on the downward grade," and the whole spread over with earth.

The most notable aqueduct built by ancient Hawaiians was the so-called Menehune Ditch on Kauai, whose ancient name was Kiki-a-Ola (Water-lead-of-Ola). It is built around the base of a high cliff which hems in the Waimea River just before it reaches its delta area on the southwest coast of the island, and diverts irrigation water from the river to the series of *lo'i* to seaward of the cliff. These *lo'i* were observed and described by both Cook and Vancouver in the 1770's and 1790's (see Waimea in the section on Kauai, Part Five). W. C. Bennett (1931, Site 26, pp. 105-107) describes the Menehune Ditch in detail.

The problem that the builders of this aqueduct solved successfully was that of constructing a wall against the cliff face and down to the river bed that would remain intact against the force of the river when in flood. They solved the problem by cutting, on all but the inner sides, the large stones—some more than 3 feet long—with which the facing wall was constructed. Thus the wall offered a smooth surface to the river at all levels, while the

It was at Waimea on the southwest coast that early explorers were most impressed by the large spread of taro plantations watered by the famous "Menehune" irrigation ditch which carried water around a cliff 24 feet above the river level. The construction of this aqueduct is attributed to the *Menehune*, the mythical little folk who were skilled in stonework, who worked at night, and were never seen by day. Attributing stoneworks to *Menehune* is equivalent to saying "origin unknown." Evidently, therefore, the development of the Waimea community and the *lo'i* that they cultivated on the delta where the river enters the sea was very early in the history of Hawaiian Kauai. In the canyon of the Waimea River there are old taro terraces and notable examples of native engineering extending back as far as eight miles into the interior. The lower end of the canyon, for several miles above the aqueduct, had wet-taro plantations. On the hillsides above the taro terraces were the low walled-in remains of sweet-potato patches.

Westward of Waimea, off Kekaha and beyond, there was very good offshore fishing, which would have provided the needed protein nutrition for the large population indicated by the agricultural development of the region.

OAHU

Prehistorically and historically, the area of densest population in all the Hawaiian Islands was that flanking Waikiki on the island of Oahu. Here the chiefs had their residences near the now famous beach and the offshore waters where conditions were ideal for their prized sport of surfriding. This in early times idyllic area was flanked by the great wet-taro lands of Manoa, and the area between that valley and the sea which was one continuous spread of taro land and fishponds; by Pauoa, Nu'uanu, Waiolani, Kapalama, and Kalihi; and by Moanalua and other cultivated lands farther to the west. It was purely coincidental that the harbor now named Honolulu—the best harbor in the islands for sailing ships, as it turned out—became the commercial center after European discovery, and that the town subsequently bordering it became the capital of the Hawaiian kingdom. Old descriptions and drawings of Honolulu show it to have been a very sparsely populated and quite barren terrain; the center of population was still Waikiki, whose beach and lagoon were ideal for outrigger canoes. Its waters, however, were not notable as fishing grounds.

Pearl Harbor (Pu'uloa), actually the finest harbor in the islands for modern purposes, was of interest to Hawaiian chiefs because it was rich in shellfish and had many fishponds and traps. There was only a moderate development of taro cultivation on lands adjacent to it—lands whose streams tapped a flank of the Ko'olau Mountain range having less altitude and hence less rainfall than that behind the lush Nu'uanu–Manoa area. But this, the district of 'Ewa, was nevertheless noted for the quality of its *poi* made from the *ka'i* variety of taro.

the ohias [mountain apples] were as large as breadfruit; they saw a fishpond within the land stocked with all kinds of fish of the sea with the exception of the whale and the shark.... The sugar cane grew until it fell over and rose again, the bananas fell scattering, the hogs grew until the tusks were long; the chickens until their spurs were long and sharp; and the dogs until their backs were broadened out.

Somewhere in the ocean beyond the horizon east of Waipi'o, Hawaii, was a mythical land named Uluka'a (Rolling-island). This was one of twelve islands "which can be seen, a cloud-like vision, with the other eleven islands, on the horizon at sunrise or at sunset." A royal castaway from Waipi'o found there "a large taro patch, the banks of which were covered with breadfruit, sweet potatoes, sugar cane, and bananas. The king eagerly partook of food and his beauty returned like the beauty of a young banana leaf" (Rice, 1923, pp. 19-31).

Famine was a local problem, brought about by sustained dearth of rain in leeward areas where subsistence depended upon seasonal rainfall; or, more rarely, it could result from a volcanic upheaval, such as occurred in Ka'u in 1868; or as a result of conflagrations known to have swept the whole countryside there at times during the 19th century. It is surprising that, in areas where famine occurred repeatedly, no systematic provision was made in anticipation of the recurrence of dearth. The reason may have been the existence, in the areas where sweet-potato crops occasionally failed, of a backlog of emergency supply in the forests and in the sea.

In the Marquesas, where provision against famine (which occurred not infrequently) was made by storing fermented breadfruit paste in pits in the ground, there were not the equivalent resources to be counted on: the hinterland was much more limited, and less rich; the sweet potato, ideally adapted to cultivation where there was little rain, was rarely planted; there was little irrigated culture of wet taro; and there were few streams and springs that could supply water for irrigation during rainless years. And, because of the precipitous coasts of these sunken islands, which lacked fringing and barrier reefs, there was less to be garnered along shore in the way of shellfish and seaweed than in Hawaiian waters.

Areas of Dearth

The areas of the Hawaiian Islands that are known to have been subject to famine are those leeward districts that would suffer drought if general precipitation from the trade winds were too light.

First we may mention the island of Niihau, just off the dry leeward southwest coast of Kauai, and so low that under normal conditions it caught little rainfall. The fishing grounds were always there, and the population was not very numerous, but when severe drought did occur the people on this almost treeless island had no recourse except to seek temporary relief with relatives on southwest Kauai.

In similar case, these people of the adjacent arid shores of Kauai were better off than it might seem. Fishing was supremely good along the northwest Napali coast and excellent even in the southwest coastal waters, owing to the currents coming around the island. Also fresh-water fish were abundant in the great streams (Waimea, Makaweli, and Hanapepe) which drained the boggy uplands of central Kauai. That island, being quite old geologically, was blessed with very large streams.

From Waimea through Kekaha to Mana on western Kauai, the area was one in which there was normally scanty rainfall. Irrigated taro was grown on the flatlands below Waimea Canyon and in Kekaha, which had springs and marshy taro lands, and there was some taro in the swampy areas of Mana and Waieli. But the people here depended largely on sweet potatoes. To what extent these could be watered by hand or irrigated is not known, but there must have been long periods of dearth, during which the uplands offered much less in this area than on the eastern and northern sides of the island.

On Oahu there were three areas subject to drought. One was the southwest end of the island from Palolo (the last of the wet taro valleys) to Hahaione. The place name Ka-imu-ki, meaning "the-*ti*-oven," refers to a time of drought when a great ground oven was made for steaming roots of the *ti* (*ki*) plant, which was one of the emergency foods gathered in the uplands there. A second area extended from La'ie, at the northern tip, westward to Waialua. Normally La'ie had ample wet taro, but the streams and springs gave scant water in periods of drought. From La'ie northwestward the mountains are low and the precipitation is much less than it is to the southeast where the windward coast is flanked by the high Ko'olau range. The coast from La'ie to Waialua has little in the way of offshore fishing, lacking as it does the good beaches, reefs, and lagoons that are found from Hau'ula to Kane'ohe on the Ko'olau or windward side. Nor was much available in the leeward uplands, compared with Maui and Hawaii.

The third dry area on Oahu was the coast along the leeward flank of the Wai'anae range, from Makua to Nanakuli. Only Wai'anae Valley supported a number of areas where wet taro was planted, watered by streams from the Wai'anae range, streams whose flows were probably constant owing to the high bogs on top of the mountains. Here in Wai'anae Valley was the only village to be seen along this coast when the area was visited by Vancouver. Along the rest of the coast he reported seeing only "a few straggling fishermen's huts" and "a small grove of shabby cocoanut trees." It is probable that there was also a village up Makaha Valley, where the taro terraces are still to be seen, having been in use up to fairly recent times. Undoubtedly there were also small settlements subsisting mainly on sweet potato, in the valleys where constant streams were lacking (Nanakuli and Makua). Along this coast the fishing is excellent. In famine times, then, there was reef fishing, fact that Kauai has all the appearance of an old land in comparison with those of the island chain to the east and south. Its interior mountains are less rugged and its streams have carved out real river beds.

The ancient Kauai volcano was a roughly circular dome which stood slightly higher than the present summit of the island. The island still has the roughly circular outline, but collapse, faulting, erosion, and later volcanism have affected its surface profoundly ... erosion has deeply dissected the dome, or faulting and collapse have dropped large segments far below their original levels (Macdonald *et al.*, 1960, p. 15).

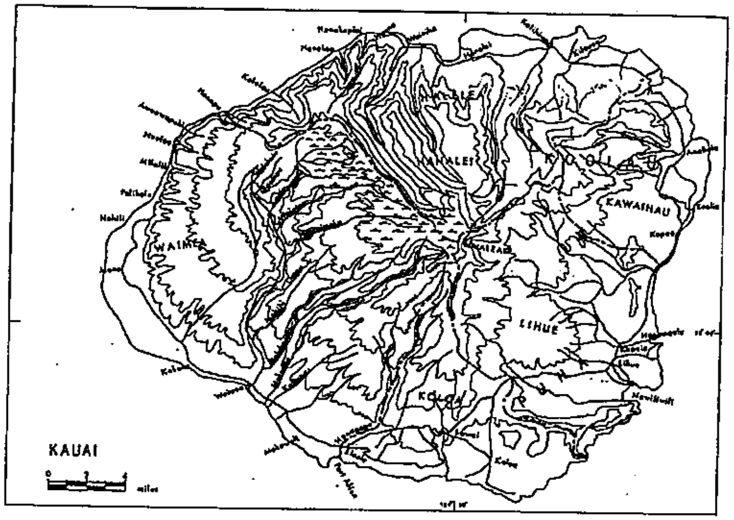


FIGURE 25.—Island of Kauai.

The most spectacular example of this is seen in relation to the original Waimea Dome whose summit is now named Mt. Wai'ale'ale, and whose principal drainage system flows down along the course of the Waimea Fault, in turn draining the "Makaweli depression" adjoining. "The high west wall of Waimea Canyon is an eroded fault scarp which is the west boundary of the [Makaweli] depression" (Macdonald *et al.*, 1960, p. 15). Almost directly across the island, on the eastern coast, another such depression (termed the Lihue depression) occurred, resulting in an almost circular basin hemmed in by the central Wai'ale'ale massif to the west, the Ha'upu volcanic ridge to the south, and the Makaleha mountains to the north. To the east the basin opens out, past a low ridge, to the sea (Macdonald *et al.*, 1960, p. 94, and Plate 10B, p. 122). This faulting and depression resulted in the most favorable harbor on the island, Nawiliwili Harbor, with the island's principal port city, Lihu'e, now lying behind it.

The Kalalau and Wainiha Faults along the northern boundary of the original volcanic caldera (named the Olokele Caldera by geologists) are responsible for the next most characteristic features of this island's physical aspect—the rugged north and northwest coast, marked by sheer sea cliffs and narrow, nearly inaccessible gorges or valleys. Wave and stream erosion have also played their part (Macdonald *et al.*, 1960, pp. 88-89).

Waimea, the Kauai Type Area

Waimea Canyon is the longest, deepest, and most complex of a number of valleys that have been eroded by large streams and drain the plateau of Mt. Wai'ale'ale, on which more than 450 inches of rain fall annually. The lavas and basalts of the original volcanic dome which erupted from the sea in late Tertiary times are termed by geologists the Waimea Series. We have chosen Waimea as our Type Area. Since it is actually a type locality geologically, so it is ecologically for our study.

Originally the island of Kauai consisted of deep eroded valleys radiating from the central dome. Of these valleys Waimea, Makaweli, Olokele, and Hanapepe on the southwest, Kalalau, Wainiha, Lumahai, and Hanalei on the north and east, are the original drainage troughs of the primary dome. On the south and east side, the ancient drainage valleys of the original dome have been filled in by flows from two later volcanoes, which erupted after a long period of quiescence and valley formation on the sides of the original dome. The first of these dates from Tertiary times. Ha'upu, or "Hoary Head," south of Lihu'e town and Nawiliwili Harbor, is what remains of the crater wall of the first of these subsidiary volcanoes. According to Stearns (1946, p. 87):

The Haupu volcanic series is the remains of an independent volcano about 2,300 feet high on the side of the ancient Waimea Volcano, and is similar to the position of Kilauea Volcano to Mauna Loa Volcano on Hawaii.

In the Pleistocene age another eruption occurred on the southern flank of the original dome, north, west and south of the Ha'upu caldera, in what is now the Koloa area. The basalts and lavas of this eruption geologists name the Koloa Series. The lava flows of this series continued down into Recent or post-Pleistocene times.

The Koloa volcanic series are correlative in composition, stratigraphic position, and age to the Honolulu volcanic series on Oahu, but are much more voluminous. They built a broad plain between Koloa and Kapa'a. Kilohana Crater is one of the largest vents (Stearns, 1946, p. 87).

Kapa'a is an area on the east coast of Puna. Kilohana Crater is inland, to the west of Hanama'ulu Bay on the southeast coast.

The Wailua River stands as the only remaining drainage system of the great ancient dome on this eastern sector of Kauai and it has cut its way right through the later flows and over spectacular falls, before emptying into its narrow, indented bay south of Kapa'a.

The overlaying of the ancient valleys of the original Waimea Dome by these later eruptions explains the peculiar topography of south and east Kauai, which fixed severe limitations for Hawaiian wet-taro culture. Instead of the deep, broad valley bottoms characteristic of the geologically less complex Ko'olau (or windward) Oahu, both windward and leeward Kauai shore lines, from Wahiawa on the southwest to Kalihi on the north, consist of small indentations flanked by narrow valleys which offer relatively little land for terracing. Yet behind these there are innumerable pockets, within and above irregular valleys and streams, which were developed as *lo'i* areas. Hanalei *ahupua'a* alone, with its fine broad stream, has an extensive seaward valley bottom and delta area comparable to the many great taro valleys of Oahu.

The taro lands of Waimea, on the *kona* or southwest coast, were developed upon the broad delta below the mouth of the canyon described hereafter. This was feasible only after means were devised for bringing irrigation water at a sufficiently high level around the cliff on the west side of the canyon base. For the rest, interior valley planting in Waimea and the adjacent canyons of Olokele and Hanapepe was a matter of terracing small flats on the canyon floors, near the streams and high enough not to be washed away by the heavy floods which sweep down these canyons at times of heavy rain.

On the northeast, or Napali coast, facing the trade winds, Kalalau is the largest of these nearly inaccessible valleys. It is actually just the upper end of a great drainage trough running northeast from the Waimea Dome. Its lower valley floor has been largely washed away by the pounding of trade-wind surf action which followed submergence owing to a rise of the sea level when the glaciers in the polar ice cap melted and released their waters into the oceans, after the end of the Pleistocene age.

