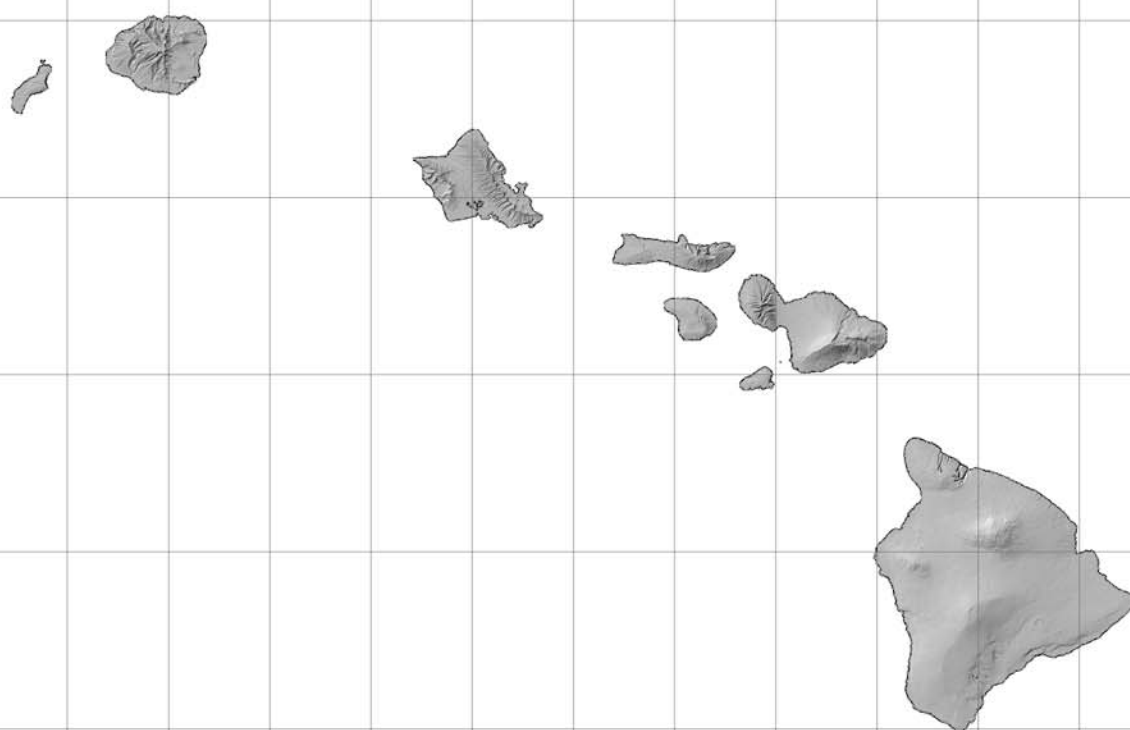
AGRICULTURAL WATER USE AND DEVELOPMENT PLAN

December 2003



Department of Agriculture

STATE OF HAWAII

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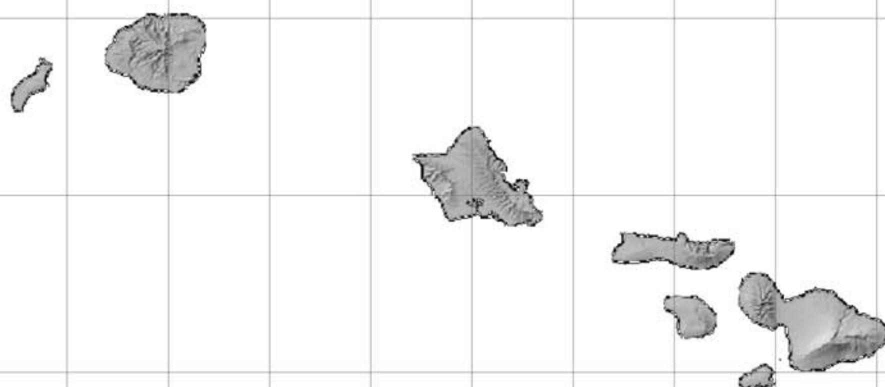

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STATE OF HAWAII

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ABBREVIATIONS

ADC	Agribusiness Development Corporation
AWUDP	Agricultural Water Use and Development Plan
BOR	Bureau of Reclamation
CRM	Concrete Rubble Masonry
CWRM	Commission on Water Resource Management
DHHL	Dept of Hawaiian Home Lands
DLNR	Hawaii Department of Land and Natural Resources
EKIS	East Kauai Irrigation System
EKW	East Kauai Water Company
EKWUC	East Kauai Water Users' Cooperative
gpm	Gallons per minute
HBOA	Hawaii Board of Agriculture
HC&S	Hawaiian Commercial & Sugar Co.
HDOA	Hawaii Department of Agriculture
HDPE	High-density polyethylene
KEDIS	Kekaha Ditch Irrigation System
KODIS	Kokee Ditch Irrigation System
kW	Kilowatt
LHDIS	Lower Hamakua Ditch Irrigation System
LLC	Lihue Land Company
LPC	Lihue Plantation Company
MDWS	Maui Department of Water Supply
MG	Million gallons
mgd	Million gallons per day
MIS	Molokai Irrigation System
MLP	Maui Land and Pineapple Company
NEPA	National Environmental Policy Act
NRCS	Natural Resources Conservation Service
O&M	Operations and Maintenance
PMIS	Pioneer Mill Irrigation System
SCADA	Supervisory Control and Data Acquisition
SCS	Soil Conservation Service
USDA	United States Department of Agriculture
WDIS	Waiahole Ditch Irrigation System

Chapter 1. INTRODUCTION

HAWAII'S AGRICULTURAL BACKGROUND

For the first half of the twentieth century, Hawaii's economy was dominated by its monocrop (sugar and pineapple) agriculture industry which in turn was dominated by corporate farming enterprises that included plantations, irrigation water companies, sugar mills, and pineapple canneries. The monocrop industry was a principal driving force behind multi-ethnic culture, having invested extensive capital and human resources. The industry, as the economic engine, also provided the basis for Hawaii's newly developing economy.

Beginning in the late 1950s, the tourism industry gradually moved to the economic fore front and the monocrop agriculture industry began to lose its prominence. However, the agriculture industry continued to make a significant contribution to Hawaii's economic base.

Prior to the decline of monocrop farming, Hawaii's diversified agriculture farming developed in small pockets throughout the State in regions that were already inhabited by persons with some farming background. Marketing of diversified crops were mainly localized to within the county or transshipped to Honolulu, the State's population center.

The decline of the monocrop industry in Hawaii was the result of many factors. Several of these factors included: (1) transfer of monocrop cultivation to emerging third world countries, (2) reductions in price supports for sugar, (3) gain of collective bargaining by industry-wide labor forces, (4) adjustments in U.S. sugar quota formula, (5) urban pressures, and (6) enactment of stringent environmental laws and regulations. Over several decades beginning in the 1970s entire plantation operations were closed or consolidated for cost effectiveness, and by the late 1990s very little of the monocrop agricultural industry remained.

Irrigation systems, sugar mills, roads, drainage, hydropower systems, housing camps, various structures (offices, well filtration, and pump stations), and equipment were abandoned, idled, or sold; as a result of plantation closures. This was a serious blow on the agricultural communities that had developed around a plantation culture, and efforts were undertaken to salvage the associated infrastructures by transforming them into other uses or converting them to support new enterprises.

Diversified agriculture seemed to be a logical choice to replace monocrop farming as it could with minimum effort utilize much of the existing plantation infrastructure. The major concern was whether or not water was adequate to serve this transformation from monocrop into diversified agriculture.

OBJECTIVE OF AWUDP

The Agricultural Water Use and Development Plan (AWUDP) was conceived by the State Legislature to ensure that the plantation irrigation systems affected by plantation closures would be rehabilitated and maintained for future agricultural use. Thus, in 1998 the Legislature enacted Act 101 to provide authority for the AWUDP to become a part of the Hawaii Water Plan on a par with municipal water use and development plans.

This report evaluates those irrigation systems deemed to be important and viable to Hawaii's growing diversified agricultural industry and existing monocrop industry.

This report is the first step in meeting the objectives of the AWUDP: (1) to assess and plan for an orderly rehabilitation of former plantation irrigation systems which are considered to be the most important infrastructural need to expand Hawaii's diversified agricultural industry, i.e., IRRIGATION WATER SUPPLY, and (2) to ensure that the irrigation water supply will be reliable and adequate to meet the current and future water requirements of the agricultural industry.

SCOPE OF THIS REPORT

This report, prepared in conformance with the requirements of Act 101, includes a total of 13 irrigation systems—five selected as important to Hawaii's diversified agriculture industry, five HDOA operated systems, and three privately owned and operated systems.

Most of these irrigation systems are covered in a chapter in which there is an historic description of the original infrastructure, a short narrative of the existing conditions, an assessment of the current concerns and needs, and estimates of costs for improvements and maintenance.

Based upon the assessment, a list of improvements to address system needs was developed. There are two categories of need—capital improvements and maintenance improvements. *Capital improvements* are considered to be those that add and improve the value of the system, whereas *maintenance improvements* are considered to be those that are necessary to maintain operational efficiency and viability of the system. The other factor that sets these two types of improvement apart is that *capital improvements* require engineering design and construction by contractors, whereas *maintenance improvements* can be constructed by normal operation and maintenance crews with little or no subcontracting work required. Since capital improvements require additional costs for engineering and environmental studies, such costs were added to construction costs, resulting in a total rehabilitation cost.

AUTHORITY

The AWUDP was authorized by the 1998 State Legislature under Act 101. The Act required the Hawaii Department of Agriculture (HDOA) to:

(1) inventory the irrigation water systems;

(2) identify the extent of rehabilitation needed for each system;

(3) subsidize cost of repair and maintenance of the systems;

(4) establish criteria to prioritize the rehabilitation of the systems;

(5) develop a 5-year program to repair the systems; and

(6) set up a long-range plan to manage the system.

Chapter 2. SETTING FOR THE PLAN

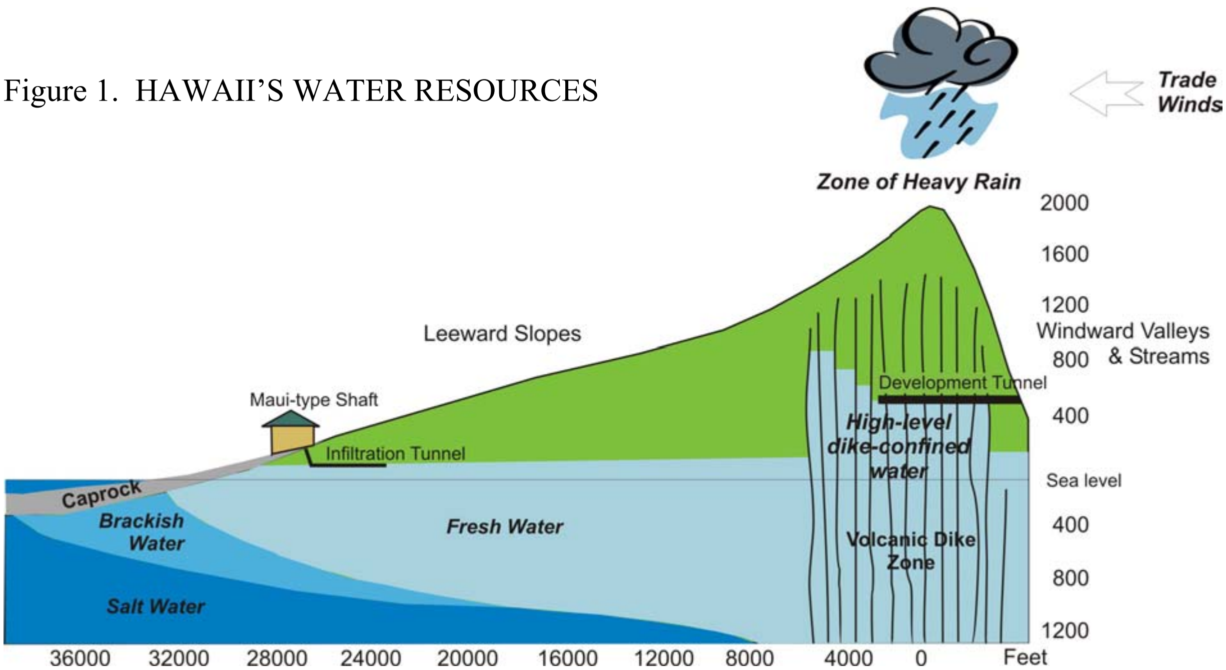
WATER RESOURCES

The major Hawaiian Islands have mountain slopes over 2,000 ft high and are endowed with up to 300 inches of rainfall a year. Such abundant rainfall is the result of persistent tropical trade winds that strike the islands from the northeast and thereupon release their moisture on "windward" mountains and valley rain forests facing the trade winds (Figure 1). Over geologic time, such large amounts of rainfall have carved the windward or northeast slopes into deep, rugged valleys with perennial streams. On the other hand, the leeward or southwest slopes of the islands have formed less-eroded, fertile, but dry gentle slopes. The abundant occurrence of water resources, both surface water and ground water, rely not only on trade wind rains, but equally on the island's highly permeable volcanic terrain, which can readily absorb and store rainfall in large groundwater aquifers.

Hawaii streams, the primary source of water for all irrigation systems in Hawaii, are typically very flashy in nature, due not only to their steep profiles and small drainage basins, but also to the intensity of tropical storms. During a rainstorm, a stream especially on the windward side of the island can reach very high rates of flow in a matter of hours and return to normal flows just as rapidly. Aside from the peak, storm-related part of Hawaii's stream flows, there is a perennial component fed by in-channel springs of "high-level" or "dike-confined" ground water. Such ground water generally occurs in areas where annual rainfall is high and valley streams have eroded deeply into the core of the island, where a number of impermeable volcanic dikes (vertical, thin walls of dense lava) have intruded permeable lava flows. In this setting, mountain rainfall is stored as ground water in compartments of permeable lava flows at high elevations and ultimately discharges as springs throughout sections of a stream's profile, forming perennial flows.