Waimea Canyon Area

The great Waimea Canyon, whose reddish-yellow (*mea*) river has carved out a course for itself over 2,800 feet in depth below its mountain rim, bisects the western third of Kauai approximately north to south (see Fig. 26). Its chief headwaters, the Po'omau (Many-heads), drain down from the Alaka'i Swamp, which lies above and behind the high back walls of the valleys of the Napali coast—the northwestern sea cliffs of the island. All the lower tributaries of the Waimea flow into the river from the eastern rim, where they in turn have carved out deep valley courses draining from the western slopes of

Kauai's central mountain, Wai'ale'ale. Known as "the wettest spot on earth," Mt. Wai'ale'ale is 5,080 feet in altitude; the western canyon rim is from 3,500 to 4,000 feet.

As may be guessed from the above, the western canyon rim is the more precipitous, with fewer gulches and no extensive watered valleys. The geologic fault which the canyon represents appears to have broken the western tip of Kauai almost apart from the original center of vulcanism on the island, inter-

Figure 26.—Detail map of Waimea Canyon area, Kauai.

cepting and draining off the abundant waters precipitated by the cloudy central peaks and leaving this western tip mostly barren and dry, save for the seasonal rainfall. The heights of the western rim are under verdant forest, but the ridges rapidly become barren and eroded as they slope down westward to the sea.

From this forested rim one looks down into the colorful, fantastically eroded depths of the upper canyon, with its red jutting cliffs and upstanding low peaks—low, that is, from this vantage point; and across into the steeply rising valleys whose greenery gives rise to a bluish haze hovering over the purple-red erosion. Up here the air is bracing at all times, often chill—cold in the winter months, even when the rains that blow down from Mt. Wai-'ale'ale are not drenching the *koa* and *lehua* forests and filling the canyon with mists.

Looking upcanyon from the rim, along the course of the Po'omau River with its numerous unseen tributaries—the Kauaikuana, the Kawaikoi, the Waiakoali streams, and the larger Mohihi River—and across to the twin-forked valley of the Koai'e, it is difficult to realize that this wild area could once have supported a sizable population.

For one thing there is the climate. On a summer's day the impression from above is as if the canyon below were simmering. Yet when actually in the canyon, following the river and the tributary watercourses, the atmosphere is cool and airy, for the canyon acts as a funnel for the winds gathered high at its head and draining down its eastward valleys from the high mountains.

In the second place, there is the question of water, that *sine qua non* of life and cultivation. Can there be enough in those rocky-looking gulches? That there is enough to support wild verdure is made clear even at this distance by the clumps of silvery-green *kukui* trees amid the darker foliage, marching up the valley courses that are within view. And following the windings of these valleys on foot, it becomes abundantly clear that there is adequate water and flatland near enough to water to have supplied extensive irrigated taro *lo'i*. Furthermore, the remains of such irrigation systems are still extant and visible—up the main course of the canyon itself, up the Wai'alae Valley, up the Koai'e at least five miles to the main fork (two-thirds of the way along the nine-mile length of the valley), and presumably to some distance up the Po'omau Stream, although there has been no recorded systematic exploration for planting and dwelling sites beyond these points.

W. C. Bennett (1931, p. 110) describes an irrigation ditch on the north side of the Koai'e River, which is well over eight miles in the interior. This ditch runs for about 400 feet around a cliff and is elevated from 3 to 20 feet above the stream bed, constructed with undressed but carefully fitted stones, the channel lined with overlapping flat stones. This indicates the development of irrigated cultivation far up into Waimea Canyon. The remains of this ditch were seen (summer, 1953) by an exploring party organized and led by Mrs. Ruth Knudsen Hanner for the Kauai *Hui o Laka*. The party likewise discovered taro *lo'i* walls far up the Koai'e stream course below the falls, and also house sites and the walls of a seven-terraced enclosure which was probably a healing or planting *heiau* for the local community. Terraced *lo'i* for taro and sites suitable for other cultivation were observed along the main Waimea stream wherever flatlands afforded tillable areas on either side of the river, and even as far as eight or ten miles inland—that is, from three to four miles above the present pumping station for the Kekaha Plantation ditch. Hunters have found terraces up as far as the Waipo'o Falls—four miles farther.

That most of these must have been dwelling as well as cultivation sites is to be expected from the fact that the distance inland along the river was considerably lengthened by the tortuous trail which, repeatedly blocked by sheer canyon walls, crossed and recrossed the river, making the trip in and out too arduous for frequent comings and goings between home and work site.

THE BACKLANDERS (KUA'AINA)

All these indications point to the almost settled certainty that Kauai's areas of canyons (including Makaweli, Olokele, and Hanapepe-Koula, to the eastward of Waimea) possessed in olden days something not known elsewhere in the Hawaiian Islands except in a very few localities: the anomaly of an inland (literally backland) population which had at best but infrequent contacts with the sea. In Waimea Canyon there was an estimated terrain of about 25 linear miles of varying width along watercourses on which irrigated cultivation was practicable. This estimate is based upon observed sites up the Wai'alae and Po'omau streams as shown on the topographic map (Fig. 26).

It is characteristic of this, as of other less wild and inaccessible inland areas, that every foot of land that could be leveled by terracing above the floodwater stage, and to which a ditch could bring stream water, was utilized for taro *lo'i*. It is said today by *kama'aina* (native "old-timers") that in these upland *lo'i* the green-stemmed *ha'o-kea*, a fast-maturing taro variety adapted to cold stream water and shallow soil, was grown. There is also a wild taro that grows in high inaccessible places in this region, and it is called *na-kalo-a-'Ola*, "the taro of 'Ola," who was an *ali'i* anciently ruling all the island, and whose name appears in many of the chants of old Kauai.

Above the areas capable of being flooded, on not-too-rocky hillsides and in leveled soil pockets, sweet potatoes were planted. It seems a likely assumption that the famous *mohihi* varieties, white and red, were originated hereabout in the eastern feeder canyon named Mohihi. It became a widespread favorite, and one well adapted to just such soil and climatic conditions.

There is plainly no question that, with these food staples and the various supplemental items which could be cultivated alongside, the canyon areas could have supported a large and very nearly self-sufficient population. That they did so is attested to not only by legend but by the extent of the terraced remains. Undoubtedly, as elsewhere, sugar cane (*ko*), bananas (*mai'a*), *'olena* (or turmeric) used as a yellow dye and also medicinally and for ceremonial purification, and the starchy food plant *pia* were cultivated around the edges of the patches; probably also *uhi*, the mountain yam, in wet gulches. Even the streamless gulches, large and small, on the eastern side of the canyon must have been damp most of the year, and in them wild bananas and *'awa*, the root yielding a favorite soporific drink, would have been found; probably also *wauke* and *olona*, the economic plants needed for making *tapa* cloth and fish-net and line fiber; perhaps even *ti*, with its innumerable economic and ceremonial uses, grew in the lower wet gulches. As in all moist upland valleys the *kukui* or "candlenut" tree flourished plentifully, furnishing its oily nuts for food seasoning (*'inamona*) and for light. In most valleys where the *kukui* grew the *'ulu* or breadfruit could be grown also. Down in the drier canyon bottom it is likely that gourds flourished on the hillsides above the small planting areas of taro.

There was no dearth of animal food. The streams abounded in shrimps (*'opae*) and the prized fresh-water fish, the *'o'opu* (guppy). Wild hogs ranged the canyons and wooded rims, and dogs would certainly have been raised here for food as in all other island communities.

The wild jungle fowl (*moa*) of the upland were certainly hunted for food, and doubtless domesticated. Other wild fowl included small birds, plover (*kolea*), migrant duck (*koloa*) and the heron. The wild goose (*nene*) seems not to have been found on Kauai.

Nor was the canyon community (more likely a series of communities) completely isolated. The present difficult down-river trail to the sea was formerly a good stone-paved one, and in addition there were other old lines of communication. Trails ascended the west walls at at least three points of fairly easy access: one now known as the Kukui Trail just below the juncture of the Wai'alae and the main stream; another nearly opposite the opening of the valley of the Koai'e. A third, starting far along the Waiahulu Stream (beyond the junction with the Po'omau), leads up to the forested rim region of Halemanu and Koke'e. There were also *lua*, or steep ascents, to the eastward uplands from all the main stream valleys mentioned above.

For these backlanders (*kua'aina*) the trails leading from the ridge between Koai'e and the Po'omau into the forested area of Halemanu and Koke'e joined to form "the way" (*ke ala*) along the Alaka'i Swamp and down to the sea. It was their closest route into the more populous valleys and beaches of Wainiha and Hanalei on the north coast, or to Kalalau and the neighboring narrow valleys of the rugged Napali coast to the northwest. The construction of this difficult road, which actually crossed a portion of the swamp on a "corduroy" of tree-fern trunks, is also attributed to 'Ola, the ancient *mo'i* of the island, and bore his name, Kipapa-a-'Ola. It was an achievement celebrated in chants along with the Kiki-a-'Ola, the famous aqueduct modernly referred to as the "Menehune Ditch."

Probably this northern coast, rather than that of Waimea and Kekaha to the west, was the backlanders' "shore." They would have had ample exchange items to bring with them, things seldom or never to be found in the lowlands, such as bird feathers for capes and helmets; *mokihana* berries for perfumed *lei; kukui* nuts; *olona* fiber; *'awa* roots (there are two places near the Alaka'i

Swamp trail called Ka-'awa-ko'o); the light wood of the *wiliwili*, much desired for outrigger floats; the fragrant sandalwood; *koa* wood for bowls and calabashes; unworked adz stones from the dike quarries still to be found (and recognizable by the stone chippings) along the canyon wall (these rough adzes to be ground and sharpened below); and not least important, the fine-grained wood of the *koai'e* or *koa 'oha*, highly prized for spears and paddles and shark hooks.

The *kua'aina* also had need of weapons, for which this typical wood of their uplands was best suited. For although there is traditional evidence of friendly relationship through occasional intermarriage with the coastal *'ohana* (extended family), there is likewise similar evidence of at least sporadic feuding between the communities of Waimea Canyon, Olokele Canyon, and the deep valleys next eastward along the southerly coast. These backland planters and hunters were doubtless of the stuff of mountain men the world over—they treasured their privacy and their independence and their rugged homeland, and were prepared to defend them against all comers. There is a rocky promontory at a narrow turn of the main canyon above and just opposite the inflow of the Koai'e which is said to have been a fort—strategically set to command both the mouth of the Koai'e and the upper reaches of the main canyon. Even lightly manned, such a vantage point could have repelled almost any threatened invasion.

On the heights of the west canyon wall and at the extreme northern tip (now a United States Coast and Geodetic Survey station) there is another jutting promontory, artificially flattened and with enough stone remains to indicate an ancient enclosure of considerable dimensions, with smaller terraced levels below, away from the canyon rim. It is thought to have once been a fort, since it offers a clear view in all directions from Waimea and Olokele Canyons to the summit of Mt. Wai'ale'ale, and would have been an excellent spot for fire or torch signaling. Below it is a grassy glade enclosing an old house foundation (*paepae*), probably a place of refuge for those using the overland trail into the forest and on to Kalalau or the Alaka'i Swamp. Old-timers know the spot as Hale (House), which would indicate a halfway house for travelers.

This site is just above the junction of the Koke'e road and the present road leading to Hale Manu (Bird Dwelling), where the pioneer Valdemar Knudsen built his mountain retreat (later the summer home of his grandson and namesake). Halemanu Valley was undoubtedly the ancient haunt of bird-catchers in summer, and named for the shelters (*hale*) which bird (*manu*)-catchers erected for their use during the snaring season. It is still verdantly forested with ancient *koa* and *'ohi'a-lehua* as well as the introduced eucalyptus, Australian wattle, silky oak, Tasmanian *koa*, and so on. Many native and new shrubs abound, including wild ginger (*'awapuhi*); and it is still the haunt of birds and jungle fowl. As it has a fine spring of water (very rare on this dry western rim, attracting birds of all sorts) which flows into the Waiahulu (Water-of-feathers) Stream, it would have been anciently (as it is today for a favored few) an ideal place for a seasonal sojourn, particularly if the business in hand was hunting fowl or snaring birds for their feathers. In famine time *kama'aina* would have come seeking out the roots of the wild morning-glory (*koali 'awahia*) and the *hapu'u* and *pala* ferns, which grow here.

FOREST OF THE WEST CANYON RIM PLATEAU[1]

This extensive forest which covers Halemanu, Koke'e, and in fact the whole upland region of the west canyon rim at altitudes of from 3,000 to 4,000 feet, deserves a fuller description. Its distinctive tone continues even today to be set by the predominance of the gray-trunked, silvery, crescent-leafed koa, massive and gnarled, and by the *'ohi'a-lehua* trees tall and stately in deep forest, with their darker green foliage and feathery red pompoms in the flowering season, and, on wind-swept crags, twisted into fantastic shapes like demonic animal forms.

Quite obviously the ancient forest has dwindled. There are still numerous *'ohi'a* stumps measuring 4 feet in diameter, mute evidence of the widespread felling of these giants for temple images long ago. The *'ohi'a-lehua* is a tree which lives to great age, and it seems likely that before cattle, goats, and wild hogs ranged these uplands, and ranchers began (since 1800) to seek out this durable wood for use as fence posts, there were many hoary trees of great size in this Koke'e forest. Still, today there are living trees more than 100 feet high.

Another characteristic growth along forest trails today is the tall bare stalk (maximum 40 feet) of the *kahalua* (a lobelia variety restricted to Kauai) with its broad crown of long fluted leaves fluttering in the wind. Its milky juice may here have been used as bird lime in snaring, as was the milky juice of the lobelia *'oha kepau* in other areas. The somewhat similar-looking but distinct *halapepe* is also found growing here. The *loulu*, the native palm, still survives in some areas of the forest even up to 4,000 feet elevation, although it is now rendered almost extinct because rats eat the seed of the fruit (*hawane*) after the birds have feasted on the outer flesh. Natives used to eat the unripe seed, and the fanlike leaves were used for thatch (Neal, 1948, pp. 85-87).

There are still occasional sandalwood trees found here where anciently there were so many. This is the *'iliahi*, prized by early Hawaiians for its scent; and later so much more prized by the kings who followed the first Kamehameha. Because of its money value in the China trade, the forests were

[1] See Appendix for plant identifications.

practically denuded of it. Hawaiians powdered the wood to perfume their *tapa* cloth, and used it also to scent coconut oil for use as an unguent.

The Kauai *kauila* (*Alphitonia ponderosa*, distinct from the *Colubrina oppositifolia* native to the island of Hawaii) is still found here and there, where once it abounded. It is a straight and stately tree often attaining a height of 80 feet, and its wood, very hard, very heavy and of a dark red color streaked with black, was used for spears and *tapa* beaters.

The beauty of this forest is enhanced by the twining green *maile* shrub, precious for making fragrant leafy garlands (*lei*), the *hoi kuahiwi*, and other vines that trail from the trees; by a dry gray lichen or ferny moss that covers many branches, and by the abundant ferns. Nor is color lacking. Of flowering plants, Rock (1913, p. 57) mentions the *iliau*, found on canyon rims and mingling its yellow flower heads with the taller blue flower clusters of the *Lobelia yuccoides;* the handsome bright blue bloom of another lobelia (*Cyanea leptostegia*), growing tall and palmlike along the upper stream courses—particularly the Wai'alae; the white begonia-flowered *ha'iwale;* and the *po'olanui*, a shrub with large drooping yellow flowers, a species of the common *ko'oko'olau* (beggar ticks) but found only on Kauai. The native white hibiscus —*koki'o keokeo*—is peculiar to Kauai and originated in this area.

Many shrubs formed a distinctive undergrowth in this ancient forest, and some still lend distinction amid many now prevalent introductions. The *'uki* is an herbaceous ground cover with notable violet-colored berries. *Popolo* is not properly a shrub, but a plant which grows large then dies down when its purple berries are harvested; Rock (1913, p. 57) names it *popolo-'ai-a-ke-akua* (food-of-the-gods); its young leaves were eaten as greens and used medicinally. But perhaps the most distinctive of the area are still the *mokihana* and *pukiawe*. *Mokihana*, whose wood, leaves, and berries carry a long-lasting anise fragrance which makes it sought after as a scent and for garlands, is peculiar to Kauai upland forests. *Pukiawe*, a ground growth in lower zones, is here a straggly shrub of 10 to 15 feet in height, tough, with tiny, brittle, blue-green leaves, covered in flowering season with a spectacular array of pink-white blossoms and berries colored from white through shades of pink to bright red. Its branches make a thick somewhat creosotish smudge, used in olden days by the *kahuna* for fumigation in connection with prayers to temporarily deprive an *ali'i* of his *kapu* quality (Rock, 1913, p. 366, quoting N. Emerson).

An idea of the great variety of foliage in this forest zone may be gained by the following list of species which Rock (1913) names as native to this particular locality—species still extant and once much more prolific before introduced varieties began to crowd them. This list (not exhaustive, and additional to those already described) includes the *'ohi'a-ha;* the *kalia*, a large tree which, some 57 years ago, Rock estimated to comprise 30 percent of the

Kauai forest; the *'ohe kiko'ola,* a tree peculiar to Kauai, marked by large whorls of glossy thick leaves and rose-colored flowers; the *ho'awa,* 30 to 40 feet high, with smooth white bark, growing at from 2,000 to 4,000 feet elevation; the *'a'ali'i-ku-makua,* a short tree with very hard heartwood and leaves used medicinally; the *'akia,* valued for its bark which furnished a strong fiber, and notable for its large bright-red poisonous fruits; the *uhiuhi;* the *a'e* or *hea'e;* the *'ala'a;* the *pilo'ula,* really a tall shrub; the *ahakea,* a sturdy tree that grows to 25 or 30 feet, and the rough-trunked *holio,* found with the *ahakea* in drier and less dense parts of the forest; the *pu-'aha-nui,* a dark, shiny-leaved shrublike tree that companions the *hahalua* along stream courses; the *koi* (*Coprosma kauaiensis* and also the related *Coprosma waimeae,* called *'olena* by natives because of its yellow wood but not to be confused with turmeric) which are shrublike in growth but classified as small trees sometimes 20 feet high, and found only on Kauai. Last to be named here is the important Kauai species of the *mamaki* (*Pipturus kauaiensis*), a small tree with broad white-backed leaves whose bark was anciently beaten into *tapa* cloth before *wauke* (paper mulberry) was brought in.

LOWER WAIMEA VALLEY

This part, below the Pumping Station and roughly six or eight miles inland along the Waimea River, probably in olden days constituted a community fairly separate from the upper reaches of the Koai'e and the Po'omau, even from the beautiful but steeply ascending valley of the Wai'alae, which joins the main Waimea stream about three miles above the Pumping Station. Doubtless this straggling riverside community had more contact with the southern and western coastal plains folk than it did with the upland and overland regions.

Archibald Menzies, ship's surgeon with the Vancouver expedition, wrote briefly (Menzies, 1920, p. 31) of his exploration of this area in 1792, after the canoe passage through the plantations watered from the "Menehune" aqueduct below.

> When we came to the meeting of the two streams [the Waimea and the Wai'alae?], we pursued the northwest branch [this would have been the main stream, the Waimea] for about a mile further, and then... were obliged to quit the canoe and landed in a small plantation economically laid out and richly cropped with the esculant vegetables of the country. The valley also became much narrower, and was on both sides hemmed in by high steep cavernous rocks of a most romantic appearance. Yet it seemed inhabited much higher up than we traced it.

Taro is still grown in some of the *lo'i* near the Pumping Station, by and for those who live there. Downstream and as far as the upper end of the present valley road, the terraces are generally abandoned; most of the water is taken higher up by the Kekaha Plantation ditch. The Omao and Mokihana

Streams come down through such precipitous valleys that it is doubtful if they were cultivated or inhabited to any extent in the upper reaches. W. C. Bennett (1931, pp. 23, 107) cites a quarry and a *heiau* in this area, and tradition says that blocks for the famed Menehune aqueduct and the *heiau* were quarried here.

NA KIKI-A-'OLA: THE "MENEHUNE DITCH"

Formerly the taro *lo'i* above the end of the river road and many still lower down were watered by the famous Kauai aqueduct anciently known as Na Kiki-a-'Ola, or water-lead of 'Ola, the *Ali'i* of Waimea; and more generally, according to legend, as the "Menehune Ditch," because of the difficult features of its construction and unusual workmanship. Vancouver (1798, Vol. 1, pp. 376-377) in his detailed description of lower Waimea Valley cultivation remarks upon this engineering feat with admiration:

> Most of the cultivated lands being considerably above the level of the river, made it very difficult to account for their being so uniformly well watered. The sides of the hills afforded no running streams; and admitting there had been a collection of water on their tops, they were all so extremely perforated, that there was little chance of water finding any passage to the taro plantations.... A lofty perpendicular cliff now presented itself, which, by rising immediately from the river would effectually have stopped our further progress into the country, had it not been for an exceedingly well constructed wall of stones and clay about twenty-four feet high, raised from the bottom by the side of the cliff, which not only served as a pass into the country, but also as an aqueduct, to convey the water brought thither by great labour from a considerable distance; the place where the river descends from the mountains affording the planters an abundant stream, for the purpose to which it is so advantageously applied. This wall, which did no less credit to the mind of the projector than to the skill of the builder, terminated the extent of our walk; from whence we returned through the plantations, whose highly improved state impressed us with a very favourable opinion of the industry and ingenuity of the inhabitants.

W. C. Bennett (1931, pp. 22-23) in his archaeological survey of Kauai, refers to the aqueduct as "the acme of stone-faced ditches" (see section, "Structure of Aqueducts" in Part One). It is clear from his description of the aqueduct as he saw it in 1928 that considerably more of this remarkable archaeological relic—certainly one of the most interesting, and perhaps historically the most significant, existing in the Hawaiian Islands—was to be seen in that year than is at present visible. Many of the cut stones have since been taken for a foundation for the Protestant Church in Waimea, and others may be recognized here and there in various modern structures.

Bennett prefaces his detailed description of the aqueduct by saying that of all the irrigation ditches studied, the "Menehune Ditch alone . . . has any record preserved of its construction—and that is a myth." He has reference, of course, to the tradition of the *Menehune,* the little folk believed to inhabit mountain and forest, who worked only in the nighttime and were never (or seldom) seen. And yet the first part of his statement is inexact, for most of the stoneworks of ancient Hawaii, including certain *heiau*, dams, roads, causeways, and aqueducts, are also attributed to the *Menehune*. These "records" from protohistoric times are often entirely specific in placing the event in the time of a given *ali'i*, whose name and reign identified the story for later generations (before the innovation of the calendar year).

Such was the case with the Menehune Ditch of Waimea. It is explicitly recorded in ancient chants of Kauai as having been built at the behest of 'Ola, high chief of Waimea, the same chief celebrated also for ordering the construction of the stone-paved road to Kalalau Valley, through or along the Alaka'i Swamp in the upper reaches of the canyon.

Of all the islands of the Hawaiian group, Kauai has always been noted as the early chiefdom of the *Menehune* folk, and there are more tales of their powers there than elsewhere. According to legend, they migrated to Kauai-o-Mano-ka-lani-po (Kauai-of-the-heavens-of-four-thousand-nights), the island to which a great chief, Mano-ka-lani-po had given his name. They came from out the Moana-nui-kai-o'o (Great-engulfing-ocean) and settled at La'au-haele-mai in the heights above Wainiha. Their numbers increased so fast that it was said there were not fish sufficient to feed all their numbers, except shrimp (*'opae*), which became their staple. They were said to be industrious, to cultivate food for themselves, and to occupy their prodigious strength and energies in building trails along the cliffs, still visible and still called Ke-ala-pi'i-a-ka-Menehune (The-climbing-road-of-the-*Menehune*). These "climbing trails" seem to have been particularly numerous in the general area with which we are concerned. From the steep valleys of the Napali coast, through Mana, up the north rim of the Waimea Canyon, through Koke'e to the Kalalau northwest lookout they built their trails, and "in the little hollows on the cliffs, they planted wild taro, yams, ferns, and bananas. No cliff was too steep for them to climb" (Rice, 1923, p. 35). Some of these taros, planted at 'Ola's request, grow still on the cliffs of Kalalau. They also built for the *mo'i* a huge *imu*, or ground oven, between Kalalau cliff and Waimea, called Kapu-ahi-a-'Ola, the Sacred Fire of 'Ola (Rice, 1923, p. 46). According to one story, the small hill called Pu'u 'Opae (near the larger Puka-Pele), on the north canyon rim about halfway between Halemanu Valley and Waimea town, was so named because here the *Menehune* were given their reward of shrimp (*'opae*) after completing a task set them by 'Ola. So great was their rejoicing that "the hum of their voices gave rise to the saying: *'Wawa ka Menehune i Puka-Pele ma Kauai, puohu na manu o na loko o Kawainui ma Ko'olaupoko Oahu'*: 'The hum of the voices of the *Menehune* at Pu'u-ka-Pele, on Kauai, startled the birds at the fishpond Kawainui, on Oahu'" (Hofgaard, n.d., pp. 10-11).

However fanciful the Hawaiian belief that in olden days a large population of *Menehune* folk lived in the mountains and valleys of Kauai and on occasion did the bidding of the *ali'i*, it remained for King Ka'umuali'i's census takers in the early 19th century to register 65 persons as *Menehune* amongst the 2,000 recorded inhabitants of Wainiha Valley! (Luomala, 1951, p. 12.) The 65 all dwelt at La'au, deep in the upper forested vastnesses of Wainiha and close to Mt. Wai'ale'ale and the Alaka'i Swamp, where their ancestors were reputed to have built a swamp trail of "sticks" for King 'Ola (Rice, 1923, p. 35). Ka'umuali'i was the last *mo'i* to rule independently over Kauai, and he died in 1824.

The clearest rendition of the Hawaiian legend of "King 'Ola's Water-lead" is to be found in William Hyde Rice's story of 'Ola in his collected *Hawaiian Legends*, published in 1923 toward the end of his long lifetime as a resident of Kauai. According to this story (p. 45) before 'Ola, whose name means Life, was born, the *Menehune* had for some reason left Kauai. When, at the death of his father, 'Ola as *mo'i* began to plan what would today be called "public works," his chief *kahuna* (expert), Pi, had to summon the *Menehune* back again.

> His ['Ola's] first thought was for his people whose troubles he well knew. They had a great deal of difficulty in bringing the water from the Waimea River down to their taro patches in the Waimea flats, as none of their flumes had lasted.
>
> Wishing to remove this trouble 'Ola consulted his *kahuna*, Pi, who gave him this advice: "Establish a *kapu* so that no one can go out of his house at night. Then I shall summon the Menehune to build a stone water-lead around the point of the Waimea River so that your people will always have an abundant water supply."
>
> 'Ola established the *kapu*. No man, woman, or child was to go out of his house at night. Then Pi summoned the Menehune to come from foreign lands and make the water-lead in one night.
>
> Beforehand Pi had arranged the stones in a cliff, every one of the same size and shape. From this cliff each Menehune took one stone which he called Ha'awe-a-Pi, the Pack-of-Pi, and placed it in the lead. This water course is still called Kiki-a-'Ola, and it has stood the floods of many years.

In lower Waimea Valley, on the east side of the stream as far as the junction of the Waimea and Makaweli Rivers, the old terrace lands which once benefited from the aqueduct were planted in 1935 mostly in rice and cane, with some truck and Chinese bananas for market. Where these two rivers join there are extensive flatlands below the cliffs, where most of the old terraces were, in 1935, still intensively cultivated in wet taro for the *poi* mills.

The Makaweli River, which flows from the eastern uplands into the Waimea River a little more than a mile inland from the sea, will be dealt with as a quite separate area, including its division, some five miles inland from its mouth, into upper Kahana Valley and the steep canyon of the Olokele, which drains the eastern end of the Alaka'i Swamp and the Kaumahaloa Forest.

Waimea Delta

There are a number of excellent early descriptions of the well cultivated area known as the Waimea Delta. Captain James Cook (1784, Vol. 2, pp. 225, 244) was the first white man to describe it:

> [The] moist ground, produces taro, of a much greater size than we had ever seen [in southern Polynesia]; and the higher ground furnishes sweet potatoes, that often weigh ten and sometimes twelve and fourteen pounds, very few being under two or three.
>
> What we saw of their agriculture, furnishes sufficient proofs that they are not novices in that art. The vale ground has already been mentioned as one continuous plantation of taro, and a few other things, which have all the appearance of being well attended to. The potato fields, and spots of sugar cane, or plantains, on higher ground, are planted with the same regularity; and always with some determinate figure; generally as a square or oblong; but neither these, nor the others, are enclosed in any kind of fence.

We have also some descriptions from the journals of officers who were with Captain Cook on this voyage. James King (Cook, 1784, Vol. 3, p. 116) writing of "Atooi" (Kauai) and particularly of Waimea Bay and Waimea Delta, says:

> Its productions are the same with those of the other islands; but the inhabitants far surpass all the neighbouring islanders in the management of their plantations. In the low grounds, adjoining to the bay where we lay at anchor, these plantations were divided by deep and regular ditches; the fences were made with a neatness approaching to elegance, and the roads through them were thrown up and finished, in a manner that would have done credit to any European engineer....

Five years later Nathaniel Portlock (1789, pp. 191-192) recorded his observations of the same scene in February, 1787:

> ...we proceeded up the valley (from Wymoa), attended by a number of the natives of both sexes, young and old, who behaved with the greatest hospitality and friendship, pressing me earnestly to go into every house we came to, and partake of the best fare in their power to give.... This excursion gave me a fresh opportunity of admiring the amazing ingenuity and industry of the natives in laying out their taro and sugar-cane grounds; the greatest part of which are made upon the banks of the river, with exceeding good causeways made with stone and earth, leading up the valleys and to each plantation; the taro-beds are in general a quarter of a mile over, dammed in, and they have a place in one part of the bank, that serves as a gateway. When the rains commence, which is in the winter season, the river swells with the torrents from the mountains, and overflows their taro-beds; and when the rains are over, and the rivers decrease, the dams are stopped up, and the water kept in to nourish the taro and sugar-cane during the dry season; the water in the beds is generally about one foot and a half, or two feet, over a muddy bottom; the sugar-cane generally in less water, grows very large and fine, and is a great article of food with the natives, particularly the lower class; the taro also grows frequently as large as a man's head, and is esteemed the best bread-kind they have...

Captain Vancouver's admiration (1798, Vol. 1, p. 170) was won by the perfection of the Waimea garden lands, despite the fact that he had already

seen much elsewhere in these islands to admire in the way of systematic horticulture.