Ancient Hawaiians developed a number of such perennial streams with diversions and ditches to irrigate and grow taro, a staple crop. Later, sugar growers copied the ancient Hawaiians with their own elaborate and extensive plantation irrigation systems. The use of intake structures to divert perennial low flows and high storm flows, and the use of water-development tunnels to intercept the high-level ground water associated with perennial streams, ultimately gave rise in the late 1800s to the construction of large-scale irrigation systems by sugar plantations. Miles of ditches, tunnels, flumes, and siphons were constructed to transport water primarily to irrigate sugar cane grown on distant arable lands on the dry, sunny, gentle leeward slopes of each major island. A number of these irrigation systems are no longer in use for sugar cane farming, but they continue to be important sources of irrigation water for diversified agriculture.

Figure 1. HAWAII'S WATER RESOURCES



During droughts, the sugar plantations relied on groundwater sources, tapping large quantities from lenses of fresh water floating on salt water. Where feasible, irrigation systems included large capacity wells near irrigated fields in low-lying coastal areas. To increase supply, horizontal infiltration tunnels were constructed near sea level with access provided by a vertical or inclined shaft (Figure 1). The first such groundwater shaft was constructed on Maui in the 1890s. These groundwater sources, called Maui-type shafts, continue to serve as supplemental backup irrigation water supplies, especially during droughts.

CLIMATE AND SOILS

Climate. Hawaii experiences only two seasons: from May through October when weather is warmer and drier, and from October through April when weather is cooler and more cloudy and wet. Solar energy and length of day are relatively uniform throughout the year and the surrounding ocean provides moist air and keeps temperatures fairly constant without extremes throughout the year. These conditions contribute to a continuous 12-month growing season.

Moist, northeasterly trade winds are the primary source of Hawaii's abundant rainfall. As trade winds move over mountainous areas, the air expands, cools, and its moisture condenses into clouds and rains which create Hawaii's water resources.

Drought in Hawaii occurs infrequently, but during the last decade has become more persistent due to El Nino and La Nina weather conditions. These weather conditions affect the ocean temperatures which govern weather fronts and pressure systems and in turn result in failure of the trade winds and development of winter storms. In the dry leeward agricultural areas, lack of winter storms can result in severe droughts. For the water-rich windward areas, the interruption of trade winds diminishes rainfall, stream flow and consequently the water supply of irrigation systems.

Soils. Hawaii's soils originate from the weathering (physical and chemical decomposition) of basaltic lavas and volcanic ash, but differ in places due to variations in degree of weathering, drainage, rainfall, etc. Hawaii's soils have been classified and extensively mapped, using both the obsolete Great Soil Group System and the USDA Soil Conservation Service's comprehensive system of soil classification (National Cooperative Soil Survey Classification).

For cultivation of agricultural crops the soil classified in the following categories are the most suitable and desirable:

- *Oxisols*—occur on old, stable surfaces of relatively flat lands in the lower elevations of the older islands and possess exceptional properties for intensive mechanical cultivation and are considered important agricultural soils in Hawaii.

- *Ultisols*—occur on old, stable surfaces on steeper slopes and at more unstable sections of the higher elevations of the older islands. These soils possess exceptional properties for intensive mechanical cultivation and are considered important agricultural soils in Hawaii.

- *Mollisols*—occur in moderately dry, well-drained areas and are relatively young soils which develop on lava, alluvium, or coral. Generally rich in plant nutrients, this soil is also suitable for agricultural cultivation.

PLANTATION PERIOD (1860s to 1990s)

Although Hawaii's sugar industry started during the 1860s, most of the plantation irrigation systems were developed around the turn of the twentieth century. Large quantities of surface water from perennial streams were diverted by intake structures (see Ave. Flow column in Table 1) into miles-long transmission ditches and tunnels, moving water from the windward side of the islands to the leeward plains, where abundant dry, fertile lands required irrigation to grow sugar cane. Generally, intake structures include a dam across the streambed, an inlet channel, control gates, trash screen, and a connecting tunnel or ditch into the main transmission structure—usually another tunnel or ditch.

Table 1. PLANTATION DITCH SYSTEMS

Plantation and ditches	Date	Ave. Flow (mgd)*	Capacity (mgd)
KAUAI PLANTATIONS			
***Lihue Plantation Co/East Kauai Water Co*.**		140**	
Rice Ditch	1856		
Lower Lihue Ditch			
Upper Lihue Ditch			
Hanamaulu Ditch	ca. 1870		
Kapaia Ditch			
Waiahi-Kuia Aqueduct (Koloa ditch)	1915		60-90
Waiahi-Iliiliula-N. Wailua ditches	1926		
N. Wailua Ditch		(23)	
Stable Storm			
Hanalei Tunnel	1926	(28)	
Kaapoko Tunnel	1928		
Wailua Ditch		(14)	
Kapahi Tunnel and Makaleha system	1922-1929		
Makee Sugar Co.			
Anahola, Kaneha, Kapaa ditches	ca 1880-1900		
Grove Farm		26**	
Several small ditches	1865-1868		
Halenanahu Ditch	1884		
Huleia Ditch	1893		
Upper Ditch	1917		
MainDitch (later Lower Ditch)	1928-1948		
***Koloa Sugar Co*.**		20**	
Dole's "water lead"	1869		
Wilcox Ditch	1885, 1893		
Mill Ditch	1902		
Waita (Koloa) Reservoir	1906		

Plantation and ditches	Date	Ave. Flow (mgd)*	Capacity (mgd)
McBryde Sugar Co.		95**	
Kamooloa Ditch	1907		
Wainiha Powerplant	1906	50	65
Pump 3	ca. 1908	34	
Alexander Reservoir	1932	10	
Kilauea Sugar Co.			
System of reservoirs and ditches	ca.1880-1900		
Reservoirs: Kalihiwai, Stone Dam, Puu Ka Ele, Morita, Waiakalua, and Koloko			
Ditches: Mill, Koolau, Puu Ka Ele, Koloko and Moloaa, Hanalei			
Hawaiian Sugar Co/Olokele Sugar Co.		100**	
Hanapepe Ditch	1891	35	42
Olokele Ditch	1904	66	
Gay & Robinson			
Koula Ditch Tunnel (Hanonui Tunnel)	1948	40	
Waimea Sugar Mill Co.			
Waimea (Kikiaola) Ditch	1903	5	
Kekaha Sugar Co.		50**	
Kekaha Ditch	1907	30	40
Kokee Ditch	1927	15	55
OAHU PLANTATIONS			
Waiahole Irrigation Co/Oahu Sugar Co.		32**	
Waiahole Ditch		42-27	100
Waialua Sugar Co.		30**	
Oahu Ditch (Mauka Ditch Tunnel),	1902		
Wahiawa, Helemano, Tanada ditches	ca. 1902		
Opaeula Ditch	1903		
Kamananui Ditch	1904		
Ito Ditch	1911		
Kahuku Plantation Co.		10**	
Punaluu Ditch	ca. 1906	10	
Waimanalo Sugar Co.			
Kailua Ditch			
Maunawili Ditch			
MAUI PLANTATIONS			
East Maui Irrigation Co.		160**	440
(Old) Hamakua Ditch	1878	(4)	
(Old) Haiku (Spreckels) Ditch	1879		
Lowrie Ditch (Lowrie Canal)	1900	(37)	60
New Hamakua Ditch	1904	(84)	
Koolau Ditch	1905	(116)	85
New Haiku Ditch	1914	25	100
Kauhikoa Ditch	1915	(22)	110
Wailoa Ditch	1923	(170)	160-195

Plantation and ditches	Date	Ave. Flow (mgd)*	Capacity (mgd)
Wailuku Sugar Co.		30**	
Waihee (Spreckels) Ditch	1882	10-2	20
Waihee (Ditch) Canal	1907	27	
Nine other smaller ditches			
Honolua Ranch & Pioneer Mill Co.		50**	
Honokohau Ditch	1904	20	35
Honolua (Honokohau) Ditch	1913	30-18	50-70
Honokowai Ditch	1918	6	50
Kahoma Ditch		3	
Kanaha Ditch		3.8	
Kauaula Ditch		4.5	25.5
Launiupoko Ditch		0.8	
Olowalu Ditch		4	11
Ukumehame Ditch		3	15
HAWAII PLANTATIONS			
Kohala Ditch Co.		30**	
Kohala Ditch	1906		
Kehena Ditch	1914	(6)	
Hamakua Sugar Co/HIC		50**	
Upper Hamakua Ditch	1907	8	
Lower Hamakua Ditch	1910	30	60-45

* Average flows are based on the historical record except for those in parentheses, which are from USGS records.
**Estimated average total surface water diverted.

Source: Modified after Wilcox, Carol, 1977.

As the plantations grew, they generally were able to encumber the more productive lands and assure the continued use of their irrigation systems. The monocrop (sugar cane and pineapple) farming industry became a strong economic and political force in Hawaii.

At the peak of the monocrop industry in 1920, approximately 250,000 acres were in production, with irrigation systems diverting an average of 800 mgd (million gallons per day) of water. The plantation irrigation systems provided water not only for irrigation, but also for transportation (of harvested cane), sugar mills, hydropower plants, and plantation villages. The island of Kauai had the most systems (see Table 1), followed by Maui, Oahu, and Hawaii. Because of generally porous soils, large storage reservoirs needed for reliable water supply were not feasible. Consequently, most irrigation systems included only small reservoirs or none at all, in which case diverted stream flows were transmitted directly to sugar cane fields through ditches, tunnels, siphons, and flumes.

Changes in the Monocrop Industry. The monocrop industry (sugar cane and pineapple) was the major contributor to Hawaii's economy during the first half of the twentieth century, but by the late 1950s air travel began to create a new, more lucrative industry—tourism—which did not require the arduous labor of agriculture. Also around this time sugar and pineapple workers were caught up in a labor movement for better working conditions and fair wages. The tourism industry encroached upon agricultural land and infrastructure uses, especially on the neighbor islands. Resort (hotel sites), recreational (golf courses, parks), and public access (parking, water development sites) uses began to erode the large contiguous plantation land holdings.

After World War II, better economic conditions and increased demand for housing resulted in marginal agricultural lands being converted into urban subdivisions. Plantation closures began in the 1970s with most of pineapple plantations closing and sugar plantations merging, shutting down sugar production, or converting to other crops, such as macadamia nuts.

The Land Use Law, Chapter 205, HRS, was enacted in 1961 to provide for orderly development of land in the state. However, the provisions of this law were subjected to broad interpretation which often resulted in decisions unfavorable to agricultural interests. This caused further decline in lands available for true agricultural pursuits by allowing gentlemen farm and certain urban-type uses on agriculturally zoned lands. Nearly 200,000 acres have been reclassified from agriculture since the land-use law was implemented. Such broad interpretation continues and probably will greatly impact the availability of prime agricultural land formerly in monocrops and now idled by plantation closures for conversion into diversified agriculture uses. Land owners and estate trusts with large tracts of fallow sugar cane lands have a unique opportunity to re-evaluate their land use objectives.

The plantations grew sugar and pineapple with the use of extensive irrigation ditch systems that traversed many miles. Records indicate that close to 100 irrigation ditches were built to support the monocrop industry (Table 1). Some of the more prominent systems that were abandoned by plantation closures were: (1) Kohala and Kahena Ditches on the windward slopes of North Kohala, Hawaii, (2) Olaa flume on the eastern slopes of Mauna Loa, Hawaii, (3) Kilauea plantation's system of six ditches on the northern coast of Kauai, (4) Maunawili ditch system on the windward slopes of Oahu (now partially taken over by the

State's Waimanalo Irrigation System), (5) Lanai's irrigation system, (6) Oahu Sugar Co.'s Kalauao-Aiea ditch systems on the slopes above Pearl Harbor, and (7) Kahuku Plantation's system of ditches and wells in northeast Oahu.

By the end of the twentieth century there remained approximately 15 to 20 active ditch systems. Of these remaining systems very few were operating at full capacity due to plantation closure or reduction in the farming activity served by the ditch system. The physical characteristics of these irrigation systems were designed and constructed prior to the enactment of environmental and zoning statutes. Today (2003) it would be nearly impossible to plan, design, and construct similar irrigation systems without enormous effort and cost, making such a project uneconomical.

With the introduction of drip irrigation technology in the early 1970s to replace furrow irrigation of sugar cane, irrigation water requirements for sugar cane were reduced, enough in some instances to sustain plantations short on irrigation water supply. By 1986, major drip irrigation systems were completed at 11 plantations. To protect crops from droughts, the agricultural industry needs to maintain the original capacities of the agricultural water systems.

For Hawaii's agriculture industry the most critical need has always been the availability of reliable irrigation water. Historically, those plantations without irrigation water were at a big disadvantage and often failed or merged with other plantations possessing water.

POST-PLANTATION PERIOD (1990s to 2003).

Collapse of Sugar Industry. In 1998, with the collapse of the sugar industry from over 250,000 acres to less than 50,000 acres in production, plantation irrigation systems were abandoned and left to deteriorate. With the lack of maintenance, ditches have been overgrown by vegetation, intake structures have been damaged or clogged, and siphons and flumes have deteriorated. By the late 1990s, government economists, private businesses, and farmers were advocating the development of a new diversified agriculture industry to take the place of the large, corporate sugar plantations. Figure 2 illustrates the contribution to the State's economy from monocrops and diversified agriculture over the last two decades and reflects the deep decline of monocrop revenues.

By 2000, only two sugar plantations (Gay & Robinson on Kauai and Hawaiian Commercial & Sugar Co. on Maui) and three pineapple companies (Maui Land & Pineapple

Co., Dole Company, and Del Monte Corporation on Oahu) were left, with about 35,000 acres in production.

Diversified Agriculture—A Prime Alternative. With fertile volcanic soils, mild climate, prime agricultural lands and irrigation systems made available by sugar plantation closures, and a 12-month growing period, the State of Hawaii has an unparallel opportunity to support and develop a new and significant diversified agriculture industry. In Hawaii, diversified crops include any agricultural commodity (including orchards, livestock, and poultry) except sugar and pineapple. The diversified crops now being considered for production are on the high-value end of the spectrum, with the potential to produce value-added products such as packaged and specialty items.