> I proceeded along the river-side and found the low country which stretches from the foot of the mountains toward the sea, occupied principally with the taro plant, cultivated in much the same manner as at Woahoo; interspersed with some sugar-canes of luxuriant growth, and some sweet potatoes. The latter are planted on dry ground, the former on the borders and partitions of the taro grounds, which here, as well as at Woahoo, would be infinitely more commodious were they a little broader, being at present scarcely of sufficient width to walk upon. This inconvenience may possibly arise from a principle of economy, and the scarcity of naturally good land. The sides of the hills extending from these plantations to the commencement of the forest, a space comprehending at least one half of the island, appeared to produce nothing but a coarse spiry grass from an argillaceous soil, which had the appearance of having undergone the action of fire....

Vancouver's surgeon, Menzies (1920, pp. 28-29), a trained naturalist and good observer, was also much impressed with Waimea as he saw it in 1792.

> That [stream] which comes from the north-west [Waimea River] appears more considerable, as it is navigable for their canoes some way up. We walked to the confluence of these two streams [Waimea and Makaweli?] and found that the aqueduct which waters the whole plantation is brought with much art and labor along the bottom of the rocks from the north-west branch.... Indeed the whole plantation is laid out with great neatness and is intersected by small elevated banks conveying streams from the above aqueduct to flood the distant fields on each side at pleasure, by which their esculent roots are brought to such perfection, that they are the best of every kind I ever saw.

During the first quarter of the 19th century, just thirty-two years after Menzies left his account of the Waimea Delta, Hiram Bingham made a journey to Waimea (the "capital" of Kauai) to lend assistance to the lone missionaries then stationed there, Mr. and Mrs. Whitney. This was in May of 1824, the fifth year of the establishing of the Christian Mission in "the Sandwich Islands." At this time the "King" of Kauai, Ka'umuali'i—already a convert and a student, along with Queen Ka'ahumanu (widow of Kamehameha I) and other high chiefs at the main Mission school—was in Honolulu; but Waimea was his seat.

It is of interest to note how few external changes seem to have taken place here in the interval since the accounts quoted previously. A fort had been built by Russian fur traders (with the permission of the King of Kauai) on a point of land at the mouth of the river, and it was still standing, although the Russians had been ordered home by Kamehameha. Foreign trading vessels came more frequently and some of their trade items such as iron and tools were in use here and there. Lieutenant James King of Captain Cook's party had reported "about 60" thatched houses in the village and Bingham (1847) estimated "about four hundred habitations" in the lower valley, "including those on the sea-shore." But the natural scene was little altered, it would seem. Bingham's description (1847, p. 217) is of a very attractive spot:

To the spectator from the missionary's door, or from the fort, or either precipice, is presented a good specimen of Sandwich Islands scenery. On a calm and bright summer's day, the wide ocean and foaming surf, the peaceful river, with verdant banks, the bold cliff, and forest covered mountains, the level and fertile vale, the pleasant shade-trees, the green tufts of elegant fronds on the tall cocoanut trunks, nodding and waving, like graceful plumes, in the refreshing breeze; birds flitting, chirping, and singing among them, goats [an innovation] grazing and bleating, and their kids frisking on the rocky cliff, the natives at their work, carrying burdens, or sailing up and down the river, or along the sea-shore, in their canoes, propelled by their polished paddles that glitter in the sun-beam, or by a small sail well trimmed, or riding more rapidly and proudly on their surf-boards, on the front of foaming surges, as they hasten to the sandy shore, all give life and interest to the scenery.

A large proportion of the habitations above referred to were apparently in the upper delta or lower valley area, for he writes of them as being "beautifully interspersed" with "numerous patches of the nutritious arum" (taro), breadfruit and coconut trees, banana and sugar-cane plantings; and adds: "On each side of the valley, the country rises, with easy ascent, toward the interior, forming, at length, precipitous walls to the valley, or river-bed. . . ." The broad stream Bingham had previously described as "The beautiful river, formed of the limpid waters of two rapid streams, descending from the mountains in the north. . . ." Within a mile or so of the village it is "broad, deep, and silent" and "glides almost imperceptibly along, while the sportive fish leap out from its smooth surface, or play incautious around the native, angler's hook." At last it meets the dunes thrown up by the sea and, gathering force, cuts its narrow channel and so "its waters pass briskly into the sea."

Waimea Village and the Coastal Environs

Captains Cook and Vancouver, as quoted above, have commented upon the natural and cultivated beauties of the lower Waimea Valley and Delta (they did not penetrate into the canyon itself). With their aid it is interesting to attempt to reconstruct a partial picture of the seaside village whose people came out to greet those early explorers when their ships first came to anchor in Waimea Bay.

From the log of Lieutenant James King (1778), who was with Captain James Cook on the *Resolution* in late January of 1778, we learn that Waimea village was quite extensive, consisting of a compact group of "about 60" grass-thatched houses stretching along the beach west of the river mouth. Others were more widely dispersed over a distance of a mile and a half inland along both sides of the stream (this upper region of more scattered dwellings being undoubtedly the chief planting area). This inhabited area, extending to "where the Eastern direction of the Valley divides and diminishes in its breadth," was evidently observed as far as the junction of the Waimea and Makaweli Rivers, for King says that "down these valleys run the rivers, which pour at the foot of this steep hill, and run in one stream to the seaside overflowing the lowland and making the piece of water, where we filled our Casks."

Of the Makaweli side he says:

The Land to the Eastward of the river, & opposite the watery place is of a moderate height, gradually declining to the Seaside, whereas on the West side, there is a tolerable border of low land before it rises to the hills, the hills on both sides are not wooded for two miles inland, although the side slopes of the high mountains are tolerably wooded.

Returning to King's description of the coastal aspect of Waimea village, which stood mainly to the west of the river mouth rather than eastward toward the Makaweli Valley, we quote the following:

The soil of the Valleys is of a blackish colour intermix'd with sand, & the ground about the Village is cut with ditches of Water intersecting in different parts & roads which are carv'd & seem artificially made. In the dryer places were plantations of Plantains and the paper mulberry trees, kept very clean and in good order, there were but few Coconut trees & those small, with fewer bread fruit trees: The Soil of the higher ground was of a red colour'd stiff consistence & very good, but almost void of cultivation; there are now & then spaces of Potatoe beds & sugar cane, which however are generally in the Valleys. This higher ground is doubtless capable of cultivation, for the grass was very high; & we observ'd for a considerable extent it is clear of woods; this district they call Wy'maia, the Island Atoui; the larger one to the Westward, Neehow . . . & the smaller one Oreehoua & one we saw to Windw. Hoahoo.

KEKAHA

Apparently the members of Captain Cook's first landing party at Waimea in 1778 (where they replenished their ship's stores and water casks) did not explore to the westward of "Wy'maia" village along the steadily widening sea plain, although they later traded with the offshore islands of Niihau and Lehua ("Oreehoua") opposite this area. But nine years later Captain George Dixon (1789, p. 125), in command of one of the two expeditionary ships (Captain Portlock the other) sent out to continue Captain Cook's Northwest Coast explorations, did walk westward and observed a well-established settlement at Kekaha, just inland from what is now shown on the map as O'omano Point. He called it "A Tappa," and noted that the country through which he walked from Waimea Bay was "very dry," and the soil "light red," mostly covered with coarse grass.

A Tappa is a pretty large village, situated behind a long row of cocoa-nut trees, which afford the inhabitants a most excellent shelter from the scorching heat of the noon-day sun. Amongst these cocoa-nut trees is a good deal of wet swampy ground, which is well laid out in plantations of taro and sugar-cane.

The land thereabout, he observed, averaged about two miles in width between shore and mountains. Portlock (1789, pp. 170-171), walking along the westward sea plain a month or two earlier in search of a sheltered harbor

Wailua, like Waimea, was one of the two most important areas on Kauai. It was the seat of the ruling *ali'i* of the island when Captain Cook discovered it. At one time and another it shared this distinction with Waimea. Its importance is attested to by the fact that there were six *heiau* of prime importance here (Bennett, 1931, pp. 125-128). North of the Wailua River on the sandy plain below Ka-lae-o-ka-manu *heiau*, near a stone said to have been the sacred birthplace of Kauai's high chiefs, was an historically famous grove of coconut trees, which was also *kapu* because it was the place where the high *ali'i* had their homes. The *heiau* named Holoholoku was near the grove: to this *heiau*, tradition says, was brought the first "drum" (*ka'eke*) that came to Hawaii. *Ka'eke* or *ka'eke'eke* means, not drum, but bamboo pipes (Pukui and Elbert, 1957, p. 102) varying in lengths from one to several feet, open at one end, which were tapped on the floor or ground, giving out resonant, deep sounds like muffled xylophone notes. In Tahiti the *to'ere* is a split bamboo, which is tapped rythmically to accompany the *'upa'upa* dance, the equivalent of the *hula* in Hawaii. One wonders whether Holoholoku (Walk-erect) was not a *hula* shrine rather than a *heiau*, the place where the *hula* dancers of the ruling *ali'i* were trained.

Wailua has the largest river on Kauai and in the Hawaiian Islands, formed by the joining of two large streams. There is ample evidence of an abundance of coconut and breadfruit trees in former times. In 1935 this great *ahupua'a* was studied in detail and the following description was written (Handy, 1940, pp. 67-68).

Along the lower 2 miles of Wailua River, above the sandy coastal plain, are many broad, open, level areas, formerly in terraces, now mostly in sugar. Opaekaa Stream, which flows into tidewater Wailua River, watered many terraces both above and below the falls. The large area of terraces below the falls is now planted mostly in rice, a few of the upper terraces being used for sweet potatoes, while the uppermost are pasture. There are terraces in the canyon of the north fork of the Wailua River; presumably there are terraces also in the flatlands along Kawi, Keahua, and Iole Streams, which form the headwaters of this fork of the river. There were sizable terrace areas on both sides of the south fork of the river above the junction with the north fork. Extensive areas of terraces fill the valley immediately above Wailua Falls and along the river for 3 miles above Waikoko. Iliiliula, Waiaka, Waiahi, Kaulu, Palikea, and Halii Streams, which form the headwaters of the south fork of the Wailua River, undoubtedly all had small terraces along their lower courses. The flatland between the sea and Kalepa Ridge shows no traces of terraces, though it is probable that the swampy areas watered by springs were once used for wet taro.

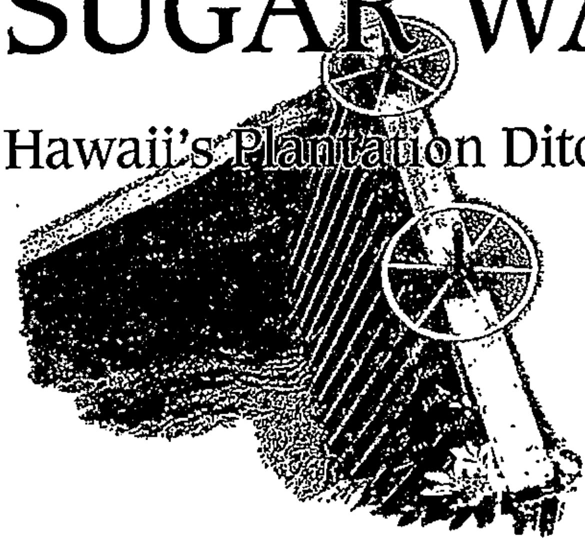
Undoubtedly much *wauke* and *olona* were grown, as well as yams, bananas, *pia*, and all the other cultivated plants. The streams and river were famous for shrimps and guppy fish, said to be the largest in the islands. And the forested interior was rich in all the trees and other plants treasured by Hawaiians: *koa*, sandalwood, fragrant *maile* and *mokihana* vines, and others.

South of Wailua there is a very large stream named Hanamaulu flowing

CAROL WILCOX

SUGAR WATER

Hawaii's Plantation Ditches



A Kolowalu Book
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EXHIBIT 4

them diverted essentially all the water from the Hanapepe River, so that the mouth of the river was usually dry. That balance—the allocation of that water between the two plantations—was upset with the construction of Koula Tunnel. By taking more water at the upstream diversion, the tunnel diminished the supply previously available to downstream user McBryde. McBryde sued Gay & Robinson. The Hanapepe Case resulted in the landmark 1973 Supreme Court decision in water rights commonly known as the McBryde Decision.

In 1994, Gay & Robinson announced that it was taking over Olokele Sugar Company—a surprising case of the minnow swallowing the whale that leads one to contemplate the power of controlling the water source.

WAIMEA SUGAR MILL COMPANY

In 1884, W. D. Schmidt, E. E. Conant, and G. B. Rowell, along with several other investors, leased land from the family of missionary George Rowell and incorporated the Waimea Sugar Mill Company. W. D. Schmidt was the majority stockholder and first manager. The Waimea Sugar Mill Company, with only 275 acres in cane by 1890, was a small one.

The Waimea Sugar Mill Company was irrigated with groundwater and water pumped from the swamps, which tended to be brackish. Excessive use of the groundwater, however, soon caused the water to become more saline. The shareholders' minutes of 25 February 1902 warned: "The obtaining of fresh water from the Waimea River seems to be the only plan of saving the plantation and continuing it, owing to the condition of its present water supply."

With assets of $41,000 and indebtedness to Castle & Cooke of $47,000, it would appear that Waimea Sugar Mill Company was not in a position to undertake a major development project. Nevertheless, it negotiated water rights with Gay & Robinson for $800 a year, as well as a right-of-way to the Waimea River for another $400. Engineer E. Tappan Tannatt estimated the cost of obtaining water from the Waimea River at $29,000. By December 1902, surveying for the new ditch had begun. The Waimea Ditch, later known as Kikiaola Ditch, was completed in September 1903 at a cost of $36,278. There were no tunnels along its almost 6-mile length. It delivered 5 mgd from the Waimea River to this small plantation.

Hans Peter Faye, Knudsen's nephew and manager of Kekaha Sugar Company, bought the Waimea Sugar Mill Company lands from the Rowells in 1904. Faye's interest in acquiring this small plantation was primarily for the right-of-way it had acquired from Gay & Robinson. As the acquisition of this right-of-way would seem to have been to Kekaha Sugar Company's advantage, it is curious that when Faye offered his holdings to Kekaha Sugar it was rejected. Thus Faye became owner of one plantation and manager of the other.

Although working in the water as pictured here might have been refreshing at times, this was not always the case. Occasionally, enormous flows were released into tunnels—as during the digging of the Waiahole Tunnel. The engineer reported "for the last three hundred feet the tunnel was a whirling rainstorm, a giant shower bath, a waterspout and a typhoon combined. From sides, roof and face the water spurted in continuous streams, in some instances with a force against which one could not stand." (Private collection.)

Faye was a gifted sugar planter: by 1910 he had paid off Waimea Sugar Mill Company's debts and was paying dividends. The freshwater supply from the Kikiaola Ditch made the critical difference. By 1910, this plantation was producing 7.25 tons per acre, a most respectable yield for the time. By 1915 Faye was sole owner of all 5000 shares of this company.

From 1914 to 1922, the manager of Waimea Sugar Mill Company was George R. Ewart, a Scot. In 1923 Ewart, an engineer, repaired and realigned Kikiaola Ditch and built tunnels to replace the iron flumes. Upholding the Scottish reputation for assiduous thrift, Ewart wrote that these repairs cost "something like $45,471.30."

In 1969 the Waimea Sugar Mill Company reorganized into the Kikiaola Land Company, leasing its ditch and cane lands to Kekaha Sugar. As Kekaha Sugar had its own ditch taking water from the Waimea River, it closed the Kikiaola Ditch from the source to the town, putting water back into the lowland section of the ditch for field irrigation.

KEKAHA SUGAR COMPANY

The lands of Waimea and Mana, on the west side of Kauai, were once vast marshlands. There were large villages of Hawaiians living at Barking Sands, and rows of thatched houses along the foothills. Hawaiians traveled by canoe from Mana to Waimea by way of an inland waterway. Although Hawaiians at some earlier time had attempted a ditch at Waiele in order to drain the marsh, they apparently abandoned the project when they struck sandstone.

Valdemar Knudsen started what was to become Kekaha Sugar Company in 1878. He held crown leases on Kekaha, Kokee, and Mana lands, marshy land that he initially sublet to small sugar and rice farmers. Noting the success of the fledging sugar industry elsewhere in Hawaii, he determined to try sugar in Kekaha. Knudsen widened and deepened the old Hawaiian ditch with pick and shovel, and by this means drained the marsh. He and Captain Hans L'Orange then planted sugarcane, using groundwater for irrigation.

Knowing that the groundwater supply was limited, Knudsen looked to the Waimea River. Considering the eventual success of this river as a water source, it is somewhat surprising that time and again the experts concluded that tapping the Waimea was not a viable option. The first of several feasibility studies was conducted in 1881 by G. N. Wilcox, though his recommendations do not survive. The second study, by an unidentified engineer in 1892, advised: "I am fully convinced that it is impossible to obtain a water supply from the Waimea River at a high altitude except at a cost which would be prohibitory as a business investment." Even at a lower elevation a ditch would cost $160,000 and a great deal in maintenance. "I cannot think," said this engineer, "that the scheme is likely to prove a financial solution of the water supply difficulty at Kekaha and certainly cannot recommend it as such." A third study by Jim Taylor in 1898 concluded yet again that such a project would be too costly.

Kekaha Sugar Company, Waimea Sugar Mill Company, and the small, independent rice and sugar growers in the area intensified their use of groundwater. In 1898, Kekaha Sugar installed a new 10-mgd-capacity Fraser and Chalmers pump. In the early 1900s, drought and overuse of groundwater ruined that supply for everyone. Within a few years the salt content had gone from 7 grains to 100 grains per gallon. The Mana well levels dropped 4 feet in four years. Although the plantations also had to contend with leaf hoppers, extremely hot weather, and a shortage of labor, their major problem was lack of water. The supply dropped from 23 mgd in 1904 to 17 mgd in 1905. Pumping one well caused others to fail. Crops were lost or simply not planted at all. Kekaha Sugar Company was forced to take a much more serious look at developing Waimea River water.

Kekaha Sugar Company had incorporated in 1898 with Hans Peter Faye as the new manager. Faye dramatically influenced the sugar industry during his forty-five years on the west side. He was born in Drammen, Norway, in 1859, came to Hawaii in 1880, and arrived on Kauai in 1882. Hans L'Orange was his brother-in-law, and Valdemar Knudsen his uncle. He started his career in sugar on land leased from Knudsen in 1884, and later purchased Rowell's Waimea lands, the Waimea Dairy, and, in 1906, gained control of the Waimea Sugar Mill Company. As manager of Kekaha Sugar Company for thirty years, he oversaw the construction of the Kekaha and Kokee ditches, supervised the reclamation of the marshlands, and is credited with major innovations in field practices.

Faye, impressed with the difference the fresh water supplied by the new Waimea (Kikiaola) Ditch was making at Waimea Sugar Mill Plantation, contracted yet another study. He hired engineer J. S. Malony to investigate the possibility of using the surplus water from the Kikiaola Ditch. Malony determined the supply insufficient, so he proceeded to survey the Waimea Valley at three different levels and concluded that a new ditch could be constructed at the 500-foot elevation at a cost of $130,000. This time it looked like a reasonable expense.

Started in May 1906 and finished in September 1907—and with the help of a new hydroelectric plant—the Kekaha Ditch was an immediate success. (This ditch was originally referred to as the Waimea Ditch and is variously known as the Waimea-Kekaha Ditch and the Kekaha Ditch, the name used here. The 1903 ditch built by Waimea Sugar Mill, also originally known as the Waimea Ditch, is here called the Kikiaola Ditch.) Once leases were arranged with the government and other Waimea landowners, the Kekaha Ditch was begun. The construction contract went to J. S. Malony, who hired James L. Robertson as supervisor. Originally the ditch was 20 miles long—16 miles on the *mauka* lands and 4 on the lowlands—and it was later extended another 8 miles. Water was taken from the Waimea River at an elevation of 550 feet. Most of the unlined ditches and tunnels were driven through hard rock and were unlined. A 2190-foot steel inverted siphon, since replaced, crossed the Waimea River.

Although the construction cost was estimated at $130,000, in fact it reached $240,000 to $290,000, not including the powerplant, a later extension, or repairs. The capacity was rated at 45 mgd, and average flow was 30 mgd. Four to five hundred additional acres above the ditch were put into cane, utilizing the hydropower to pump the water to the higher elevation. It was noted that the tunnels would have to be cemented if more land was put into irrigation. At this point the groundwater pumps, although kept in working order, were retired.

Ditches reached up into the Waimea mountains. While the sides were reinforced with cut stone to minimize erosion, the ditch floor was unlined. (Private collection.)

Labor raiding occurred to one degree or another on many plantations throughout Hawaii, although it was strongly discouraged by the sugar factors. It is within the context of building the Kekaha Ditch that we glimpse the beginning of such a struggle between Makaweli Plantation (Hawaiian Sugar Company) and neighboring Kekaha Sugar. Through correspondence between their respective managers, Ben D. Baldwin and Hans P. Faye, we learn that a struggle was well under way in 1905 and continued into the 1920s. In 1905, Faye complained to Hackfeld & Company, agents for Kekaha Sugar, that a great many of his men were leaving to take up favorable contracts at Makaweli. Since the Olokele Ditch was finished by then, this additional labor must have been used to expand the plantation's fields.

In 1906, Baldwin complained to his agent, Alexander & Baldwin, about the exodus of workers to Kekaha Sugar Company, which was then embarking on the construction of the Kekaha Ditch. A&B filed a forceful complaint with Kekaha Sugar's agent, Hackfeld & Company, which it relayed to Faye: "We have already advised you that Mssrs Alexander & Baldwin Ltd DID lodge a strong complaint with us in regard to your taking away men from the Makaweli Plantation and it appears that Manager Baldwin has greatly exaggerated the matter."[1]

Faye assured Hackfeld that he expected "to secure most of the laborers for constructing the new ditch without interfering with the other plantations." So Baldwin wrote directly to Faye:

> *You state that you do not want our men. Of course contractors will claim that men come from Honolulu, Hawaii, Waialua, G——, etc. and to a certain extent their claim is true, but when we sift this question down to the bottom we generally find that a great proportion of the men are taken from right under our noses here, however, I will not say anything further at this writing in regard to this subject, as you have assured me that you will prevent as far as possible the taking of our men.*

But things did not improve, and later Baldwin again complained emphatically to Faye: "You stated among other things that it was *not so* that your contractors were invading our camps to entice our men away. It *was so* and they are still *doing it*." Baldwin writes that although he has heard that Kekaha has thirty dissatisfied loaders who are threatening to come over to Makaweli to work, of course he will not hire them. The record then falls silent.

The Kekaha Ditch was not enough. By 1909 the *mauka* cane lands had been so expanded that the plantation again relied on its groundwater pumps to supply water to irrigate the *makai* lands. The water in those wells was reported "much improved" from its previously saline condition. But Kekaha Ditch's water production had dropped so dramatically that by 1912 the water from the ditch was inadequate even to run the hydroelectric plant. The cause was increased seepage. It was then decided to develop more water by extending the upper portion of the ditch another 280 feet above the existing intake and, at the same time, to build a second hydro, the Mauka Powerhouse, at the original intake.

Although a large storm in 1920 inflicted substantial damage on the Kekaha Ditch and Mauka Powerhouse, the plantation was hesitant to undertake expensive maintenance until the government, which held the lease to nearly all of Kekaha's sugar lands, renegotiated new lease agreements. These were executed in 1923. They stipulated that 2000 more acres of *mauka* pasture land should be put into cultivation and allowed water development in the head reaches of Waimea Canyon to irrigate this additional acreage. In 1923, the company undertook major repairs of the Kekaha Ditch, expanding its capacity to 50 mgd and its average to 35 mgd. At the same time Kekaha Sugar started construction on a new ditch, to be known as the Kokee Ditch.

Faye started the Kokee Ditch—sometimes referred to as the Great Mauka Ditch—in 1923. The construction contract went to George Ewart, previously with Waimea Sugar Mill Company. Although the cost estimates were between $200,000 and $250,000, the actual cost was variously reported as $500,000 and even $680,000—the higher amount might have included the hydro plant.

This ditch diverted tributaries of the Waimea River in the Kokee area—starting at over 3000 feet elevation with the Mohihi and including the Waiakoali, Kawaikoi, Kauaikinana, and Kokee streams—and comprised forty-eight tunnels averaging 1000 feet, the longest being 3000 feet. The total length was 7 miles of tunnel and 12 miles of open ditch, measured to Kitano Reservoir. Water was running through the ditch by January 1925, and the final upper section of Mohihi was completed early the next year. Puu Lua Reservoir, the major storage facility for this system, was finished in 1927, with a 262-million-gallon capacity, at a cost of $168,581. The capacity of the ditch is still 55 mgd up to the reservoir (beyond that point it is 26 mgd); the average flow is 15 mgd.

The average delivery of the Kekaha and Kokee ditches combined is 50 mgd. Besides its surface water sources, Kekaha Sugar has four pumps with a capacity of 26.5 mgd and an average of 22 mgd. The Huluhulunui Shaft, which pumps 10 mgd, provides the water to run the factory.

Kekaha Sugar planted on a variety of terrain. Field elevations range from 2010 feet down to sea level. The cane was transported down the ridge by flume and then by rail in the lowlands. So flat were these miles of coastal lands that

there were no brakes on the cane cars. By 1947, trucks had replaced the flumes and railroads.

Kekaha Sugar is the only plantation with a majority of its land leased from the state. It recorded 14 tons per harvested acre in 1983—one of the highest yields of any Hawaii plantation—thanks to the Kekaha and Kokee ditches. In 1994, Amfac/JMB consolidated many functions of Kekaha Sugar and Lihue Plantation as a cost-cutting measure.

A copy of the "***Kekaha Sugar Infrastructure Study Drawing Set***", is available for review at DLNR, Land Division offices on Kauai and Oahu

JOB NO. 1-KL-A
REPORT NO. R-114

KEKAHA SUGAR INFRASTRUCTURE STUDY

Kekaha, Kauai, Hawaii

FINAL REPORT
April 17, 2000

Prepared for:
State of Hawaii
Department of Land and Natural Resources
Land Division
Honolulu, Hawaii

Prepared by:
Bow Engineering & Development, Inc.

In Association with
Tom Nance Water Resource Engineering, Inc.
Hawaii Pacific Engineers, Inc.
MK Electrical Engineers, Ltd.

EXHIBIT 5

II. BACKGROUND OF PROJECT AREA

A. DEVELOPMENT HISTORY

The earliest agriculture on the Kekaha-Mana plain consisted of rice cultivation around the edges of the Nohili and Kawaiele marshes. This took place from the mid-1800 through the 1920's. Even after the first missionaries came to Waimea in the 1820's, commercial production of sugarcane was limited to the Waimea area. Expansion of the commercial cane production to the Kekaha area and the beginnings of the present plantation did not occur until 1878 using the Huluhulunui Spring as a source of irrigation. As the cane acreage increased, the irrigation supply of springs and intermittent streams proved to be inadequate. To fulfil this demand for freshwater, the first irrigation wells were drilled in the early 1800's. However, most were drilled too deep and at locations too far makai. They became too salty to use within one to several years. Most of the wells were abandoned and are now buried and lost.

In 1898, the present day Kekaha Sugar Company was founded. As part of its expansion program, three surface water diversions were constructed to address the failure of the well supply. In 1903, the Waimea Ditch was dug to divert water from the Waimea River to nearby fields. The success of this venture prompted the construction of the Kekaha Ditch in 1905, which carries water from an altitude of about 500 feet on the Waimea River to Kekaha. The ditch was completed in 1907 and the well water quality began to improve. In 1926, the Kokee Ditch was completed diverting water from Mohihi Stream and the headwater of the Waimea River in the Alakai Swamp at an altitude of about 3,400 feet. About one-fourth of the Kokee Ditch supply has irrigated the highland cane fields below Puu Opae reservoir on Niu Ridge, and the balance has irrigated the highland fields east of Kokee Road.

With the draining of the Nohili and Kawaiele Marshes in 1922 and the continued expansion of sugarcane acreage, another period of well development took place in the 1920's – 1930's. Initially, this consisted of batteries of closely spaced drilled wells, but Maui-type shafts located along the foot of the bluffs subsequently replaced these. Four of these shafts were constructed in the 1930's, two (2) more in the late 1940's, and the last two in 1957. All eight (8) of the shafts remain in use today, three (3) for potable supply and the other five (5) for irrigation.

B. LAND OWNERSHIP AND CURRENT USE

The Kekaha Sugar Company, Limited entered into a 25-year lease (General Lease No. S-4222 (expired)) with the State of Hawaii by its Board of Land and Natural Resources on January 1, 1969. A copy of the lease is in Appendix "A". The lease is currently being renegotiated and a DRAFT version dated April 23, 1999 is available in Appendix "A". The new lease will cover approximately 27,720 acres of land on parcels 1 and 23 of Tax Map Key 1-2-2. Approximately 7,758 acres of the total leased lands are used for the cultivation of sugarcane.

Kekaha Sugar Company, Ltd. presently uses the lands for sugar cane and diversified agriculture. Kekaha Sugar has the right to store, take and use all the State-owned or controlled surface water flowing in the Kokee and Kekaha ditch systems. Kekaha Sugar Co. also have the rights to the groundwater from existing wells and shafts on the leased lands and the right to use all the ditches, tunnels, roadways and trails located within and outside the watershed area that connects the watershed to the property.

C. CLIMATE

Kauai lies just south of the Tropic of Cancer in the belt of the northeast trade winds. Its mild and generally uniform climate results from the latitude, the oceanic environment, and the orographic effects. Departures from the normal weather pattern are caused by cyclonic storms associated with cold fronts out of the north and with tropical disturbances out of the east, south, or west. Most of the interruptions of the normal trade wind weather (trade winds prevail about 80 percent of the time) occur during the winter months from cyclonic disturbances passing over or near the island. Such disturbances are known as kona storms and are characterized by several-days of sultry calm or variable winds blowing mostly from the south and west.

D. RAINFALL

The average annual precipitation in the Kekaha-Mana Plain is less than 20 inches per year near the coast and increases to about 40 inches on the ridges. Sugar cane cultivation requires approximately 90 inches of water per year, so surface and groundwater provide the balance of its water supply sources.