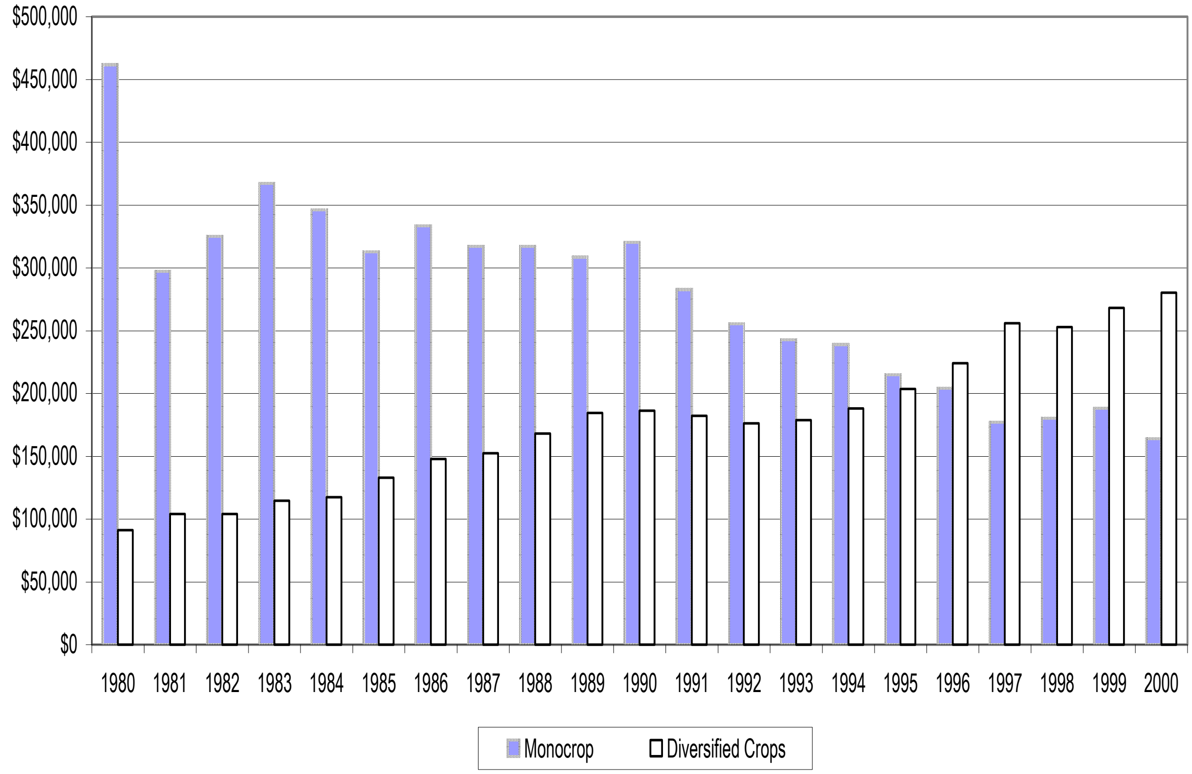
Diversified crops grown in Hawaii for export purposes must be of high value to be competitive because markets are distant and transportation costs are high. With this inherent limitation, other growing options—besides high-value crops—that need to be explored include: (1) growing local crops to replace corresponding imports; (2) pursuing niche markets (specific vegetables and fresh fruits during winter when they are not available from the mainland U.S. or other sources such as Mexico and South America); and (3) growing new or specialty crops (Asian-based crops for immigrant population centers in the United States). In general, any diversified crop grown for export must compete with other producing regions and more importantly must be grown on sufficient acreage to provide an adequate supply throughout the year.

Hawaii imports a majority of the produce it consumes and all of its fresh fruits except for papaya, pineapple, watermelon, and some banana.

Besides local and overseas markets, another potential market for fresh produce is the cruise ship and tourism industry.

By the late 1990s every irrigation system associated with plantation closure became available for conversion into supplying irrigation water for diversified agriculture farming. Concurrently, an almost unlimited amount of prime agricultural lands (former sugar cane fields) also became available for diversified agriculture farming. Most of these lands have agricultural water sources and access roads still in place, making such acreage ideal for small diversified agriculture farms.

Figure 2. VALUES OF MONOCROP vs DIVERSIFIED CROPS (1,000 dollars)



Source of Data: Hawaii Agricultural Statistics Service

Current Developments. With the demise of the monocrop industry and plantation closures only two of the six major islands (Kauai and Maui) have a plantation cultural base. The remnants of plantation culture have slowly changed into rural community settings. Nothing remains or is being developed to keep the cohesiveness of plantation-provided housing, utilities, employment, local commerce, etc. This social disruption has caused the younger generation to look for opportunities outside of agri-based vocations, leaving a void in the normal succession of the agricultural labor pool. Agriculture to be viable must now draw upon the urban labor pool or look to immigrants from third world countries for successor generation of farmers.

Former Sugarcane Lands. Former sugar fields now lie fallow with some in "low-level" agricultural uses such as grazing or tree farms. Based upon HDOA data, the State has an estimated 293,600 acres of prime agricultural lands, and since sugar and pineapple were cultivated on these lands, they presumably represent prime agricultural lands. However, according to the 2001 Statistics of Hawaii Agriculture only 66,100 acres were in monocrop cultivation. This indicates that a substantial amount of prime agricultural lands on every major island is now idle and potentially available for transformation into diversified farming (see Table 2).

Table 2. PRIME AGRICULTURAL LANDS IN HAWAII

Island	Classified Prime (acres)	Currently in Monocrop (acres)	Idle and Available
Kauai	56,000	10,600	45,400
Oahu	49,500	11,000	38,500
Molokai	11,400	0	11,400
Maui	67,900	44,500	23,400
Hawaii	108,800	0	108,800
TOTAL	293,600	66,100	227,500

Recent and ongoing agricultural land transfers by owners include:

1. Amfac/JMB Hawaii which has sold most of their plantation fee lands at Lihue and Kealia, Kauai, and at Olowalu and Lahaina, Maui;

2. Campbell Estate, which has sold lands at Ewa and Honouliuli, Oahu;

3. Castle & Cook, Inc., which has sold lands at Mililani and Waiawa, Oahu;

4. Grove Farm, Inc., which has sold lands at Nawiliwili and Puhi, Kauai; and

5. A&B, Inc., which has sold lands at Kahului and Wailuku, Maui, and at Kukuiula and Lawai, Kauai.

These lands are being converted into urban and other non-agricultural uses. The sale of prime agricultural lands can easily escalate because of their inherent suitability for urban development, i.e., gentle terrain, deep soils, and dry and sunny climate. Large landowners are not inclined to encumber their lands for long-term agricultural use if the opportunity exists for greater revenue streams through urban development, nor would they want to lose the opportunity to obtain and "land bank" governmental development rights by encumbering their lands with long-term agricultural leases.

Legal and Environmental Concerns. Currently, Hawaii's existing irrigation systems are in a state of flux while the State's agricultural industry is attempting to transform from monocrop cultivation into diversified farming. Several legal (State Supreme Court) and environmental (administrative rules) rulings and decisions regarding water resources have affected the future stability of these irrigation systems to some degree. References include the following: (a) the McBryde-Hanapepe case, relating to surface water, which had a precedent-setting impact concerning surface water and raised the legal question of out-of-watershed transfers of water, (b) enactment of Chapter 174C, HRS, (State Water Code), (c) Reppun case, relating to surface water, which altered the rights to stream diversion, (d) City Mill case, relating to ground water which confirmed the Western Common Law on Correlative Rights, (e) Waiahole contested case, (f) the Total Maximum Daily Loads (TMDL) rule, and (f) the pending Water Quality Certification rule.

Generally, the legal implications of these references probably affect in some way directly or indirectly the stability and certainty of operating and maintaining irrigations systems in Hawaii. In some cases, the threat of the regulatory enforcement provisions may deter potential investors, venture capitalist, large farming interests, and especially new or start-up farmers from investing capital and effort into diversified agriculture. These legal decisions and rules have projected the perception that agricultural water in Hawaii is not an easy commodity to acquire, requiring an unpredictable amount of time and effort.

With the recent administrative changes in State government, a greater understanding and appreciation is anticipated of the importance of Hawaii's agricultural industry, particularly diversified agriculture, to the overall interest and well being of the State. Equally important is support from the administration in the preservation and maintenance of the complex agricultural water systems which are the backbone of diversified agriculture. The AWUDP should be the cornerstone of this greater understanding and appreciation.

Persistent droughts and low rainfall periods over the past five years have adversely affected perennial stream flows and depleted high-level groundwater aquifers that supply Hawaii's irrigation systems. In the upper reaches of streams where most of the irrigation systems divert water, the reduction in rainfall has diminished stream flows and recharge to associated dike-confined aquifers. During droughts, soil moisture may be completely depleted in un-irrigated, fallow cane fields, causing dust storms and loss of top soils from wind erosion, as has happened on the western slopes of West Maui at Lahaina and Olowalu after the closure of Pioneer Mill Plantation.

ASSESSMENT OF HAWAII'S DIVERSIFIED AGRICULTURE POTENTIAL

Diversified agriculture as used in this report is a term that includes all agricultural commodities except sugar and canned pineapple. As indicated elsewhere in this report, Hawaii has the once-in-a-lifetime opportunity to expand its diversified agriculture industry during the current transition from sugar cultivation. With large acreages of prime agricultural lands lying fallow and readily available, a comprehensive plan is needed to avoid conflicts and duplication in diversified crop selection and production, which would be detrimental to farmers' markets and pricing structures.

Local Market. Hawaii has traditionally imported the majority of the fresh vegetables and fruits it consumes. In many instances these imports can be grown locally and with equal or better quality than imports. However, the produce that is chosen to replace a corresponding import must be grown and marketed year-round in sufficient quantity to meet local market demand. Without this commitment it is difficult for local growers to compete effectively with imported produce. Locally grown crops that have partially succeeded in competing with imports, include watermelons, bananas, watercress, sweet potatoes, fresh corn, and ginger root, according to reports by the Hawaii Department of Agriculture's Market Analysis and News Branch. The potential for locally grown produce to replace corresponding imports need to be evaluated in terms of the best locations of available sugarcane lands with best growing conditions, i.e., soils, climate, solar radiation, etc. The HDOA report indicates the following produce are currently (2000) imported to Hawaii, but have the potential to be replaced by locally grown crops: asparagus, green beans, broccoli, carrot, lettuce (head), mushroom, dry onion, table potato, squash, avocado, tangerine, lime, lemon, strawberry, and grapefruit.

There is a need for the development of forage and grain feed for the local livestock industry. Certain forage grasses and legumes currently are grown in scattered locations throughout the state, including guinea grass on Molokai, alfalfa on Kauai and Hawaii, feed corn on Hawaii, and field grasses on Hawaii. These forage crops are used to supplement the supply of imported grain feed. Currently, several ranchers on Hawaii and Oahu are cultivating forage grasses for finishing livestock and the results are promising. Using marginal sugar cane lands for pasture grass cultivation with irrigation and fertilization (organic and chemical) could profitably provide improved forage to replace imported feed grain for locally grown beef cattle, while at the same time restoring the scenic greenery once provided by sugar cane fields. Green pastures on upper coastal slopes would provide welcomed open vistas to visitors and residents alike. The major problem with forage grass and hay production in Hawaii is the slow drying process that accompanies the island's high humidity and the high moisture content of locally grown grass.

Based upon recent newspaper articles, Hawaii will experience a build up of military forces which will trigger an increase in Oahu's defacto population. This population increase probably will increase the market for locally grown produce and should be taken into account when planning for agricultural expansion. Expected military buildup includes a new Stryker Brigade for the Army probably at Schofield Barracks on Oahu, a new battleship carrier task force probably based at Pearl Harbor with its aircraft wing based at Kalaeloa, Oahu, and a still tentative new B-17 bomber squadron to be based somewhere in Hawaii.

Also, military housing construction currently underway will increase both an opportunity for local produce market expansion and a shortage of construction-related labor which probably will result in an influx of out-of-state workers and their families. This influx should cause an increase in the locally grown produce market.

Along the same line of increased business opportunities for diversified agriculture, the infant Hawaii cruise industry is expected to expand significantly. One cruise line (Norwegian) currently operates out of Hawaii and will be expanding operations in the next couple of years.

The following cruise lines are coming to Hawaii: Princess Cruise Line, Holland America Line and Norwegian Cruise Line (with new ships). Recently there was an agricultural trade show hosting Norwegian purchasing officials. It was reported that these ships need fresh produce and fruit to supply the equivalent of 10 restaurants per ship and serve up to 2,000 passengers daily. This is another opportunity for diversified agriculture expansion.

Niche Markets. Another potentially profitable market for locally grown produce is the new and largely untapped niche or seasonal overseas market. With a 12-month growing season in Hawaii, it is possible to time the growing and marketing of selected high-value or high-demand produce to parts of the U.S. and Canada during their off-season and non-growing periods. However, careful planning and good business sense will be required to successfully establish niche markets due to such factors as marketing, shipping, quarantine regulations, product shelf life, etc. A successful niche market operation probably will also require adequate funding and a detailed market analysis.

In addition to export niche markets, there is potential for local niche markets such as providing resort hotels and upscale restaurants with specialty fresh fruits and salads. Success depends on close coordination between the chef's needs and farmer's production capabilities. Some farmers have already successfully entered this niche market.

Export Markets. Expansion of the existing export market and development of new diversified crops for export to the U.S., Canada, Japan, and Hong Kong have great potential. Current export crops include papaya, macadamia nut, fresh pineapple, coffee, seed corn, processed guava, orchids, anthuriums, and a variety of nursery plants. Not all of these export crops are candidates for expansion, but those with potential for expansion include papaya, seed corn, flowers, and nursery plants. Most of these export crops are actively grown on all of the major islands and farmers are knowledgeable and experienced in their production and marketing.