E. WATER QUALITY AND SOIL SALINITY/ALKALINITY

The water presently applied to sugar cane and other crops on the Kekaha-Mana plain is obtained from mountain streams, wells, and reuse of drainage water. In general, the quality of the well water and stream diversions is satisfactory to excellent. The drainage waters have never been tested for salinity, but the plantation personnel indicate that the silt dredged from the channels mauka of Kaumualii Highway can be reused in the cane field. The silt makai of the Highway is not reused due to mixing with the ocean water.

There is no evidence of alkali conditions in these lands. The pH values do not exceed 8. (Per Malcolm Fernandez, Environmental Director, Kekaha Sugar Company). The practice of taking pH measurements at all the fields was discontinued in 1969.

IV. IRRIGATION SYSTEM

A. GENERAL

1. Introduction

There are three ditches that divert surface water to the Kekaha Sugar Company lands for irrigation. These are the Kekaha Ditch, Kokee Ditch, and Waimea Ditch. (See Figure 1, Kekaha, Kokee, Waimea Ditch Map) From these main ditches, approximately 2,668 acres of sugar cane in the highland area and approximately 5,090 acres in the coastal (Kekaha-Mana) plain are irrigated from a network of lateral ditches and drip irrigation system. Distribution of the water is by one of the following methods:

a. Gravity flow directly from the ditches (furrow irrigation).
b. Pumpage of water to fields from the ditches.
c. Mixing of imported surface water with pumped ground water for distribution on the coastal plain.
d. Pumpage from drainage channels back into the ditches for redistribution on the coastal plain.

2. Overview of Irrigation Facilities

a. Kekaha Ditch

The Kekaha Ditch diverts water from the Waimea River and supplies water as far west as the Polihale and "N" reservoirs. The total length of the Ditch is approximately 27 miles. The Kekaha Ditch will provide water not only for plantation use but also to other water users like the Kikiola Land Co. and Knudsen Land Co.

The Kekaha Ditch is also replenished with recycled water from a drainage channel at the mauka end of Field 218. Two (2)-8" diameter PVC pipe lines exit the pump station; one leads to Reservoir 117 and the other directly to the Kekaha Ditch.

b. Waimea Ditch

The Waimea Ditch is no longer in service due to a landslide that covered portions of the ditch approximately 10-years ago. The Ditch has since been abandoned. Kekaha Sugar Co. provides irrigation water to the users from the Kekaha Ditch.

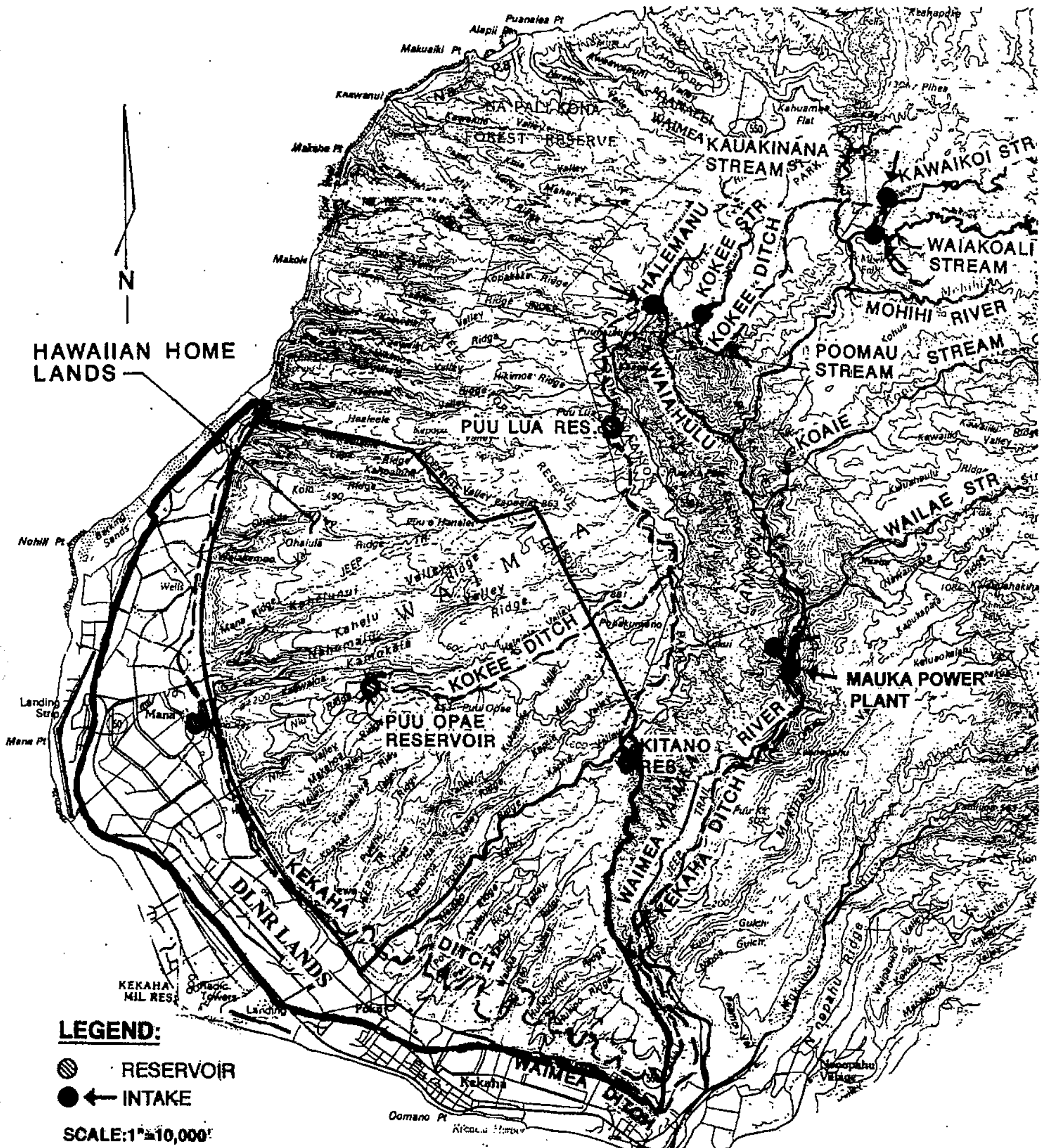
c. Kokee Ditch
The Kokee Ditch diverts water from Mohili Stream and the headwater of the Waimea River in the Alakai Swamp at an altitude of about 3,400 feet. About one-fourth of the Kokee Ditch supply irrigates the highland (mauka) canefields below Puu Opae reservoir on Niu Ridge, and the balance irrigates the highland (mauka) fields east of Kokee Road. The total length of the Kokee Ditch is approximately 21 miles. This ditch supplies three major reservoirs:
- Puu Lua Reservoir, 262 million gallon
- Puu Opae System, 88 million gallon
- Kitano Reservoir System, 36 million gallon

d. Distribution Systems
- Drip Irrigation System
  Approximate 6,598 acres or 85% of cultivated area uses drip irrigation. Drip irrigation is used on all the mauka lands and parts of the makai section; predominately to the west of Field 110 and 210. (See Dwg.I-0.1, Irrigation System Schematic)
- Furrow Irrigation System
  Approximately 1,160 acres or 15% of cultivated area still uses surface irrigation. The system consists mainly of shallow furrows. Furrow irrigation is limited to the makai section and uses both Kekaha Ditch and Mill water. The use of furrow irrigation is restricted to Fields 101 to 107, 201, and 206 to 209. (See Dwg.I-0.1, Irrigation System Schematic)

B. DESCRIPTION OF THE EXISTING IRRIGATION SYSTEM

1. Kekaha Ditch System

a. General Layout of the Irrigation System
The Kekaha Ditch diverts water from the Waimea River at an elevation of approximately 500 feet at the Mauka power plant. The waters from the Waiahulu, and Koaie streams converge at the Waimea dam site located at approximately elevation 850'. The water is diverted by a series of tunnels that lead to the intake point (elevation 700') of an 18" diameter penstock that drops the water to the Mauka power plant. The Waimea River is also routed through the power plant, then discharged into the Kekaha Ditch as shown on Figure 1, Kekaha, Kokee, Waimea Ditch Map.



Reference: Kokee Water Project, Island of Kauai
Department of Land and Natural Resources
1964 Report R22

FIGURE 1
KEKAHA, KOKEE & WAIMEA DITCH MAP

From the Mauka power plant, the Kekaha Ditch winds its way south generally following the alignment of the Waimea River through a series of concrete lined and earthen channels, and tunnels. Just above Waimea Town, the Kekaha Ditch turns westward and supplies water as far west as the Polihale and "N" reservoirs. (See Drawing I-0.1) The total length of the Ditch is approximately 27 miles. The Kekaha Ditch will provide irrigation water not only for plantation use but also to other water users as identified in Section B.1.e, Other Users of the Kekaha Ditch Water.

b. Existing Condition
The Kekaha personnel rate the existing condition of the Kekaha Ditch as satisfactory. The Ditch is inspected daily for debris, blockage and leaks. Minor repairs are made as needed to insure the continuity of the Ditch flow. Annual repairs are made during the summer when the stream flows are low. The annual operation and maintenance cost can be found in Section C.

c. Makai (Kekaha-Mana Plain) Region
The Kekaha-Mana plain is irrigated from the Kekaha Ditch. Approximately 6,598 acres or 85% of the cultivated lands are irrigated through a drip irrigation system. The drip irrigation system is shown on Drawing I-0.1, Irrigation System Schematic. Generally, the Kekaha Ditch will fill a reservoir designated for a region to be drip irrigated. The water from the reservoir is passed through a sand or fine mesh filter before being pumped into the irrigation mains to the fields. The list of irrigation pumps and motors for each Region is shown in Appendix A. The Standard Operating Procedures for the drip irrigation system is shown in Appendix B.

Approximately 1,160 acres or 15% of cultivated area still uses surface irrigation. The system consists mainly of shallow furrows. Furrow irrigation is limited to the makai section and uses both Kekaha ditch and Mill water. The use of furrow irrigation is restricted to Fields 101 to 107, 201, and 206 to 209. (See Drawing I-0.2, Irrigation System Schematic.) The control of the flow rate into the furrow ditch is accomplished manually with header gates from the Kekaha Ditch. The Standard Operating Procedures for the surface (furrow) irrigation system is shown in Appendix B.

d. Mauka Region
Irrigation water for the mauka region is taken directly from the Kekaha Ditch and pumped to the fields as shown on Drawing I-0.2, Irrigation System Schematic. The mauka fields irrigated from the Kekaha Ditch are as follows: 601, 611, 612, 621, 631, 642, 643, 651, 652, 661, 662, 663, 671, 672, and 673. The water from the Ditch is passed through a sand or fine mesh filter before being pumped into the irrigation mains to the fields.

e. Other Users of the Kekaha Ditch Water
The Kekaha Ditch system provides irrigation water to the users shown below. The total irrigation water taken is approximately 9 million gallons per day (mgd).

Average Irrigation Usage by Others

Company	Usage (mgd)	Comments
Kikiaola Land Co.	2.5	
Knudsen land Co.	2.0	
Taro Farmers	2.5	5" diameter supply line (PVC)
Waimea Dairy	0.5	2.5" diameter supply line (galvanized)
Pioneer Corn Co.	1.2	(Field Nos.: 409, 201, 228 and 128)
Narvortis Corn Co.	0.3	
Total	9.0	

The Kekaha Sugar Co. personnel estimated these irrigation flow rates. The irrigation water to these users is proportionately reduced when the Ditch flows are below normal levels. There are no flow metering devices installed to monitor the water usage by the users, except for a meter recently installed to monitor the Knudsen Land Co. water usage. Amfac Sugar Kauai could not release copies of the lease agreements with these water users.

f. Current usage
The average usage varies depending on the season of the cane growing cycle. The average irrigation flows are shown on Table 1, Kekaha Ditch Flows. The average flows for the first 6-months of 1999 was 35-mgd.

g. Surplus or Shortage of Water
The average in the Kekaha Ditch in the last 50 years from 1946 to 1996 is 1015 million gallons per month (mgm) as shown on Table 2, Average 50-Year Kekaha and Kokee Ditch Flows. The average flow in the past 12 years is approximately 922 mgm, which is a 9% reduction in flow. (See Table 1).

According to the Irrigation System personnel, the optimum Kekaha Ditch flow for sugar production is approximately 50 mgd. The current average flow for the past 12 years is approximately 35 mgd. Therefore, there is a shortage of approximately 15-mgd.

2. Kokee Ditch System

a. General Layout of the Irrigation System.
The Kokee Ditch starts at Camp 8 within the Alakai Swamp and draws water from Waiakoali Stream. The Kokee Ditch diverts water from the Mohili,

Kawaikoi, and Halemanu streams as shown in Figure 1, Kekaha, Kokee, Waimea Ditch Map.

The capacity of the Kokee Ditch between Camp 8 and the first reservoir, Puu Lua Reservoir, is approximately 55 mgd. If the ditch appears to be reaching its capacity, Kekaha personnel will "spill-off" water into Kauhao Stream to protect the ditch from overtopping its banks.

The Ditch capacity between Puu Lua Reservoir and the junction of Puu Opae Reservoir and Kitano Reservoir is approximately 26 mgd. The Ditch capacity from the junction to Puu Opae and Kitano is approximately 7 mgd and 19 mgd, respectively. All ditch capacities are taken shown on Drawing I-0.2, Irrigation System Schematic.

b. Existing Condition.
The Kekaha personnel rate the existing condition of the Kokee Ditch as good. The Ditch is checked daily for debris and blockage. Annual maintenance is perform on the Ditch during the dry summer season.

c. Mauka Region
The Kokee Ditch serves exclusively the mauka region. The Ditch system is a combination of 21 miles of open channel flow and tunnels. The following three reservoirs that are filled by the Ditch:

- Puu Lua Reservoir, 262 million gallon capacity.
- Puu Opae System, 88 million gallon capacity
- Kitano Reservoir System, 36 million gallon capacity.

All the mauka fields are served by a drip irrigation system as shown on Drawing I-0.2, Irrigation System Schematic.

Irrigation system personnel have estimate that the Kitano Reservoir is approximately 50% of its original capacity due to siltation. It was noted that the reservoir was last dredged in the late 1970's. Siltation of the other reservoirs has occurred, but the exact decrease in capacity is unknown at this time. It does not appear that the siltation of the reservoirs has hindered

d. Other Users of the Kokee Ditch Water
The Kokee Ditch system provides approximately 0.5 mgd irrigation water to the Hawaiian Home Land Pastoral Lots. The irrigation water is supplied through a 2" PVC/galvanized steel pipeline.

e. Current Usage

The average usage varies depending on the season of the cane growing cycle. The average irrigation flows are shown on Table 3, Kokee Ditch Flows. The average flows for the first 6-months of 1999 was 11-mgd.

f. Surplus or Shortage of water
The average in the Kokee Ditch in the last 50 years from 1946 to 1996 is 438 million gallons per month (mgm) as shown in Table 2. The average flow in the past 12 years is approximately 392 mgm, which is a 10% reduction in flow. (See Table 3).

According to the Irrigation System personnel, the optimum Kokee Ditch flow for sugar production is approximately 15 mgd. The current average flow for the past 12 years is approximately 13 mgd. Therefore, there has been an average shortage of approximately 2-mgd for the past 12 years.