Potential new export crops include Asian fruits and vegetables grown in limited quantities for local consumption and introduced by newly arrived immigrants from southeast Asian countries. Such tropical specialty fruits and vegetables show great promise for export since the approval and construction of irradiation plants in Hawaii. With irradiation treatment, fruits and vegetables can be shipped to the mainland in better condition then when treated conventionally by chemical and heat. A detailed evaluation of a specific produce or herb would be needed to determine if it can be profitably grown in Hawaii.

Summary. There is an urgent need to develop a comprehensive statewide agricultural water use and development plan to bring an orderly sense to the current transitional period following plantation closures. There is no organized effort by any central authority to plan and coordinate the future of the thousands of acres of former sugar and pineapple lands and the complex irrigation systems associated with those lands. Without a concerted effort to bring together every stakeholder to discuss, exchange ideas, and evaluate the situation, these fallow lands and irrigation systems could be taken out of agricultural use forever. It is the State's (Legislature and Executive) responsibility to carry out the mandate of Article XI, Section 3, of the State Constitution, which states:

> "The state shall conserve and protect agricultural lands, promote diversified agriculture, increase agricultural self-sufficiency and assure the availability of agriculturally suitable lands. The Legislature shall provide standards and criteria to accomplish the foregoing. Lands identified by the state as important agricultural lands needed to fulfill the purposes above shall not be reclassified by the state or rezoned by its political subdivisions without meeting the standards and criteria established by the Legislature and approved by a two-thirds vote of the body responsible for the reclassification or rezoning action."

The AWUDP is envisioned as one of the necessary tools, a guide, to be used in carrying out this mandate. Unfortunately, there are no large agribusinesses or related organizations to champion the contributions of Hawaii's agricultural industry to the State's overall well-being. Following the demise of the sugar industry, there remains only the State government, together with Federal and County counterparts, to support and recognize agriculture as one of the State's most important industries.

The AWUDP must first explore all facets of the potential opportunity for diversified agriculture. The AWUDP needs to consider what, where, and how to meet the diversified agriculture demand on the potential needs for irrigation water on those former monocrop lands in diversified agriculture.

With properly planned and coordinated assistance from government, Hawaii could realistically become self-sufficient in producing most of its currently imported food supply, including fresh produce, fish, livestock, and poultry. For this to occur, the State must first adopt a viable agricultural water plan and then implement the improvements to the agricultural water systems which will supply the water needed to sustain a diversified agriculture industry.

Chapter 3. PLANNING PROCESS

PURPOSE

The AWUDP has a twofold purpose. The first is to meet the provisions of Act 101, Session Laws of Hawaii by evaluating those irrigation ditches abandoned by plantation closure by proposing a rehabilitation program, and by providing a long-range management plan. The second is to review and discuss the potential for transitioning from monocrop corporate farming into diversified crop farming along with the potential opportunities available in the new diversified farming.

LIMITATIONS AND ASSUMPTIONS

Due to limited funds and time, a comprehensive plan could not be completed. Instead, the HDOA has commissioned this initial planning report to meet the provisions of Act 101, as amended.

A comprehensive agricultural water use and development plan would include several components not outlined in Act 101, but considered necessary to adequately meet the HDOA agricultural water planning guidelines and requirements of the Commission on Water Resources Management (CWRM). The CWRM components include the water demand forecast, water demand areas and type, and projections of water demand over the planning period outlined by the CWRM. Studies of these components have not been funded and are not included in this report.

This report has been prepared on a strict time schedule to meet the reporting mandate of Act 101, as amended. With limited funds and time, a second report is planned (mid-2004), which will include interim agricultural water use requirements as outlined in the Commission on Water Resource Management's AWUDP Integration Framework, dated July 2003.

The assumptions made in preparing this report include the following: (1) construction and rehabilitation cost estimate for improvements and maintenance works are estimates only, and are not based on engineering design plans, (2) in most instances no field assessments of the proposed improvements were made, (3) water service areas were based on old plantation field maps provided by the current system operators and were not field checked for accuracy or status, (4) water use rates were taken from information available in the HDOA's files, (5) certain program and management scheduling was based on anecdotal information and experience of the former HDOA administrator handling those HDOA programs, and (6) operations and maintenance estimates were adapted from HDOA's irrigation program operation and maintenance (O&M) costs.

No studies were conducted to determine the effects of soils, terrain, climate, crop suitability, marketing availability, and related factors normally considered in advance agricultural water planning. This was necessitated by limited funds and a short time schedule.

This report covers only those irrigation systems for which information could be gathered in a timely manner. This report includes most of the inventory, assessment, and estimated rehabilitation cost data of 10 systems presented in the U.S. Bureau of Reclamation and HDOA joint report entitled, *Hawaii Water Resources Study, Agricultural Water Systems, September 2003.* Three additional irrigation systems, which are privately owned, are also included in this report.

FURTHER REQUIRED STUDIES

Other irrigation systems which have not been discussed include the following:

- Island of Kauai
    1. Olokele Ditch
    2. Waiaki-Iliiliula Ditch
    3. Upper & Lower Lihue Ditch
    4. Upper & Lower Haiku Ditch
    5. Koloa & Wilcox Ditches
    6. Anahola Ditch
    7. Kaloko & Puukaele Ditches
    8. Waiahi-Kuia-Waita aqueduct

- Island of Hawaii
    1. Kahena Ditch
    2. Kohala Ditch

- Island of Oahu
    1. Oahu Ditch (consisting of Wahiawa, Helemano, and Tanada)
    2. Opaeula Ditch
    3. Kamananui Ditch
    4. Ito Ditch

Future reports need to identify whether any of these systems are still active and evaluate those meeting the criteria outlined in Act 101, as amended. For privately owned systems, an effort should be made to convince the current owners/operators to have their systems included in the final AWUDP. However, funds for such work are not available.

The AWUDP, as envisioned, should include a comprehensive study of current and future water demand for agricultural programs and projects based upon careful assessment of the future potential of Hawaii's diversified agricultural industry. A 20-year projection period should also be considered. Further, more consideration should be given to the different rates of consumptive water use for different diversified agriculture crops, such as truck crops, orchard, pasture, etc. Climatic factors, such as rainfall, wind, evaporation, sunlight, etc., also need to be considered at each location and evaluated in determining the water requirements of individual crops.

The irrigation systems (source, capacity) and especially their condition need to be updated and field checked as to status of use, zoning, and availability for farming. Further, to facilitate 20-year planning projections, various studies are needed on crop and soil suitability, potential markets, availability of market price support for selected crops, etc.

Chapter 4. EAST KAUAI IRRIGATION SYSTEM

INVENTORY

The East Kauai Irrigation System (EKIS) was built in the 1920s by the Lihue Plantation Co. (LPC) and the East Kauai Water Co. (EKW), which held a water license from the State for all flows in the North Fork of the Wailua River, Kapaa Stream, Anahola Stream, and Hanalei River and their tributaries. The complex system consisted of interconnecting ditches, tunnels, flumes, and reservoirs that collected surface waters from the Hanalei and Wailua Rivers. This system irrigated sugar cane on 6,000 acres in the Kapaa area, 6,500 acres in the Kalepa area (region of the North and South Forks of the Wailua River), and thousands of acres in the Lihue-Hanamaulu area (privately owned area not included in this study). The EKIS included 51 miles of ditches and tunnels, 18 stream intakes, three major reservoirs, and two hydropower plants and the average capacity was 100 to 140 mgd (Map 1).

Kapaa Section. The Kapaa section of the EKIS consisted of 22.5 miles of ditches and tunnels and diverted waters from the North Fork of the Wailua River (Wailua Ditch Intake) and Kapaa Stream (Kapaa Stream Intake). From the Wailua Ditch Intake, water moved east via the Wailua Ditch to the Wailua Reservoir (240 MG), and from there, northeast, through a series of tunnels and unlined earthen ditches to the Upper Kapahi Reservoir (30 MG) and the Lower Kapahi Reservoir (25 MG), located in the Kapaa area. From the Kapaa Stream Intake, water moved via ditches to the Upper and Lower Kapahi Reservoirs. Eight separate laterals (unlined earthen ditches) and a number of "Pani" (control) gates directed water from the Wailua Ditch eastward (toward the coast) to the cane fields.

Kalepa Section. The Kalepa section of the EKIS originally diverted Hanalei River water: (1) through the 6,028 ft Hanalei Tunnel, (2) to a tributary of the North Fork of the Wailua River, (3) down the tributary to Stable Storm Intake located at the 700 ft elevation on Wailua River's North Fork, (4) through Stable Storm Ditch, and (5) to the Hanamaulu Ditch Intake located on Wailua River's South Fork (Map 1). Further upslope and roughly parallel to the Stable Storm Ditch, the Iliiliula-North Wailua Ditch begins at the Blue Hole Intake (1,100 ft elevation) and diverted headwaters of Wailua River's North Fork and Iliiliula Stream south to the Upper Waiahi Hydropower Plant and then east to the Lower Waiahi Hydropower Plant. The Lower Waiahi Hydropower Plant was initially built to provide 600 kW of power for mill operations, four small towns, and pumping water. In the late 1930s, its capacity was increased to 800 kW. A second power plant, the Upper Waiahi Hydropower Plant (500 kW), was built upstream at the 1,050 ft elevation.

From the lower power plant, Iliiliula-North Wailua Ditch water flowed east to Wailua River's South Fork. Downstream, the Hanamaulu Ditch Intake diverted flows from both Iliiliula-North Wailua Ditch and Stable Storm Ditch into Hanamaulu Ditch, a series of ditches, tunnels, and wooden flumes which conveyed water east to cane fields in the Kalepa and Hanamaulu-Lihue areas.

Hanamaulu-Lihue Section. In addition to the Hanamaulu Ditch, the cane fields in the Hanamaulu-Lihue area were served by the Upper and Lower Lihue Ditches which diverted water at the Lower Waiahi Hydropower Plant and from the Hanamaulu Ditch, respectively. This section of the original EKIS is located on privately owned land and is not included in this study.

EXISTING CONDITIONS

The East Kauai Irrigation System, after the closure of the LPC in 2000, continues to be operated as three interrelated sections by two new entities: the East Kauai Water Users' Cooperative (EKWUC), incorporated in March 2001, and the Lihue Land Company (LLC), successor to the Lihue Plantation Co. The principal owners of the system, by virtue of land ownership, are the State of Hawaii and LLC. Some of the distribution and lateral ditches, however, are owned by other entities or in some cases by dual owners.

Kapaa Section. The Kapaa section, which includes the Wailua Ditch and Kapaa Stream Intakes, consists of old facilities which are generally in fair condition with a few exceptions. Lateral 8, a transmission ditch from Upper Kapahi Reservoir to Twin Reservoir, traverses a wooded area, exposing the ditch to intruding tree roots and falling leaves and branches. Ditch water losses occur because of eroded earthen banks and a badly corroded section of corrugated metal pipe. The Wailua, Upper Kapahi, and Twin Reservoirs all have control gates with wooden catwalks that are in disrepair or inoperable.

Kalepa Section. The Kalepa section, which serves the region between Wailua River's North and South Forks, is fed primarily by Stable Storm Intake, as the Hanalei watershed no longer contributes water due to an un-repaired blockage of the Hanalei Tunnel (blockage not repaired due to an unresolved dispute). Stable Storm Ditch then conveys North Fork water to the South Fork and then to Hanamaulu Ditch. Although Stable Storm Ditch traverses mainly on State lands, its waters must traverse a privately owned (LLC) portion of Hanamaulu Ditch. Presently, an agreement among EKWUC, Department of Land and Natural Resources (DLNR), and LLC allows Stable Storm Ditch water to re-enter the State-owned portion of Hanamaulu Ditch (Map 1). Hanamaulu Ditch is in good condition, with heavy vegetation along most of its length, but it is accessible through abandoned cane fields.

ASSESSMENT OF NEEDS

The EKIS is being maintained adequately by the EKWUC, but facilities are old and show signs of long-term neglect. Most of the control gates and their wooden catwalks and gate boards need to be rehabilitated, replaced, or renovated. Several wooden flumes are badly deteriorated and scheduled to be replaced by HDOA. Unlined reservoirs show signs of siltation and heavy tree root intrusion on the embankments. The concrete rubble masonry diversion dams and intakes have been damaged repeatedly by storm flows, as have their concrete aprons. In some instances, repairs are needed to prevent failure of the diversion structures. The tunnels show spalling from loose rocks and soil at their portals and some work is needed to prevent flow blockage. Wailua Reservoir should be assessed for potential liability and safety before it is used for public fishing, as has been proposed. The reservoir embankment needs to meet dam safety standards if opened for public use.

Most of the system's control gates, ditch service laterals, and "pani" (control) gates need rehabilitation and retrofit to meet the requirement for more precise flow control for diversified agriculture instead of sugar cane irrigation. Sugar cane required large amounts of water for short periods and large, roughly-constructed wooden gates sufficed for flow control. On the other hand, diversified agriculture requires a smaller, more regulated flow of irrigation water, thus impacting the size and type of control gates needed. A more comprehensive evaluation should be conducted to determine whether the existing wooden control gates need to be relocated and rebuilt, and if so, the costs.

The Wailua Ditch, a series of ditches, tunnels, and wooden flumes connecting Wailua Reservoir to Upper Kapahi Reservoir, is in overall good condition. However, all control gates, especially those on the reservoirs, are in need of repair. One wooden flume near Kapaa Stream is in urgent need of repair. The Hanamaulu Ditch, consisting of ditches, tunnels, and flumes, is also in good condition having been in active use since LPC closed in 2000. Some rehabilitation work is needed at the Stable Storm Intake and construction of an access road to the intake is needed because it is remote and accessible only by foot. As mentioned under existing conditions of the Kalepa section, water supply from the State's Stable Storm Intake traverses a section of privately owned land. Because of this uncertain situation, a portion of Hanamaulu Ditch should be replaced in the future with a new by-pass pipeline located entirely on State land to assure service to State lands at Kalepa.

If the EKIS should be allowed to go dry, the reservoirs, ditches, tunnels, and wooden flumes would crack, and be subject to extensive water losses. Consequently, every effort should be made to maintain flows.

Plantation closure has resulted in over 1,400 acres of fallow agricultural land in the Kapaa area and 6,500 acres in the Kalepa area inland of Kalepa Ridge. Land use is slowly evolving to diversified agriculture. New privately owned properties in the Kapaa area that need irrigation water include the Kapaa 382 Property, which is subdivided into 19 agriculture-zoned lots, and the Kapaa 1400 Property, which is planned for agricultural use. These two properties may require about 75 percent of the Kapaa section's water supply.

In the Kalepa area, Hanamaulu Ditch continues to flow and the Department of Land & Natural Resources (DLNR) is preparing an agricultural use master plan for 6,500 acres of State-owned lands. After completion of the plan, the DLNR is expected to issue agricultural land leases. Consequently, the water supply of the Kalepa section of the EKIS will need to be evaluated at that time.

PROPOSED CAPITAL IMPROVEMENTS

The Hawaii Department of Agriculture's current effort is to maintain the EKIS's interim flows until related land and water use decisions and policies are made by both private land owners and the DLNR. Based upon those decisions, other improvement measures will be identified for future implementation. However, such future activities are beyond the scope of this study.

The improvements listed below address the more pressing needs and problems determined during the system's assessment. Rehabilitation cost estimates include the complexities of engineering design, environmental permitting and clearances, and acquisition of easement.

1. Rehabilitate Lateral 8 Transmission Ditch. Improvements are needed on leaking ditch bank sections and a 40+ feet section of badly corroded corrugated metal pipe. A temporary repair of the 30" corrugated steel pipe was done by insertion of a polyvinyl chloride pipe to allow continued use, but that repair is leaking badly and is also causing the normal flow in the ditch to become obstructed. The repair has changed the gradient of the ditch and has impacted the water delivery characteristics, which need to be fixed.

2. Replace 100+ feet wooden flume on Hanamaulu Ditch. The flume is subject to flooding and sedimentation and has been temporarily repaired with corrugated metal pipe to allow continued use. The flume's wooden support structure is completely buried and the flume channel is now at ground level. Thus, a future major storm flow may destroy the flume in this dry gulch. Corrective action is needed to clear the storm channel under the flume or replace the flume with a pipe.

3. Rehabilitate Wailua Reservoir, Upper Kapahi Reservoir, Twin Reservoir, and Reservoir 21 (serving Fern Grotto). Rehabilitate wooden access catwalks to control gates and make improvements to bypass gates, and outlet/inlet gates. Most, if not all, of these structures need to be rehabilitated or replaced due to deteriorating materials.

4. Retrofit controls. Most gates were constructed to support sugar cane operations, which required large quantities of water for short periods of time. However, with diversified agriculture, controls are needed to regulate more modest flow. To make this transition, the control, bypass, service laterals, and release gates need to be retrofitted to meet the flow control requirements. Approximately 10 to15 gates will need retrofitting to effectively make the switch.

5. Repair diversion works. Kapaa Stream Intake, Wailua Ditch Intake, Stable Storm Intake, and Hanamaulu Ditch Intake need various improvements to the diversion works (concrete masonry dams and aprons and channel inlet gates).

6. Re-route a portion of Stable Storm Ditch to avoid privately owned lands. The project would involve a new storage reservoir(s) and a new ditch or pipeline alignment. The

existing ditch would need to be redesigned to serve DLNR's master plan for its Kalepa lands and Department of Hawaiian Home Lands' plans for its exchanged Wailua lands.

PROPOSED MAINTENANCE IMPROVEMENTS

The maintenance projects listed below are needed for the same purpose as discussed above. Although they are not considered capital improvements, they are just as important to the system's integrity and continued operations. As a result, they should be given equal consideration for funding and implementation purposes.

1. Remove root intrusions. Prepare a root intrusion removal program to periodically inspect and remove root intrusions along open ditches and inside tunnel entrances. This will improve efficiency of ditch flows..
2. Access road repairs. Need to repair access road to Wailua Ditch intake by grading and installing sub-base foundation and drainage swales to divert storm runoff from road bed.

ESTIMATED COSTS

Estimated costs consist of two types: *Rehabilitation costs,* related to capital improvement projects and *maintenance costs,* related to ordinary operations and maintenance work. Capital improvement projects (CIP), as used in this report, are those which add or improve the value of a system. On the other hand, maintenance costs are for work required for efficient operation of a system on a day-to-day basis.

The table below lists the CIP proposed for the EKIS and their total rehabilitation cost. Capital improvement projects require design engineering, a licensed contractor; and other costs. The total cost is defined as the rehabilitation cost.

CAPITAL IMPROVEMENT COSTS
(EKIS)

No.	Item	Improvements	Construction Cost
1	Lateral 8	Demolish 100 LF of 30" CMP; install 100 LF of new 30" CMP; improve ditch bank; and repair lateral 8 siphon inlet	$ 15,000
2	Hanamaulu Flume	Demolish wooden flume and salvage; excavate unclassified backfill & buried wooden trestle; backfill earthen ditch; install new reinforced concrete flume; and install concrete flume	58,000
3	Twin Reservoir	Demolish catwalks; install new wooden catwalks and concrete platform; creosote treatment for lumber; and install new control gates	216,000
4	Upper Kapahi Reservoir	Demolish catwalk; install new wooden catwalk and concrete platform; creosote treatment for lumber; and install new control gate	216,000
5	Wailua Reservoir	Demolish catwalk; Install new wooden catwalk and concrete platform; creosote treatment for lumber; install new control gate; and retrofit intake gate structure to main transmission line	191,000
6	Reservoir 21	Install new control valve	13,000
7	Control Gates	Retrofit approx. 15 control, bypass & release gates	112,000
8	Diversion Works	Renovate diversion works & inlet gates for intakes on Kapaa Stream, Wailua Ditch, Stable Storm Ditch & Hanamaulu Ditch	100,000
9	Stable Storm Ditch	Re-route portion of Stable Storm Ditch onto State land with pipeline & construct lined reservoir	4,000,000*
		SUBTOTAL	$ 4,921,000
		Overhead (15%)	738,000
		Contingency (8%)	394,000
		Profit (10%)	492,000
		State general excise tax (4.1667%)	205,000
		SUBTOTAL CONSTRUCTION COST	$ 6,750,000
		Construction mgmt (20%)	1,350,000
		Contract admin. (10%)	675,000
		Environmental permitting & clearances**	500,000
		Design engineering (15%)	1,012,000
		Easements acquisition	100,000
		TOTAL REHABILITATION COST	$10,387,000

* Estimate primarily for engineering and survey work
**Estimate based on degree of environmental sensitivity.

The table below lists the maintenance projects proposed for the EKIS and breakdown of maintenance costs required with estimated repair costs. The work can be considered fairly simple to be installed by maintenance crew as part of their routine work schedule.

MAINTENANCE COSTS
(EKIS)

No.	Description of Work	Repair Costs
1	Prepare root intrusion removal program to periodically inspect and remove root intrusions inside tunnel sections and along open ditches	$ 15,000
2	Access road repairs at Wailua Ditch intake by grading and installing sub-base foundation, drainage swales to divert rain storm flows under road bed	85,000
	Subtotal	$ 100,000
	Design Engineering (15%)	15,000
	Environmental Permitting & Clearances*	100,000
	TOTAL MAINTENANCE COST	$ 215,000

* Estimate based on degree of environmental sensitivity.

CRITERIA FOR ESTABLISHING PROJECT PRIORITY

The criteria used to establish the priority of the proposed rehabilitation projects are as follows:

1. Determine which of the proposed rehabilitation improvements will prevent the loss of a critical function of the system i.e. failure of diversion, collapse of tunnel or flume, etc.

2. Evaluate whether the cost of the rehabilitation can be funded within a reasonable period.

3. For the EKIS, meeting the needs and re-establishing service to full-time farmers was a major objective.

4. Improvements that will reduce maintenance work were given higher ranking because this system currently is managed by a single full-time manager.

FIVE-YEAR PROGRAM - EKIS

CAPITAL IMPROVEMENT PROJECTS
(EKIS)

No	Project	Year 1	Year 2	Year 3	Year 4	Year 5	Future Years
1	Lateral 8	▪ acquire rights-of-way or easements	▪ request approp. ▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances	▪ award design & constr. contract ▪ begin construction			
2	Hanamaulu Flume	▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances		▪ award design & constr. contract	▪ begin construction	
3	Twin Reservoir	▪ acquire rights-of-way or easements	▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract ▪ begin construction		
4	Upper Kapahi Reservoir	▪ acquire rights-of-way or easements	▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract ▪ begin construction		
5	Wailua Reservoir	▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract ▪ begin construction			
6	Reservoir 21	▪ request approp.		▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances	▪ begin construction		
7	Retrofit control, bypass laterals, etc.	▪ acquire rights-of-way or easements ▪ request approp.	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction	
8	Repair diversion works, gates, etc.	▪ acquire rights-of-way or easements	▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances		▪ award design & constr. contract	▪ begin construction
9	Re-routing of a portion of Stable Storm Ditch, etc.			▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances		▪ award design & constr. contract ▪ begin construction

MAINTENANCE PROJECTS
(EKIS)

No	Project*	Year 1	Year 2	Year 3	Year 4	Year 5	Future Years
1	Remove root intrusion, etc.	▪ acquire rights-of-way or easements ▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction		
2	Access road repairs, etc.	▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances ▪ award design & constr. contract	▪ begin construction			

*See "Maintenance Cost" in Estimated Costs section of this chapter for a detailed description of work.

LONG-RANGE MANAGEMENT PLAN

The management of the operations, repairs, and maintenance of the EKIS is currently being carried out by the East Kauai Water Users Cooperative (EKWUC) on an interim basis. This interim maintenance is funded through a special annual appropriation from the State Legislature and administered by the HDOA's Agribusiness Development Corporation. This cooperative was established after the closure of the system's former operator, Lihue Plantation Co., with the assistance of the Agricultural Cooperative Office of the USDA.

The majority of the intakes, reservoirs, tunnels, transmission ditches are located on State-owned lands, as are most of the system's service areas. Sections of the EKIS are still under private ownership and the State and EKWUC have existing operating agreements carried over from the plantation period. When the EKIS is fully organized into a cohesive irrigation district, those related private land parcels should be acquired through an easement purchase agreement or long-term lease.

For the EKIS, the most logical step would be to allow the EKWUC become the successor of the irrigation system's management. The EKWUC has a board of directors and its membership is composed of farmers, ranchers and other water users would give credence to having active water users govern the system (home rule concept).

The cooperative's board could, by mutual consent, have authority for setting water rates and fees, collect and enforce such tariff, control expenditures from revenues generated, and have overall operational control for repairs, maintenance, and service to water users. Currently, there is no statutory authority to give a private entity the authority to assume such a role. Such activity may fall under the Public Utility statutes as purveyor of a public commodity. Further evaluation of this matter should be conducted by the HDOA, possibly under the provisions of Chapter 167, HRS.

Another more pressing issue is the future encumbrance of the lands under the system's infrastructure. There exists no formal encumbrance, i.e., lease or easements which provides access and maintenance rights to any one agency. More important is the liability issue of damage or injury during operation and maintenance. The Department of Land and Natural Resources, the agency responsible for the management of the public lands in the Kalepa area, has not made a decision on the disposition of the irrigation system's facilities because management may shift from DLNR to HDOA, pending the implementation of Act 90, SLH 2003 which authorized transfer of agricultural lease lands to the HDOA. Until this Act is fully implemented, the system's management should remain on an interim basis with the East Kauai Water Users Cooperative.

Chapter 5. KEKAHA DITCH IRRIGATION SYSTEM

INVENTORY

The Kekaha Ditch Irrigation System (KEDIS) starts with two intakes at the 850 ft elevation on tributaries of Waimea River in Waimea Canyon. A third intake at the 550 ft elevation on Waimea River itself provides irrigation water for 5,090 acres of cane fields in the flat coastal plains of southwest Kauai (Map 2). The surface water sources were supplemented by pumping several groundwater tunnel sources (Maui-type shafts).

The Kekaha Ditch, also known as the Waimea and the Waimea-Kekaha Ditch, was started in 1906, with 16 miles of ditches, tunnels, flumes, and siphon in Waimea Canyon and four miles in the Kekaha bluffs. Later, the ditch was extended another 8 miles to Polihale. At the 700 ft elevation, the Kekaha Ditch crosses Waimea River from west to east through a penstock to a 1,200 kW hydropower plant on the east side where the system diverts additional water from Waimea River. The ditch water crosses Waimea River again to the west side through a 2,190-ft long steel siphon.

The KEDIS supplied water to Kekaha Plantation and others such as Kikiola Land Co. and Knudsen Land Co. At Waiawa gulch, a 550 kW hydropower plant utilized a 280-ft drop in the ditch system to boost system water to approximately 500 acres of upland cane fields. In the 1920s, the KEDIS had an average flow of 35 mgd (50 mgd maximum).

The KEDIS consists of approximately 27 miles of ditches, tunnels, steel siphons, and wooden flumes, and two hydropower plants.

EXISTING CONDITIONS

From the intakes on Koaie and Waiahulu Streams water flows through tunnels on the west side of Waimea Canyon to a 42-inch diameter steel penstock at an elevation of 700 ft. The penstock then crosses under Waimea River to the Waimea Mauka Hydropower Plant on the east bedrock bank at elevation 550 ft.

Just upstream of the hydropower plant, Waimea River water is diverted into a bedrock tunnel which joins with the power plant effluent in a junction tunnel inside the bedrock river bank. The merged flows exit the tunnel into a 10 ft x 10 ft unlined open ditch.

The ditch then follows the east side of Waimea Canyon through a series of tunnels, ditches, and wooden flumes with a slope of 1 inch per 1,000 ft. The tunnels in this steep canyon section of the system are accessible only at "adits" or original construction openings. The ditch is in fairly good condition, but in certain places there are leaks and seepages which provide some return flow to Waimea River. Two wooden flumes have minor leakages and are in fair condition.