C. OPERATION AND MAINTENANCE COSTS FOR THE KEKAHA & KOKEE DITCHES

The estimated annual operation and maintenance costs for the Kekaha and Kokee Ditches are as follows:

Daily maintenance of ditches:		$387,000
Labor (120 manhours/wk x 52 wk/yr. x $60/hour)	$374,000	
Equipment costs (160 hr/wk x $20/hour) truck	3,000	
Material costs (Cement, aggregate, sand, rebar)	10,000	
Annual maintenance of ditches:		$250,000
Labor (20-men x 8-hours x 20 days x $60/hour)	$192,000	
Equipment costs (160 hr/wk x $50/hour) Backhoe, dump truck	8,000	
Material costs (Cement, aggregate, sand, rebar)	50,000	
Allowance for emergency repairs		$61,000
Labor (10-men x 8-hours x 6 days x $60/hour)	29,000	
Equipment costs (50 hr/wk x $50/hour) Backhoe, dump truck	3,000	
Helicopter rental (24-hours x $1,000)	24,000	
Material costs (Cement, aggregate, sand, rebar)	5,000	
Contingency (10%)		72,000
Total		$770,000

The cost estimates were based on manhour information provided by the Kekaha Sugar Company and reflect the general market labor rates. The above estimated costs do not represent the actual cost borne by Amfac Sugar Kauai.

D. EVALUATION AND RECOMMENDATIONS

There has been a significant decrease in the irrigation flow rate from both the Kekaha and Kokee Ditches in the past few years. The cause of this decrease in flow can be attributed in part to a long running drought and possibly to a reduction in work force to maintain these ditches. It is not certain how much flow is loss to leakage, infiltration, or evapotranspiration. Further study should be undertaken to quantify this loss of water.

Some additional recommendations that should be considered in maintaining the irrigation system:

1. Detailed survey of the existing reservoirs to determine their present capacity.
2. Determine the optimum capacity of each reservoir with regard to the fields they are servicing.
3. Install flow meters to monitor use of irrigation water by other users and evaluate the impact of this use on the sugar production.
4. Implement a program to deep till (Moleboard Plow) the fields.
5. Evaluate the watering rate at each field and check the drip irrigation system to deliver this flow rate evenly.

E. SUMMARY

The Kekaha Sugar Company's staff and personnel have done an admirable job of maintaining the irrigation system within their budgetary constraints. Irrigation water is a valuable resource that must be preserved in order for sugar or any other diversified agricultural crop to succeed in the Kekaha-Mana plain and mauka areas. The operations and maintenance of 27-mile of the Kekaha Ditch and 21-miles of the Kokee Ditch and tunnels must be continued to keep agriculture alive in this area. It is anticipated that the annual operation and maintenance cost for both the Kekaha and Kokee Ditches is approximately $770,000.00.

TABLE I-1
KEKAHA DITCH FLOWS

KEKAHA DITCH FLOWS (MGM)

Month	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Ave. Flow	50yr Ave. Flow	% of 50yr Ave. Flow
January	651	718	514	1161	997	620	1236	1103	467	504	685	1037	808	907	89%
February	607	775	565	865	640	926	645	842	296	740	839	1212	746	836	89%
March	933	501	1309	845	1079	929	1119	855	750	914	833	1142	934	1077	87%
April	1138	1297	1116	925	786	845	1331	1231	986	692	1295	1191	1069	1143	94%
May	1194	1227	1178	997	883	1059	1078	1033	834	1120	1353	835	1066	1165	91%
June	749	904	1050	1103	964	834	1108	916	1017	1377	1150	802	998	1037	96%
July	961	1121	1116	879	950	995	1062	931	1156	1137	1170		1043	1113	94%
August	952	1086	848	1324	984	990	812	1049	817	1195	1153		1019	1048	97%
September	870	1093	963	850	294	695	1165	765	967	966	962		872	908	96%
October	836	1090	874	446	109	913	724	1015	1013	978	999		818	963	85%
November	791	928	779	545	615	1203	1081	625	599	1085	1098		850	988	86%
December	414	823	1182	775	920	841	1332	620	636	930	1205		880	990	89%
TOTAL FLOW	10096	11563	11494	10715	9221	10850	14687	10986	6323	11638	12742	6219	11103	12175	91%
AVERAGE FLOW	841	964	958	893	768	904	1224	916	527	970	1062	1037	922	1015	91%

* MGM = Million gallons per month

KEKAHA DITCH FLOWS (MGD)

Month	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Ave. Flow
January	21	38	24	37	32	20	40	36	19	16	25	37	29
February	21	30	43	39	30	33	23	30	19	26	30	43	31
March	30	33	42	27	35	30	36	29	24	29	27	37	32
April	38	43	37	31	26	28	44	41	33	23	43	40	36
May	39	40	38	32	28	34	35	33	27	36	44	27	34
June	25	30	35	37	32	28	37	31	34	46	38	27	33
July	31	36	36	28	31	32	34	30	37	37	38		34
August	31	35	27	43	32	32	26	34	26	39	37		33
September	29	36	32	28	29	23	38	25	31	32	32		30
October	27	35	28	25	12	29	24	33	33	32	32		28
November	26	31	26	23	20	40	36	21	20	36	37		29
December	28	27	38	25	30	42	43	20	21	30	38		31
TOTAL FLOW	346	414	406	375	337	371	416	363	250	382	421	211	379
AVERAGE FLOW	29	35	34	31	28	31	35	30	21	32	35	35	32

*MGD = Million gallons per day

TABLE I-2
AVERAGE 50-YEAR KEKAHA DITCH FLOWS

KEKAHA AND KOKEE DITCH FLOWS

COMPARING THE 50 YEAR AVERAGE 1946-1996

Month	Kekaha MGM Ave.	Kokee MGM Ave.
January	907	506
February	836	513
March	1077	591
April	1143	607
May	1165	501
June	1037	347
July	1113	404
August	1048	307
September	908	232
October	963	297
November	988	457
December	990	493
TOTAL FLOW	12175	5255
AVERAGE FLOW	1015	438

*MGM = Million gallons per month

TABLE I-3
KOKEE DITCH FLOWS

KOKEE DITCH FLOWS (MGM)

Month	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Ave. Flow	50yr Ave. Flow	% of 50yr Ave. Flow
January	679	564	514	350	389	572	555	232	701	438	350	412	480	506	95%
February	557	585	326	545	715	620	520	544	641	457	346	409	522	513	102%
March	512	606	636	745	580	446	537	334	579	551	300	333	513	591	87%
April	641	792	407	609	194	203	548	613	345	419	841	311	493	607	81%
]May	573	438	749	317	388	280	333	240	181	625	857	150	428	501	85%
June	259	269	272	391	283	104	483	234	477	487	632	263	346	347	100%
July	414	660	279	148	269	291	279	323	365	349	414		345	404	85%
August	351	329	106	421	199	247	133	400	105	194	497		271	307	88%
September	278	207	185	142	156	48	308	129	244	106	250		187	232	80%
October	247	173	71	340	299	337	463	313	181	174	176		252	297	85%
November	589	213	491	138	333	748	353	556	551	395	610		452	457	99%
December	652	324	647	579	743	562	469	450	515	526	432		536	493	109%
TOTAL FLOW	5752	5160	4683	4725	4548	4458	4977	4977	4883	4721	5705	1878	4706	5255	90%
AVERAGE FLOW	479	430	390	394	379	372	415	415	407	393	475	313	392	438	90%

* MGM = Million gallons per month

KOKEE DITCH FLOWS (MGD)

Month	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	AVERAGE
January	22	18	17	12	13	18	18	7	23	14	11	13	16
February	19	21	12	19	25	22	19	19	23	15	12	15	18
March	17	20	21	24	19	14	17	11	19	18	10	11	17
April	21	26	14	20	6	7	18	20	11	14	28	10	16
]May	18	14	24	10	13	9	11	8	5	20	28	5	14
June	9	9	9	13	9	3	16	8	16	16	21	9	12
July	13	21	9	5	9	9	9	10	12	11	13		10
August	11	11	3	14	6	8	4	13	3	6	17		8
September	9	7	6	5	6	2	10	4	8	3	8		6
October	8	6	2	11	10	11	15	10	6	6	6		8
November	20	7	16	6	11	25	12	19	18	13	20		14
December	21	10	21	19	25	18	18	15	17	17	14		16
TOTAL FLOW	188	170	154	158	152	146	165	144	161	153	188	63	154
AVERAGE FLOW	16	14	13	13	13	12	14	12	13	13	16	11	13

*MGD = Million gallons per day

V. DRAINAGE SYSTEM

A. GENERAL

1. Introduction and General Overview

This section discusses the drainage systems and facilities operated by the Kekaha Sugar Company. Background information on the project area was presented in Chapter II. Seven drawings (D-1, D-2, D-3, D-4, D-7, D-8, and D-12) showing the general locations and configuration of the drainage facilities on aerial photo base maps are presented in a separately bound set of plans.

Of the approximately 28,000 acres leased by Kekaha Sugar Company from the State of Hawaii, approximately 7,400 acres are used for the cultivation of sugarcane, pasture and other agricultural purposes. The area to the east of the Kekaha sugarcane fields consists of approximately 42 square miles of highland area that drains to the Kekaha-Mana plain. This area is characterized by a series of valley gulches that dissect steep cliffs of basalt which emerge from the plain.

Prior to the initiation of sugarcane cultivation in the 1920's, approximately 900 acres of the Kekaha-Mana plain were comprised of open ponds, marshlands and rice fields (Hawaii Pacific Engineers, 1994). There were previously two large ponds, one at Kawaiele and the other at Nohili. The ponds and other wetlands were formed as a result of the depressed topography of the area and flows from stream runoff and artesian wells. By filling in many of the low areas and by operating two large drainage pumping stations at Kawaiele and Nohili (see Drawings D-2 and D-4), Kekaha Sugar Company has lowered the groundwater table to allow cultivation in areas that were previously marsh-like in nature.

The extensive network of drainage channels and storage reservoirs, along with the cultivated fields themselves, serve to collect, store and convey both irrigation and excess drainage waters. In addition to lowering the groundwater level during dry weather, the drainage channels and pumping stations reduces the peak flood stage and duration of field inundation during periods of high rainfall.

During wet periods, excess stormwater runoff can result in significant flooding of the fields. Sources of water include stormwater runoff generated within the watershed, pumped water from subsurface wells, natural seepage of groundwater, and water imported from other watersheds via transmission ditches (Kekaha Ditch). Inundation of the cultivated fields due to heavy flooding results in significant losses to the sugar cane crop. Excessively high water table levels will result in root rot in the cane and also lower sugar yields. The performance of the drainage system in Kekaha has a direct impact on the productivity and economic viability of the agricultural operations.

During dry periods, irrigation water from surface sources can be in short supply. The drainage facilities are interrelated to a certain extent to the irrigation facilities discussed in Chapter IV. The irrigation pumps are used to pump both irrigation return and drainage runoff to the irrigation reservoirs and furrow/drip irrigation systems.

Operation of the drainage pumping stations at Kawaiele and Nohili is necessary to prevent much of the Kekaha Sugar Company fields from reverting back to its former wetland status. The Kekaha land is currently not considered to be a wetland area by the U.S. Army Corps of Engineers since it can be classified as a "previously cultivated cropland" (Lennan, 1999). The land, however, would likely be regulated as a wetland by the Corps of Engineers if it was abandoned and not used for agriculture for more than five years. Classification of the land as wetlands would result in severe restrictions on the use and development of the land. Endangered wildlife that may inhabit the newly created wetlands would fall under the scrutiny of the U.S. Fish and Wildlife Service.

The cultivated sugarcane fields and drainage channels also function as sedimentation facilities to help reduce the discharge of sediments to the ocean by the drainage outfalls. The Kekaha Sugar Company has a National Pollutant Discharge Elimination System (NPDES) permit for its discharges. The NPDES permit and associated monitoring requirements are discussed later in this chapter. A copy of the NPDES permit is included in Appendix A. The locations of the drainage outfalls and the associated NPDES identification numbers are shown on the separately bound drawings.

2. Hydro-Geologic Setting

The highland watershed consists of the mountainous topography above the Kekaha sugarcane fields which receives the heaviest rainfall and is responsible for the bulk of the surface water runoff in the region. The area exhibits steep rugged terrain, with elevations ranging from approximately 80 to 3,500 feet above mean sea level (MSL). There are five major valleys that extend inland towards the Waimea Canyon ridgeline. The streams in the valleys are intermittent and have no base flow during dry periods. The soils in the highland area, as classified by the U.S. Department of Agriculture Soil Conservation Service (SCS, 1972), consist of the Makaweli-Waiawa-Niu and Mahana-Kokee association which are generally well drained soils having a moderate to fine texture. Vegetation consists of a combination of relatively undisturbed non-native and native vegetation. The annual median rainfall ranges between approximately 25 and 50 inches per year in the highland area.

The Kekaha Sugar Company fields in the Kekaha-Mana plain are characterized by mildly sloping topography largely covered by sugarcane fields, service roads, and drainage channels. A mosaic of non-native and native vegetation is also present. Ground elevations range from about 80 feet above MSL at the base of the highland watershed to between one and three feet above MSL in the lower areas. The inverts of the ditches at the drainage pumping stations are as deep as seven feet below MSL. Soils in the lower cultivated plain area consist predominantly of the Kekaha-Nohili association that consists of well-drained and poorly drained, medium textured to very fine soils developed by alluvium. The area also consists of fill land and Kaloki, Lualualei, and Mamala soils. The annual median rainfall in the lowland region ranges between approximately 20 and 25 inches per year.

The U.S. Navy Pacific Missile Range Facility (PMRF) is located on a strip of coastal land that borders much of the western boundary of the Kekaha Sugar Company land. Runoff generated by the PMRF drainage area consists of overland flow that generally runs off either towards the ocean or the Kekaha Sugar Company fields. Much of the soil within PMRF is characterized by the excessively drained to well-drained permeable Jaucas-Mokuleia association. The median rainfall in the area averages approximately 20 inches. The amount of runoff generated within the boundaries of PMRF itself is relatively insignificant. Compared to the other two hydrologic zones, PMRF has relatively permeable soils, lower rainfall, and a relatively small area contributing runoff to the sugarcane field floodplain.

B. DESCRIPTION OF THE EXISTING DRAINAGE SYSTEM

1. General

Normal outflow of surface water from the fields occurs through a combination of drainage pumping, natural seepage into the substratum, and evapotranspiration. During flood conditions, gravity (non-pumped) outflow to the ocean occurs through various outlets to the ocean. The general layout and locations of the major drainage channels and the Kawaiele and Nohili drainage pumping stations are shown on the separately bound plans.. Schematics showing the general water flow and drainage water treatment scheme for the drainage system are presented in Figures D-1 and D-2, respectively. The pumping stations facilities and drainage channels are described in the following discussions.

2. Kawaiele and Nohili Pumping Facilities

a. Description

The Kawaiele pumping station is located south of the PMRF (see Drawing D-4). The Nohili pumping station is located further north within PMRF. The Kawaiele and Nohili pumping stations each pump discharges into their respective drainage channels that then conveys the flow to an outlet in the sandy beach area. The NPDES outfall identification numbers for the Kawaiele and Nohili discharges are 002 and 003, respectively.