The ditch flow crosses from the east to the west side of the Waimea Canyon through a 36-inch diameter steel pipe inverted siphon. The siphon is buried under the river bed in a concrete jacket.

The ditch continues southward in the west wall of Waimea Canyon and near Waimea town turns westward and follows along the steep coastal bluff at the 400 ft elevation. At Waiawa gulch, 1.5 miles west of Kekaha town, ditch flow is dropped 280 ft in a steel penstock to the Waiawa Hydropower Plant. The ditch along the bluff is mostly an unlined 5 ft x 5 ft ditch with several pipe crossings and culverts to carry flows under intersecting roads. The bluff section of the Kekaha Ditch was cut in basalt rock and has been lined in places with concrete to eliminate excessive leakage. Maintenance is high because of rock debris from storm flows over the bluffs.

At the foot of the bluffs, several scattered unlined earthen reservoirs (2 to 5 million gallons) serve as fore bays to filter stations used to provide clear water for drip and sprinkler irrigation.

ASSESSMENT OF NEEDS

The KEDIS is able to meet current water needs although the system is old and many features need rehabilitation. The unlined ditch along the foot of the coastal basalt bluffs beyond the Waiawa Hydropower Plant (Map 2) requires periodic cleaning of mud and rocks deposited by storm runoff, but there is no road for equipment access.

Deep within Waimea Canyon, the intakes on Koaie and Waihulu Streams show years of damage from storm flows and need rebuilding to assure reliable water flows for the

1,000 kW Waimea Hydropower Plant. Damage to the diversion dams and intake channels should be corrected to prevent failure of the diversion works.

Midway in Waimea Canyon at the penstock fore bay, spillage from the motorized carrier trash rack is corroding the exterior of the penstock. Also, the screw-type bypass valve, used to de-water the penstock, and its catwalk are badly deteriorated.

Approximately a half mile downstream of the junction of the Waimea hydropower plant where waters from the Waimea Intake and the power plant exit a tunnel into an open ditch, there is an existing bypass gate valve. This ditch bypass gate needs to be retrofitted with remote control and a flow recorder. When heavy rains occur in the coastal service area, such a remote-controlled gate would permit convenient and timely release of upper system flows back into Waimea River, preventing ditch overflow damage to the lower part of the system.

As the Kekaha Ditch traverses south along the east walls of Waimea Canyon, its alignment passes through a narrow plateau of highly weathered volcanic soil where several wooden flumes have been subjected to falling rocks from adjacent fractured vertical rock faces. Dislodged basalt blocks may completely damage a flume section and catastrophically disrupt ditch flow as has occurred once or twice in the past, according to anecdotal data. The wooden flume sides need relining due to wood rot and the flumes themselves need protection from potential falling rocks.

In the area upstream of the "black pipe" steel siphon, the unlined ditch is susceptible to an exotic aquatic plant (locally called "Amaju"), which grows well in the ditch and impedes flow. The plant, claimed by the locals to be edible, was imported as an aquarium grass plant, which may have become established by inadvertent disposal. The ditch needs regular maintenance to control its growth. In several places, ditch seepage losses support healthy vegetative growth laterally downslope of the ditch, reaching as far as the Waimea River.

The system's control valves and wooden control gates are outdated for the current diversified agriculture uses being planned. Sugar cane required large (10,000 gallons per day per acre), imprecise flows and controls, but now diversified crop operations require smaller (4,000 gallons per day per acre) flows and better controls. The existing valves and control gates should be retrofitted to meet this new requirement. The same rationale for retrofitting applies to reservoir inlet trash screens, outfalls, control gates and valves. Many of the unlined earthen reservoirs need to be cleaned out and lined, but until leases are awarded it is impossible to determine how many reservoirs will be retained in the KEDIS. However, the concern is mentioned as a potential need at some future date. In cases where the reservoir embankments are dams, dam hazard assessments should be conducted to meet existing public safety regulations.

The KEDIS is currently operated and maintained by an informal agricultural coalition under an interim agreement with the State (DLNR). The State (DLNR) plans to transfer its Kekaha lands and management of the KEDIS to HDOA's Agribusiness Development Corporation.

PROPOSED CAPITAL IMPROVEMENTS

The improvements listed below are needed to continue service to the existing water users of the KEDIS.

1. Waipao Gulch Pipe Crossing. Realign existing 42-inch diameter steel pipe to continue service to Waipao gulch with either a pipe crossing or inverted siphon. The potential site for the new crossing should be moved close to Pump Station No. 1, where access for equipment is readily available. The present crossing is approximately 50 ft long and 15 ft above the gulch floor.

2. Equipment Access Road. Install maintenance road for small construction equipment, along the lower Kekaha Ditch where it intersects with roads, drainage fords, and cattle crossings. The road should be of minimum width to accommodate small construction equipment capable of removing silt, mud, rock, debris, and boulder deposited by heavy runoff.

3. Koaie Stream Intake. Renovate intake on Koaie Stream in Waimea Canyon. Improvements consist of installing trash screens with automatic cleaners, replacing existing manual control gates with remotely operated automatic control gates, and replacing the stream diversion concrete aprons. Maintaining optimum diversion of flows is extremely important to feed the Waimea Hydropower Plant and provide the major portion of ditch flow.

4. Waihulu Stream Intake. Renovate intake on Waihulu Stream in Waimea Canyon. Improvements consist of installing trash screens with automatic cleaners, replacing existing manual control gates with remotely operated automatic control gates, and replacing the stream diversion concrete aprons. Maintaining optimum diversion of flows is extremely important to feed the Waimea Hydropower Plant and provide the major portion of ditch flow.

5. "Black Pipe" Siphon Inlet. Rehabilitate concrete inlet structure of the 42-inch diameter "black pipe" steel siphon on the east bank of Waimea River. The structure is being undermined by leakage at its junction with the ditch and is in danger of failure.

6. Various Control Gates. Retrofitting of control gates involves installing new valves and channeling structures, adding metering devices, and redesigning of existing control facilities. These facilities need to be renovated to meet the requirements for more precise and smaller flow control suited to diversified agriculture, which is different from the more bulk requirements for sugar cane irrigation. The sites are at the following locations: Waimea Mauka fore bay tunnel, Waimea Heights-Menehune Ditch lateral, Pali flumes, near Obake Bridge, and Menehune Ditch junction box. All of these improvements are considered O&M since the improvements do not add value to the system.

7. Pali Flume. In the future, the two wooden flumes that are exposed to falling rocks at the vertical rock face should be replaced with a bypass tunnel. This will eliminate the threat of a catastrophic shutdown of the KEDIS flows.

8. Clean out and install HDPE lining on 14 existing small reservoirs located between Waiawa Hydropower Plant and system terminus at Polihale.

PROPOSED MAINTENANCE IMPROVEMENTS

The KEDIS improvements listed below reflect needs resulting from neglected maintenance by the sugar plantation in the waning years before closure. Although most of the improvements represent typical operation and maintenance work, if undertaken as a single project, the work could be considered as a system upgrade and thus be qualified as capital improvement. One item, the siphon replacement, will eventually qualify for capital improvement due to deterioration.

1. The open ditch along the bluff at the edge of the Kekaha coastal plain needs cleaning of bottom sediments and ditch banks need clearing. The sections are located at Fields 130–127, 125–123, 119–117, 113, and 631; Pump 3; and at Pali flumes to “black pipe” siphon. The build up of sediments has occurred because of the ditch’s exposure to storm runoff and its flat gradient interrupted by many reservoirs inlets which slow flows at these points. It is important to keep the ditch clean as it alleviates overflow flooding and loss of water into the coastal wetland areas, where pumping is required to lower the ground water table to enable crop growth. Again, this work is considered O&M.

2. Although not considered a present need, the black siphon’s 42-inch diameter steel pipe will need some work as the upstream section between the Waimea River’s east bank and the siphon inlet shows signs of corrosion and deterioration. The scope of this study does not include an engineering evaluation of the siphon.

ESTIMATED COSTS

Estimated costs consist of two types: *Rehabilitation costs,* related to capital improvement projects and *maintenance costs,* related to ordinary operations and maintenance work. Capital improvement projects (CIP), as used in this report, are those which add or improve the value of a system. On the other hand, maintenance costs are for work required for efficient operation of a system on a day-to-day basis.

The table below lists the CIP proposed for the KEDIS and their total rehabilitation cost. Capital improvement projects require design engineering, a licensed contractor; and other costs. The total cost is defined as the rehabilitation cost.

CAPITAL IMPROVEMENT COSTS
(KEDIS)

No.	Item	Improvements	Construction Cost
1	Waipao Gulch Pipe Crossing	Demolish pipe; install pipe supports & 42" HDPE siphon	$ 51,000
2	Equipment Access Road(s)	Clear and grub; install pavement (1,000 ft)	22,000
3	Koaie Stream Intake	Install automatic bar screen/cleaner & control gate; install power source, equipment shelter, & concrete apron	143,000
4	Waihulu Stream Intake	Install automatic bar screen/cleaner & control gate; install power source, equipment shelter, & concrete apron	143,000
5	"Black Pipe" Siphon Inlet	Install CRM lining & 20-LF 36-in. HDPE sliplining; replace intake	100,000
6	Various Control Gates	Retrofit control gates with new valves & channel structures; add metering; redesign flow controls at Waimea forebay tunnel, Waimea Heights-Menehune Ditch lateral, Pali flumes, Obake bridge, & Menehune Ditch junction boxg	38,000
7	Pali Flume	Replace two sections of Pali flumes (80 & 120 ft) with bypass tunnel	251,000
8	Reservoirs	Clean, grade, & install HDPE lining on 14 reservoirs between Waiawa and Polihale	2,100,000
		SUBTOTAL	$ 2,848,000
		Overhead (15%)	427,000
		Contingency (8%)	228,000
		Profit (10%)	285,000
		State general excise tax (4.1667%)	119,000
		SUBTOTAL CONSTRUCTION COST	$ 3,907,000
		Construction mgmt (20%)	781,000
		Contract admin. (10%)	391,000
		Environmental permitting & clearances*	1,000,000
		Design engineering (15%)	586,000
		Easements acquisition	125,000
		TOTAL REHABILITATION COST	$ 6,790,000

* Estimate based on degree of environmental sensitivity.

The table below lists the maintenance projects proposed for the KEDIS and breakdown of maintenance costs required with estimated repair costs. The work can be considered fairly simple to be installed by maintenance crew as part of their routine work schedule.

MAINTENANCE COSTS
(KEDIS)

No.	Description of Work	Repair Costs
1	Clean open ditches of bottom sedimentation and clearing the side banks of growth at sections in fields 130-127, 125-123, 119-117, 113, and 631, at Pump 3, and from Pali flumes to black pipe siphon	102,000
2	Repair corrosion, apply protective coating, and repaint black pipe siphon, 42-inch pipe from the inlet end to the east bank of Waimea River	100,000
	Subtotal	202,000
	Design Engineering (15%)	30,000
	Environmental Permitting & Clearance*	250,000
	TOTAL MAINTENANCE COST	$ 482,000

*Estimate based on degree of environmental sensitivity.

CRITERIA FOR ESTABLISHING PROJECT PRIORITY

1. For the KEDIS, the improvements of its water source should have first consideration since they are situated in an environmentally sensitive area.

2. Due to the limited maintenance personnel, give priority to those rehabilitation projects which reduce maintenance workload in the remote sections of the system.

3. Because this system is spread out over long distances, those rehabilitation improvements that provide automation should have higher priority.

4. Due to remoteness and vulnerability to natural forces, those rehabilitation improvements that eliminate the threats should have higher priority.

FIVE-YEAR PROGRAM – KEDIS

CAPITAL IMPROVEMENT PROJECTS
(KEDIS)

No	Project	Year 1	Year 2	Year 3	Year 4	Year 5	Future Years
1	Waipao Gulch Pipe Crossing	▪ acquire rights-of-way or easements	▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances		▪ award design & constr. contract	▪ begin construction
2	Maintenance Equipment Access Road(s) (1000 LF)	▪ acquire rights-of-way or easements	▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances		▪ award design & constr. contract ▪ begin construction	
3	Koaie Stream Intake	▪ request approp.	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction	
4	Waihulu Stream Intake	▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances		▪ award design & constr. contract	▪ begin construction	
5	"Black Pipe" Siphon Inlet in Waimea Canyon	▪ acquire rights-of-way or easements		▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction
6	Retrofit all control gates, etc.	▪ acquire rights-of-way or easements ▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances		▪ award design & constr. contract ▪ begin construction		
7	Replace two sections of pali, etc.	▪ acquire rights-of-way or easements		▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction
8	Grade and Line Reservoirs		▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances		▪ award design & constr. contract ▪ begin construction	

MAINTENANCE PROJECTS
(KEDIS)

No	Project*	Year 1	Year 2	Year 3	Year 4	Year 5	Future Years
1	Clean open ditches of bottom, etc.	▪ request approp.	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances ▪ award design & constr. contract	▪ begin construction		
2	Repair corrosion, apply protective coating, etc	▪ acquire rights-of-way or easements		▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ award design & constr. contract	▪ begin construction	

*See "Maintenance Cost" in Estimated Costs section of this chapter for a detailed description of work.

LONG-RANGE MANAGEMENT PLAN

The entire KEDIS is owned by the State and is to be set aside through a Governor's Executive Order to the Agribusiness Development Corporation (ADC), as allowed by Section 171-11, HRS. The ADC is a semi-private corporation administered by a board of directors, attached administratively to the HDOA. Currently the irrigation system is being managed by an informal Agricultural Coalition under an interim agreement with the State (DLNR). The coalition manages former Kekaha Plantation's entire infrastructure operations, which include drainage, hydropower, and road systems. The informal Agricultural Coalition is in the final organizational stage and is composed of parties interested in continuing agricultural pursuits on former Kekaha sugar lands. The interim management contract should be continued until the ADC makes its decision on the disposition of the set aside lands.