Each pumping station is provided with three drainage pumps. Available design data for the pumping stations is summarized in Table D-1.

The Kawaiele station has two 40 million gallons per day (mgd) pumps (horizontal split-case) and one 20 MGD pump (vertical turbine). The two horizontal pumps are provided with belt drives and all the pumps are driven by electric motors. The two horizontal pumps were previously driven by diesel engines. The 40 mgd horizontal pump with a 100 horsepower (hp) motor and the vertical pump with a 100 hp motor are normally operated continuously. The vertical pump is provided with variable speed controls to automatically vary the pump discharge based on water level. The two horizontal pumps are provided with manual controls. The 100 hp horizontal pump is throttled using the discharge gate valve to prevent excessive current draw and overloading of the motor. The 125 hp standby horizontal pump, which is periodically "exercised," has sufficient motor capacity to operate without throttling. A vacuum pump system is provided for priming of the two horizontal pumps.

The Nohili pump station utilizes three vertical turbine pumps. Two of the pumps have a capacity of 15 MGD and 50 hp motors. The third pump has a 4 MGD capacity and a 40 hp motor. The 4 mgd pump and one of the 15 mgd pumps are operated manually. The other 15 mgd pump is operated by automatic level controls.

b. Operation and Maintenance of the Pumping Facilities

During dry weather, the drainage pumps at Kawaiele and Nohili pump groundwater and excess irrigation water collected by the drainage channels to the ocean. The pumps at the Kawaiele and Nohili pumping stations are operated as required during normal dry weather conditions to maintain the water table level in the Kekaha fields below the root zone. The pumps are typically operated to lower the water level in the drainage channel to an elevation of between approximately -3.0 and -3.5 feet below MSL at the Kawaiele pumping station and -2.0 to -2.5 feet below MSL at the Nohili station. In addition to maintaining unsaturated soil conditions in the root zone, the lowering of the water table also increases the effective stormwater storage capacity of the fields and the drainage channels to reduce flooding impacts during heavy rain.

During periods of light to moderate rainfall, the drainage channels collect excessive storm runoff from the cultivated fields and convey the runoff to the two drainage pumping stations. The Kawaiele and Nohili pumping stations are interconnected by the "main canal" (see Drawing D-2, D-3 and D-4). Under heavy rainfall conditions, the flow in the main canal tends to flow towards the Kawaiele pumping station.

AGRICULTURAL WATER USE AND DEVELOPMENT PLAN

December 2003

(Revised: December 2004)

Department of Agriculture
STATE OF HAWAII

EXHIBIT 6

ASSESSMENT OF NEEDS

Since Kekaha Plantation closed in the late 1990s, a significant decrease in ditch flow in both the KEDIS and KODIS has been recorded. This decrease may be due partly to a long running drought or reduced maintenance of the systems. A seepage loss study should be conducted to determine the extent and nature of ditch losses.

There is a need for the following: (1) a detailed survey of all the reservoir capacities, (2) an evaluation of optimum reservoir inflows relative to the current or planned water demand, and (3) installation of flow meters or other measuring devices to record water use for ditch operations.

The KODIS needs some immediate rehabilitation work. The Kawaikoi flume, a 36-inch diameter, semi-circular steel trough supported on a wooden trestle, is badly deteriorated and needs replacement (in July 2003, a section of the flume collapsed and is to be repaired on an emergency basis). The ditches, tunnels, and a 60 ft long, 36-inch diameter wood stave pipe flume named "Halemanu," experience some sedimentation, small boulder accumulation, and debris from tunnel spalling, but no root intrusions were observed in spite of many trees along the ditches and over the tunnels.

In general, the unlined ditches and tunnels from the headwater intakes to Puu Lua Reservoir are in good condition. Access for maintenance work to most of this section of the system in Waimea Canyon is severely limited.

Puu Lua Reservoir, an unlined earthen reservoir created by an earthen dam across a gulch serves as a storage and public fishing reservoir. Because the earthen dam is old, it should be assessed to determine if it meets dam safety standards. Reservoir outflow is controlled by a 24-inch globe-type valve and discharge piping buried in the dam embankment and accessible by a vertical concrete shaft with manhole on top of the dam. The valve does not operate freely and the concrete shaft weeps from seepages through the dam embankment. The section of ditches and tunnels from Puu Lua Reservoir to the Puu Moe Ditch divide is in good condition and readily accessible for maintenance.

The flow at Puu Moe divide splits between Kitano and Puu Opae Reservoirs. This ditch divide is excavated in deeply weathered, but stable basalt lavas. Severe erosion at the divide is evident and will require correction and new parshall flumes. The Puu Opae Reservoir, an unlined earthen reservoir, needs lining to prevent seepage losses. The 4-mile ditch to Puu Opae Reservoir should be replaced with high-density polyethylene (HDPE) pipe to prevent seepage and evaporation losses.

The Kitano Reservoir, an unlined cut and fill type reservoir, dug into a small ridge, is heavily silted and should be cleaned out and lined to prevent seepage losses, and fenced to prevent public access.

PROPOSED CAPITAL IMPROVEMENTS

Most of the improvements listed below for the Kokee Ditch Irrigation System are critical as the assessment indicates potential facility failures unless corrected. The system is located in an environmentally sensitive area due to its designation as a critical habitat and environmentally pristine ecosystem (it contains the Waimea Canyon rim and Alakai swamp). The high rehabilitation cost estimates for the improvements provided below reflect this complexity, and are conservative, based on normal cost analysis standards.

1. Reconstruct the Kawaikoi flume. This flume consists of a wooden trestle supporting a 48-inch diameter semi-circular steel trough. Part of the trestle is supported on a huge boulder and movement of the boulder could cause failure of the flume. As observed in March 2003, the semi-circular steel flume is leaking on the bottom in several spots. However, in July 2003, the downstream portion of the flume collapsed and Waiakoali water currently is spilling and lost to the system. Emergency repairs were completed in 2004, consisting of replacing the foundation with steel framing and installing 8-inch HDPE pipe at a cost of $30,000 provided by the ADC. The flume's capacity needs to be restored as soon as possible and its wooden support structure repositioned onto a firm foundation, possibly as an in-house project.

2. Rehabilitate existing Puu Lua Reservoir outlet pipe and control valve. The outlet pipe lies approximately 110 ft below the top of the dam. A circular concrete shaft with a surface manhole extends from the top of the dam vertically down to a globe-type control valve on the outlet pipe. The concrete shaft joints show signs of water seepage through the reservoir's embankment and needs to be sealed off. A possible solution is to install an HDPE lining on the upstream face of the embankment. The control valve

is connected to the surface by a steel shaft and is operated by a turning wheel mounted at the top of the concrete manhole. Operation of the valve is difficult as it does not function properly or as tightly as before. The outlet pipe and control valve are critical parts of the reservoir and failure of either could cause dam failure and flooding of coastal developments down slope.

3. Reconstruct Puu Moe Ditch divide. This ditch divide is important to the integrity of the system's operation, and it is where the system's flow is split, controlled, and measured between Kitano and Puu Opae Reservoirs. This divide is narrow and badly eroded in places. Also, the two measuring devices' (steel parshall flumes) accuracy has been adversely affected by erosion and deterioration. This divide should be entirely re-engineered to correct the erosion problem and provide efficient flow control and accurate flow measurement, including data logging. The existing ditch divide is inadequate for its purpose of precisely dividing and accurately measuring the system's flow to Kitano and Puu Opae Reservoirs.

PROPOSED MAINTENANCE IMPROVEMENTS

With the anticipated reduction in water use from the Kokee Ditch Irrigation System and less cultivated acres on former upland cane fields, the existing capacity may need downsizing. The HDOA has recognized the urgent need for some improvements and is proceeding with them through other funding sources. The potential for alternative uses is greatest for the Kokee system, i.e., hydropower generation, recreational activity (fishing at Puu Lua Reservoir), and stream restoration.

1. Retrofit stream intake aprons, ditch screens, and control gates to meet the change in system flow operations from sugarcane irrigation to diversified agriculture. The current need for reliable, constant ditch flows rather than the bulk flows of the past will require more precise and complete control of flow and distribution.

2. Two improvements are listed for completeness only: (1) cleaning out Kitano Reservoir which is partially silted and (2) replacing the Halemanu wood stave pipe flume (at Halemanu Stream). Improvements of these two structures are planned in 2003 by the HDOA, as authorized by the State Legislature.

ADC Ditch Flow Reports to the Water Commission 2010-13

* Table generated from data provided by the Commission

KOKE'E DITCH (Gage No. 2-49)						
WUReportID	Date Begin	Date End	Days Counted	Use MGD	Use MGM	Use CFS
2010						
441	1/1/2010	1/31/2010	31	10	310	15.47
444	2/1/2010	2/28/2010	28	11	308	17.017
445	3/1/2010	3/31/2010	31	13	403	20.111
467	4/1/2010	4/30/2010	30	11	330	17.017
468	5/1/2010	5/31/2010	31	9	279	13.923
469	6/1/2010	6/30/2010	30	8	240	12.376
506	7/1/2010	7/29/2010	29	8	232	12.376
507	8/1/2010	8/31/2010	31	5	155	7.735
508	9/1/2010	9/30/2010	30	5	150	7.735
509	10/1/2010	10/30/2010	30	4	120	6.188
510	11/1/2010	11/30/2010	30	8	240	12.376
511	12/1/2010	12/31/2010	31	9	279	13.923
2011						
513	1/1/2011	1/31/2011	31	10	310	15.47
514	2/1/2011	2/28/2011	28	9	252	13.923
515	3/1/2011	3/31/2011	31	9	279	13.923
516	4/1/2011	4/30/2011	30	8	240	12.376
517	5/1/2011	5/31/2011	31	9	279	13.923
518	6/1/2011	6/30/2011	30	8	240	12.376
519	7/1/2011	7/31/2011	31	9	279	13.923
520	8/1/2011	8/31/2011	31	7	217	10.829
521	9/1/2011	9/30/2011	30	1	30	1.547
522	10/1/2011	10/31/2011	31	6	186	9.282
557	11/1/2011	11/30/2011	30	8	240	12.376
561	12/1/2011	12/31/2011	31	8	248	12.376
2012						
564	1/1/2012	1/31/2012	31	9	279	13.923
568	2/1/2012	2/29/2012	29	9	261	13.923
569	3/1/2012	3/31/2012	31	8	248	12.376
562	4/1/2012	4/30/2012	30	7	210	10.829
555	5/1/2012	5/31/2012	31	7	217	10.829
567	6/1/2012	6/30/2012	30	7	210	10.829
560	7/1/2012	7/31/2012	31	7	217	10.829
656	8/1/2012	8/31/2012	31	8	248	12.376
657	9/1/2012	9/30/2012	30	2	60	3.094
671	10/1/2012	10/31/2012	31	0.04	1.24	0.062
670	11/1/2012	11/30/2012	30	0.04	1.2	0.062
672	12/1/2012	12/31/2012	31	10	310	15.47
2013						
673	1/1/2013	1/31/2013	31	9	279	13.923
674	NA	NA	NA	9	NA	13.923
699	3/1/2013	3/31/2013	31	9	279	13.923
727	4/1/2013	4/30/2013	30	7	210	10.829
728	5/1/2013	5/31/2013	31	7	217	10.829

EXHIBIT 7

ADC Ditch Flow Reports to the Water Commission 2010-13

* Table generated from data reported to the Commission

KEKAHA DITCH (Gage No. 2-50)						
WUReportID	Date Begin	Date End	Days	Use MGD	Use MGM	Use CFS
	2010					
441	1/1/2010	1/31/2010	31	31.96	990.76	49.44212
444	2/1/2010	2/28/2010	28	31.52	882.56	48.76144
445	3/1/2010	3/31/2010	31	37.08	1149.48	57.36276
467	4/1/2010	4/30/2010	30	37.02	1110.6	57.26994
468	5/1/2010	5/31/2010	31	37.4	1159.4	57.8578
469	6/1/2010	6/30/2010	30	28.94	868.2	44.77018
506	7/1/2010	7/29/2010	29	31.58	915.82	48.85426
507	8/1/2010	8/31/2010	31	29.95	928.45	46.33265
508	9/1/2010	9/30/2010	30	27.67	830.1	42.80549
509	10/1/2010	10/30/2010	30	21.82	654.6	33.75554
510	11/1/2010	11/30/2010	30	30.58	917.4	47.30726
511	12/1/2010	12/31/2010	31	30.63	949.53	47.38461
	2011					
513	1/1/2011	1/31/2011	31	35.18	1090.58	54.42346
514	2/1/2011	2/28/2011	28	35.43	992.04	54.81021
515	3/1/2011	3/31/2011	31	37.38	1158.78	57.82686
516	4/1/2011	4/30/2011	30	39.77	1193.1	61.52419
517	5/1/2011	5/31/2011	31	37.92	1175.52	58.66224
518	6/1/2011	6/30/2011	30	39.49	1184.7	61.09103
519	7/1/2011	7/31/2011	31	40.31	1249.61	62.35957
520	8/1/2011	8/31/2011	31	35.81	1110.11	55.39807
521	9/1/2011	9/30/2011	30	29.45	883.5	45.55915
522	10/1/2011	10/31/2011	31	33.19	1028.89	51.34493
557	11/1/2011	11/30/2011	30	40.39	1211.7	62.483
561	12/1/2011	12/31/2011	31	39.65	1229.15	61.339
	2012					
564	1/1/2012	1/31/2012	31	37.02	1147.62	57.27
568	2/1/2012	2/29/2012	29	38.14	1106.06	59.003
569	3/1/2012	3/31/2012	31	40.12	1243.72	62.066
562	4/1/2012	4/30/2012	30	39.7	1191	61.416
555	5/1/2012	5/31/2012	31	40.78	1264.18	63.087
567	6/1/2012	6/30/2012	30	39.96	1198.8	61.818
560	7/1/2012	7/31/2012	31	39.4	1221.4	60.952
656	8/1/2012	8/31/2012	31	22.64	701.84	35.024
657	9/1/2012	9/30/2012	30	24.9	747	38.52
671	10/1/2012	10/31/2012	31	14.09	436.79	21.797
670	11/1/2012	11/30/2012	30	16.51	495.3	25.541
672	12/1/2012	12/31/2012	31	23.6	731.6	36.509
	2013					
673	1/1/2013	1/31/2013	31	26.59	824.29	41.135
674	NA	NA	NA	23.66	NA	36.602
699	3/1/2013	3/31/2013	31	24.08	746.48	37.252
727	4/1/2013	4/30/2013	30	26.47	794.1	40.949
728	5/1/2013	5/31/2013	31	26.71	828.01	41.32

CERTIFICATE OF SERVICE

The undersigned hereby certifies that, on this date, a true and correct copy of the foregoing document was duly served on the following as indicated:

Via First-Class U.S. Mail, Return Receipt Requested:

Agribusiness Development Corporation
Department of Agriculture, State of Hawai'i
235 South Beretania Street, Room 205
Honolulu, Hawai'i 96813

Kekaha Agriculture Association
8315 Kekaha Road, Suite E
Kekaha, Hawai'i 96752

DATED: Honolulu, Hawai`i, July 24, 2013.

EARTHJUSTICE
David L. Henkin
Isaac H. Moriwake
223 South King Street, Suite 400
Honolulu, Hawai'i 96813

By: ______________________
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