Currently the ADC is contemplating its management role for the operations, repairs, and maintenance of the irrigation system's facilities. The ADC does have statutory authority to set, enforce, and collect water rates and fees; further it has all the powers of the State's executive department in accordance with chapter 163D, HRS. There has been no decision made pending the completion of the governors executive order.

The KEDIS is critical to the safety of the Pacific Missile Range Facility because it is a drainage system that prevents flooding of the low-lying agricultural coastal plain surrounding the coastal facility. The agricultural lands and operations provide a buffer zone from urban uses which allows unrestricted aircraft flight operations and off-shore naval research.

The current O&M agreement with the Agricultural Coalition has been funded by a federal appropriation and more recently through an agreement with ADC. There are negotiations underway between ADC, DLNR and the Agricultural Coalition on the future of this maintenance agreement. Until these negotiations are concluded it would premature to suggest a long range management plan.

Chapter 6. KOKEE DITCH IRRIGATION SYSTEM

INVENTORY

The Kokee Ditch Irrigation System (KODIS), built by Kekaha Plantation in the 1920s, diverted headwaters of the Waimea River from five tributaries (Map 3). The system started at the edge of the Alakai swamp with the Mohihi Intake at approximately 3,400 ft elevation. With connecting ditch and tunnels, the Mohihi Intake was followed, sequentially, by intakes on Waiakoali, Kawaikoi, Kauaikinana, and Kokee Streams. This mountain water was transported via tunnels and ditches 7 miles to Puu Lua Reservoir at 3,260 ft elevation. The system included 48 tunnels averaging 1,000 ft. each in length (maximum 3,000 ft) and totaling 8 miles. The system also included 18 miles of open ditches. Puu Lua Reservoir, a 260 million gallon earthen dam reservoir and the major storage facility for this system, was finished in the late 1920s. The ditch flow capacity was 55 mgd leading up to the Puu Lua Reservoir, but was only 26 mgd below Puu Lua Reservoir to the Puu Moe Ditch divide.

From the Puu Moe divide, the ditch flow capacity to the 36 MG Kitano Reservoir was 19 mgd and to the 88 MG Puu Opae Reservoir, 7 mgd. The KODIS served only the upland cane fields above the Kekaha coastal plain, utilizing the three storage reservoirs—Puu Lua, Puu Opae, and Kitano.

About one-fourth of the KODIS water was used to irrigate upland fields below Puu Opae Reservoir and the remainder to irrigate the upland fields east of Kokee Road.

EXISTING CONDITIONS

The KODIS no longer diverts water from Mohihi Stream, since the intake and connecting ditch have been abandoned. This section's remoteness and high maintenance costs were not cost effective and the water available was not as reliable as the other sources. The Waiakoali Stream Intake is now the high point of the system with water diverted by a concrete dam into an open ditch, a tunnel, and a wooden flume across Kawaikoi Stream. Supported by a wooden trestle, the flume consists of a semi-circular steel trough approximately 200 fe long and about 30 ft over the stream bed. Just upstream of the flume, Kawaikoi Stream is diverted by a natural dam of huge boulders cemented in place that directs flow into a short open ditch and then into a tunnel, joining the flume flows. The Kawaikoi Intake is the KODIS' major source of water.

The third intake is on Kauaikinana Stream which consists of a 15 ft high concrete dam across the stream bed, diverting flows directly into a tunnel. Most of the Kauaikinana Intake flow consists of the combined flows of the Waiakoali and Kawaikoi Intakes which are discharged from a tunnel exiting the stream bank upstream of the intake. The total flows then are conveyed approximately 2.5 miles through a series of tunnels along the rim of Waimea Canyon into the small Kokee watershed where the system's fourth and last intake, a concrete dam, is located on Kokee Stream. The flows enter the Kokee Valley through a series of open ditches.

From the Kokee Intake, a series of tunnels and ditches take the flows through the Canyon's rim onto its western slopes. Most of the ditches and tunnels are well maintained, but the ditches do suffer from frequent vandalism due to the proximity of vacation cabins and a small residential community.

The ditch system continues to Puu Lua Reservoir, which besides storage serves as a public game fishing site. A trout hatchery and fingerling holding pen are located in the reservoir and are managed by the DLNR. The outflow from the reservoir continues to flow near the western rim of Waimea Canyon through a series of ditches and tunnels to the Puu Moe divide.

At Puu Moe divide, the ditch flow is split, with the majority of the flow going to the Kitano Reservoir, which served upland acreages above Waimea. A limited amount of the flow at Puu Moe goes to the Puu Opae Reservoir, which serves only a small area above Mana. The Kitano leg consists of approximately 2 miles of ditches and a couple of tunnels in good condition. The Kitano Reservoir, an unlined cut and fill earthen reservoir, is currently being rehabilitated by HDOA. The Puu Opae leg consists of a smaller ditch, with less flow than the Kitano leg.

The KODIS is currently operated and maintained by an informal agricultural coalition under an interim agreement with the State (DLNR).

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. Temporary repairs are being planned. The entire flume should be replaced 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 sugar cane 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.

ESTIMATED COSTS

Estimated costs consist of two types: *Rehabilitation costs,* related to capital improvement projects and *maintenance costs,* related to ordinary operations and maintenance work. Capital improvement projects (CIP), as used in this report, are those which add or improve the value of a system. On the other hand, maintenance costs are for work required for efficient operation of a system on a day-to-day basis.

The table below lists the CIP proposed for the KODIS and their total rehabilitation cost. Capital improvement projects require design engineering, a licensed contractor; and other costs. The total cost is defined as the rehabilitation cost.

CAPITAL IMPROVEMENT COSTS
(KODIS)

No.	Item	Improvements	Construction Cost
1	Kawaikoi Flume	Demolish flume; install wooden trestle, 48” semi-circular CMP, HDPE lining; structural study	$ 86,000
2	Puu Lua Reservoir	Site work; install HDPE lining on dam; pipe burst/24-inch HDPE discharge pipe; install 24-inch globe valve, and flow meter & appurtenances	144,000
3	Puu Moe Ditch Divide	Site work; install new divide, parshall flumes, and flow meters & appurtenances	47,000
		SUBTOTAL	$ 277,000
		Overhead (15%)	42,000
		Contingency (8%)	22,000
		Profit (10%)	28,000
		State general excise tax (4.1667%)	12,000
		SUBTOTAL CONSTRUCTION COST	$ 381,000
		Construction mgmt (20%)	76,000
		Contract admin. (10%)	38,000
		Environmental permitting & clearances*	1,000,000
		Design engineering (12%)	46,000
		TOTAL REHABILITATION COST	$1,541,000

*Estimate based on degree of environmental sensitivity.

The table below lists one maintenance project for the KODIS with a breakdown of related cost estimates. The work can be considered fairly simple to be installed by maintenance crew as part of their routine work schedule.

MAINTENANCE COSTS
(KODIS)

No.	Description of Work	Repair Costs
1	Retrofit four intake aprons and inlet channels, 6-8 ditch screens, and control gates or valves	$ 90,000
	Subtotal Design Engineering (15%) Environmental Permitting & Clearance* TOTAL MAINTENANCE COST	$ 90,000 14,000 100,000 $ 204,000

*Estimate based on degree of environmental sensitivity.

CRITERIA FOR ESTABLISHING PROJECT PRIORITY

1. For the KODIS, rehabilitation improvements to its water sources are important because they are situated in a very environmentally sensitive and pristine area.

2. Because this system traverses an inhabited recreational area and exposed to public access, it is susceptible to vandalism, and projects that enhance safety is desirable.

3. Projects which reduce maintenance workload should have higher rankings.

FIVE-YEAR PROGRAM – KODIS

CAPITAL IMPROVEMENT PROJECTS
(KODIS)

No	Project	Year 1	Year 2	Year 3	Year 4	Year 5	Future Years
1	Kawaikoi Flume	▪ request approp.	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances		▪ award design & constr. contract	▪ begin construction
2	Puu Lua Reservoir		▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction	
3	Puu Moe Ditch Divide			▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances		▪ award design & constr. contract ▪ begin construction

MAINTENANCE PROJECTS
(KODIS)

No	Project*	Year 1	Year 2	Year 3	Year 4	Year 5	Future Years
1	Retrofit four intake aprons, etc.	▪ request approp.	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances ▪ award design & constr. contract	▪ begin construction		

*See "Maintenance Cost" table in Estimated Costs section of this chapter for a detailed description of work.

LONG-RANGE MANAGEMENT PLAN

The KODIS facilities are all owned by the State and are to be turned over to the Agribusiness Development Corporation for irrigation system operation purposes from DLNR through a revocable permit authorized under Section 171-59, HRS. The revocable permit will authorize the ADC to operate, repair, maintain, and control the KODIS.

Currently, the ADC is formulating its role in the administration of the revocable permit. The KODIS will serve agricultural water to State-owned lands and homestead lands of the Department of Hawaiian Home Lands (DHHL). Now the State-owned lands will be set aside to the ADC as part of the Kekaha parcel's governor's executive order, and as such may be consolidated into a single function, i.e., land and infrastructures for management purpose. No decisions have been made at this writing.

The KODIS is being operated by the same Agricultural Coalition that operates the KEDIS and under the same maintenance contract awarded by the ADC. This interim management function should continue until ADC makes its final decision on the disposition of the entire former Kekaha Plantation facilities.

A portion of the KODIS is being utilized as a recreational and sport fishing site by DLNR and that function should continue under some mutual agreement with ADC. This recreational use basically involves only the upper reaches of the system, ending at Puu Lua Reservoir which is the main storage reservoir for the system. This use is critical to DLNR's mission which would be justification to maintain current ditch flows in the upper reaches of the system.

The system's intake system lies within an environmentally sensitive and pristine area, and has the great potential for alternative uses, such as recreational fishing, hydropower generation, and flood prevention. With the multiple-use potential, the system's operations and maintenance should remain with a government agency that can assemble or has the authority to direct and coordinate the different disciplines and expertise needed for their common interests and objectives. The system will need separate programs, one for repairs and maintenance and the other for development of alternative use projects, in order to best utilize this public asset.

The long-range management plan should be formulated by an adhoc committee composed of a cross-section of all who would benefit from the system's operation.

Chapter 7. PIONEER MILL IRRIGATION SYSTEM

INVENTORY

The Pioneer Mill Irrigation System (PMIS) originally consisted of three ditch systems: (1) the Honolua-Honokohau Ditch, which diverted water from Honokohau Stream and other sources to irrigate cane fields on the northwestern slopes of West Maui between Lahaina and Kapalua, (2) the Lahainaluna Ditch which conveyed water from Wahikuli Reservoir to serve cane fields south of Lahaina, stretching 4.4 miles to Launiupoko on West Maui's southwestern slopes, and (3) the Wahikuli Ditch which conveyed ditch water from Wahikuli Reservoir to serve lower-slope cane fields along a 2.6 mile stretch north to Puukolii Reservoir. Only the Wahikuli and a portion of the Honolua-Honokohau Ditch systems comprise the existing PMIS (Map 4).

The Honolua-Honokohau Ditch developed most of its water from two West Maui areas: (1) the northwestern slopes (Honokohau, Kaluanui, and Honolua Streams), and (2) the western slopes (Honokowai, Amalu, Kapaloa, and Kahoma Streams). However, the sources of water on the western slopes have been abandoned.

The Lahainaluna Ditch utilized both Honolua-Honokohau Ditch water and surface water sources south of Lahaina (Kanaha, Kauaula, Launiupoko, Olowalu, and Ukumehame Streams). The Honolua-Honokohau and Lahainaluna Ditches were complex irrigation systems comprised of stream intakes, transmission and development tunnels, ditches, flumes, inverted siphons across gulches, hydropower plants, and large-capacity sources of ground water from coastal infiltration galleries, called Maui-type shafts. The Lahainaluna Ditch system was not studied because it is no longer a part of the PMIS and does not meet the criteria of involving State water or land ownership. Only that portion of the Honolua-Honokohau Ditch and Wahikuli Ditch, which remain a part of the current PMIS, was studied and described in this report.

EXISTING CONDITIONS

The current (2003) PMIS no longer includes the Lahainaluna Ditch system or the four western slope sources mentioned above. The PMIS, today, consists of two major parts: (1)

the 7.5 mile “front” section located entirely on privately owned land and called the Honolua Ditch, which originally was a ditch system, but now includes tunnels starting at the Honokohau Intake (840 ft elevation) on the north slope of West Maui, two intakes (Kaluanui and Honolua), a siphon across Honokahua gulch, and ending with two reservoirs and a ditch to the inlet of Honokowai siphon; and (2) the “back” section, called the Honokohau Ditch, which consists entirely of ditches and several inverted siphons and flumes, starting at the Honokowai siphon inlet and continuing along ground contour to its terminus at Wahikuli Reservoir.

Honolua Ditch Section. The 7.5-mile long Honolua Ditch consists entirely of 6.5 ft x 6.5 ft concrete-lined tunnels and is privately owned and maintained by Maui Land and Pineapple Company (MLP). This section of the PMIS was not inspected, but is considered to be in good condition (Warren Suzuki, MLP, personal communication). Honolua Ditch started out as a 30-mgd capacity system of unlined ditches, a flume, and five inverted siphons that were completed in 1904 with intakes at the 700 ft elevation on Honokohau, Kaluanui, and Honolua Streams. The unlined ditch system suffered such great seepage loss and damage from storm runoff debris that it was completely replaced in 1913 with cement-lined tunnels (6.5 miles), inverted siphons and 430 ft of open ditch aligned parallel to the 1904 ditch system. Honolua Ranch, predecessor to MLP, built the 1913 system and sold all of the water to Pioneer Mill for sugar cane. Beginning in 1923, Pioneer Mill spent five years in re-lining the Honolua section with cut stones, while increasing its capacity from 50 to 70 mgd.

By the 1980s, the PMIS was used by: (1) MLP for irrigation of its pineapple fields at Kapalua and Wahikuli, and its Kapalua Resort (three golf courses and general landscaping), (2) Maui Department of Water Supply for feed water to its Mahinahina municipal water treatment facility, and (3) Pioneer Mill Company for its Kaanapali Resort irrigation needs.

Honokohau Ditch Section. Prior to plantation closure, Pioneer Mill Company had built and operated the Honokohau Ditch section which extends from Honokowai siphon to Wahikuli Reservoir, a distance of 3.5 miles. In addition to using water from the Honolua Ditch, Pioneer Mill Company developed water from Honokowai Stream and its Amalu and Kapaloa branches in 1898 and 1918. The intakes and high-level groundwater development tunnels, located at approximately 1525-ft elevation, developed an average of over 6 mgd and were used to irrigate Pioneer Mill Company’s upper cane fields.

Amfac/JMB Hawaii, successor to Pioneer Mill Company (which closed in 1996), no longer uses or maintains these three supplemental sources, its coastal Maui-type shaft sources (ground water) at Honokowai, Kahoma, and Wahikuli, or the Lahainaluna Ditch System south of Wahikuli Reservoir, having disposed of its lands which are no longer in agricultural use.

The Honokohau Ditch is lined in places, but mostly unlined, 5 to 8 ft wide, following the topographic contour. The ditch banks are earthen and graded to protect against cross drainage runoff. Steel inverted siphons and flumes consisting of semi-circular steel plates fabricated by the plantation supported on wooden trestles, carry water across gulches and drainage channels. "Pani" (control) gates are scattered along the ditch for releasing irrigation water to fore bays on the down side of the ditch. The fore bays are small unlined earthen reservoirs which provide gravity fed water to filter stations used to provide clear water for drip irrigation.

The Honokohau Ditch terminates at unlined earthen Wahikuli Reservoir (17 MG) where Crater Reservoir (25 MG) and "New" Reservoir (5 MG) are also located (Map 4). "New" Reservoir is a partially lined (cut stone blocks) earthen reservoir that is badly silted, overgrown, and unused. Crater Reservoir occupies a natural volcanic cinder cone crater and receives overflow from Wahikuli Reservoir. Historically, Crater Reservoir has been used to recharge the underlying groundwater aquifer at Pump "M" with surplus water from the system.

Wahikuli Ditch and Pumps "M"and "K". The Wahikuli Ditch, which is concrete-lined and has limited capacity, served some State lands prior to plantation closure, but currently is inactive. The Puukolii Reservoir is the terminus for this ditch.

Pump "M", a Maui-type groundwater shaft source, which provided up to 10 mgd of supplemental and dry-weather irrigation water to Wahikuli Ditch and Reservoir, is completely shutdown, including its plantation-installed power lines. However, Pump "M" remains an important potential supplemental source of irrigation water during droughts and low-flow periods. No longer in use, Pump "M", located 700 ft south of Crater Reservoir, consists of a 322-ft deep vertical shaft which extends to the groundwater table. At the bottom of the shaft is a pump room with two 5± mgd pumps which formerly developed ground water from two horizontal infiltration tunnels totaling 3,800 ft in length. Past records show that Pump "M" produced up to 10 mgd of nonpotable irrigation water. Significant groundwater recharge probably occurs through seepage from unlined Crater Reservoir which occupies a permeable volcanic cinder cone.

Pump "K" is a booster pump station located approximately 700 ft northwest of Crater Reservoir and formerly used to boost water from Pump "M" to Wahikuli Ditch and Wahikuli Reservoir.

ASSESSMENT OF NEEDS

Of all the systems studied, the PMIS is the most fragmented and unsettled, as to ownership and water use, as explained below. However, the State's interest is based on the agricultural water needs of surrounding State lands and the need to continue scenic greenery on West Maui's western slopes for the tourism industry. The original PMIS served lands which are now under different ownerships and, as a result, various components have been dismantled and the current system no longer functions as a single unit. Pioneer Mill Company's parent company is in bankruptcy and other partial owners of the PMIS have no future plans. Consequently, the system's agricultural water uses are of a short-term and interim nature. One of the major problems of the system is the lack of control by a single entity to manage the two sections cohesively for agriculture. An important aspect of the PMIS is its history of providing the scenic greenery of sugar cane and pineapple fields on the slopes of West Maui, a tourist industry attraction. Without irrigation, brown slopes will mar this popular visitor setting. On several occasions, dust storms have occurred south of Lahaina, resulting from abandoned cane fields.

The Honolua section, owned by MLP, is in generally good condition, but needs some rehabilitation work. The Honokohau Intake grating, swivel boom, and silt baffle have been damaged by storm flows and Reservoir 140 at Mahinahina gulch needs cleaning out to restore its capacity and re-lining of the banks to reduce seepage losses (Warren Suzuki, MLP, personal communication).

Much of the Honokohau Ditch section (Mahinahina Weir to Wahikuli Reservoir) is still intact; however, the different elements are either not being used, are abandoned, or are in a state of flux (inactive) pending decisions by separate owners on future water uses. Ownership is a major concern and along the ditch itself several partial ownerships could exist. The current inventory determined that the major owners are Amfac/JMB Hawaii (successor to Pioneer Mill Company), Kamehameha Schools (an educational trust), the State of Hawaii, Peter Martin, and MLP.

The Honokohau section is in relatively good condition, although maintenance has been minimal since plantation closure. The ditch will require continued heavy maintenance due to heavy vegetative growth and there is a concern for ditch bank protection from storm runoff erosion and siltation. The siphons and flumes across gulches are in fairly good condition, except for some flumes needing O&M type improvements.

Wahikuli Reservoir is heavily silted and in need of dredging to restore its capacity. The reservoir serves as the hub for distribution of water by gravity to local fields and to

Wahikuli Ditch, if activated, to serve State and private lands at lower elevations. Wahikuli Ditch is concrete-lined, has limited capacity, and crosses one gulch with an inverted polyvinyl chloride pipe siphon in fairly good condition. Puukolii Reservoir is heavily silted and an evaluation needs to be made of the necessity to rehabilitate it.

Currently inactive, “New” Reservoir is badly silted and in need of dredging to restore its capacity. With rehabilitation, “New” Reservoir can provide supplemental storage to Wahikuli Reservoir.

Because the PMIS has inadequate flows and severally delivers water along its route to MLP’s pineapple fields, the County’s Mahinahina municipal water treatment plant, and to other scattered users, there often is not sufficient water during low-flow periods for those users on the end of the system. Restoring the capacity of Wahikuli and “New” Reservoirs as well as restoring Pump “M” and booster Pump “K” will alleviate this problem.

There is a need to organize the existing individual ditch users and land owners into a cohesive and formal organization, possibly an irrigation cooperative. The purpose would be two fold: first, to settle the matter of ownership and place the entire system under one entity and secondly, to allow for orderly development of responsibilities for operation and maintenance of the entire irrigation system, from Honokohau Intake to Wahikuli Reservoir.

PROPOSED CAPITAL IMPROVEMENTS

The assessment indicates a shortage of ditch flows during low rainfall and corresponding high water-use periods. The PMIS experiences water shortages along its downstream section, especially during drought and low-flow periods. At the same time, a review of existing farming activity reveals there is greater agricultural potential in the downstream section, particularly in the Wahikuli Reservoir area. The improvements listed below are needed to correct both situations by reducing seepage losses, increasing storage capacity, and providing a supplemental/standby groundwater source.

1. Rehabilitate “New” Reservoir. Need to remove accumulation of silt in order to restore reservoir capacity. Install base course, geotextile and HDPE lining.

2. Rehabilitate Wahikuli Reservoir. Need to remove accumulation of silt and sediment in order to restore reservoir capacity. Install base course, geotextile and HDPE lining to reduce seepage losses. Also install new piping and flow control between the reservoirs to allow flow from “New” to Wahikuli Reservoir.

3. Restore Pump “M”. Restoration of Pump “M” with three pumps of 1 mgd capacity each would provide a reliable, supplementary source of water during low ditch flow and drought periods to upper and lower State lands. Restoration would involve the following: removing old horizontal pumps and appurtenances and installing new pumps and discharge piping in the existing vertical shaft and installing new pump controls with building and fencing. Restoration would also include reactivation of electric power to the pump site.

4. Restore Pump “K”. Restoration of Pump “K” is needed to complement the restoration of Pump “M” by making Pump “M” water available to Wahikuli Ditch and Wahikuli Reservoir which serves upper State lands. Restoration would include downsizing Pump “K” to match the restored pump capacity of Pump “M”, installing pump controls, and restoring electrical power to the site.

5. Renovate Honokohau Intake. Honokohau Intake has sustained damage and deterioration from heavy storm flows and its continued function is vital as it is the principal water source for the PMIS. The control gate, known as “Aotaki,” needs to be renovated along with silt baffle. Replace intake grating and swivel boom. Install 200 ft concrete channel and control valve.

6. Renovate Reservoir 140. Reservoir 140 located at the Mahinahina weir is a storage reservoir serving State lands at the boundary with MLP. It is badly silted and its existing cut stone lined banks are eroding and causing seepage losses. The reservoir needs to be cleaned out and its stone lined banks replaced with HDPE lining.

7. Restore open ditch. Install lining on Honokohau Ditch banks to prevent erosion and ditch siltation and to lessen high weed/shrub maintenance.

8. Construct cross drainage structures. Construct concrete intake structures at the various transverse drainage channels and inactive ditch systems intercepted by the Honokohau Ditch. There are at least four major ones. The existing improvements used to capture or control the cross drainage storm flows are minimal, not well planned, and therefore are likely to cause siltation and damage to the Honokohau Ditch.

9. Construct reservoirs at stilling basin sites. Increase the storage capacity of the Honokohau Ditch section by constructing and lining 14 new reservoirs on the upslope side of the ditch to capture storm flows at the location of existing stilling basins and cross-connected ditch systems. With increased water use, there will be a need for more

storage capacity along Honokohau Ditch to offset the incremental reduction in system flows as water users scattered along the ditch withdraw water.

10. Replace Wahikuli Ditch. Replace Wahikuli Ditch with pipeline, laterals, and control valves to serve lower State and private agricultural lands situated along the ditch. Because Wahikuli Ditch has limited service areas and crosses some lands that may become non-agricultural in the future, replace ditch with a closed pipeline system.

11. Redesign flow meter recorder at Mahinahina weir, including reconstruction of the enclosure and replacement of the transmission device.

PROPOSED MAINTENANCE IMPROVEMENTS

The assessment revealed many PMIS concerns caused by inadequate maintenance during the period when the sugar plantation was experiencing financial difficulties. Normal plantation maintenance would have kept this once extensive and complex irrigation system intact. However, when the plantation closed, different owners of land parcels over which the system traversed, particularly from Wahikuli to Olowalu, destroyed the integrity of the original system and left only the Honolua-Honokohau Ditch section (Kapalua to Wahikuli Reservoir) and the Wahikuli Ditch section (Wahikuli Reservoir to Puukolii Reservoir). These two sections, now called the Pioneer Mill Irrigation System, are not well organized because the State (DLNR) has not made any policy decisions on the future use of its related agricultural lands. The assessment indicates that numerous operation and maintenance type improvements are required to adequately serve water in the area. If these O&M improvements were combined into a single system-wide project, they might be considered as capital improvement (the distinction is meaningful in that capital improvements add/improve value and are funded by bonds, whereas O&M improvements do not and are funded by operating revenues).

There is great potential for reclamation of treated sewage effluent on this system, as indicated by ongoing planning activities with Maui County. For example, commercial establishments have expressed interest in utilizing treated effluent for non-agricultural irrigation.

Suggested maintenance improvements for the PMIS include:

1. Repair the tunnel cave-in at the Honokowai siphon outlet. This work is considered O&M, but may qualify as capital improvement as it adds or improves the system's value.

2. Remove silt and sediments from Puukolii Reservoir, Honokohau Ditch, and the associated stilling basins scattered along the entire length of the ditch. However, this work is considered to be O&M rather than capital improvements.

3. Replace the semi-circular shaped steel flume across "B-1" gulch. This flume is constructed of steel sections joined together and supported by interlocking steel straps attached to a wood trestle. Based upon anecdotal information, the steel sections and straps were shop fabricated by the former plantation from thin steel sheets and probably are not available as stock items.

4. Inspect root intrusion along the sides and bottom of tunnels at certain locations along the Honolua Ditch section and initiate program for periodic removal of roots and repairing concrete lining damaged by root intrusion.

5. Repaint exterior and check interior of siphons in the Honolua Ditch section to determine if concrete lining is still intact.

ESTIMATED COSTS

Estimated costs consist of two types: *Rehabilitation costs,* related to capital improvement projects and *maintenance costs,* related to ordinary operations and maintenance work. Capital improvement projects (CIP), as used in this report, are those which add or improve the value of a system. On the other hand, maintenance costs are for work required for efficient operation of a system on a day-to-day basis.

The table below lists the CIP proposed for the PMIS and their total rehabilitation cost. Capital improvement projects require design engineering, a licensed contractor; and other costs. The total cost is defined as the rehabilitation cost.

CAPITAL IMPROVEMENT COSTS
(PMIS)

No.	Item	Needed Improvements	Construction Cost
1	"New" Reservoir	Remove silt; install base course, geotextile, and HDPE lining	$ 328,000
2	Wahikuli Reservoir	Dewater remove silt; install pipe bypass, base course, geotextile, and HDPE lining; Level II dam hazard assessment	2,190,000
3	Pump "M" (Maui-type shaft)	Remove pump house & pumps; install 3 new pumps, 10" D.I. pipe & 10" HDPE pipe, new building, fence & gate; reactivate electrical service	265 ,000
4	Pump "K" (booster)	Remove pump house & pumps; install 3 new pumps, 10" D.I. pipe & 10" HDPE pipe, new building, fence & gate; reactivate electrical service	188,000
5	Honokohau Intake	Replace grating & swivel boom; renovate silt baffle & Aotaki gate; install 200 ft concrete channel, control gate and valve	89,000
6	Reservoir 140	Remove silt; repair cut-stone lining; install HDPE lining & bypass pipe	333,000
7	Open Ditch	Install lining (gunite) on sides of ditches through loose earthen sections	64,000
8	Cross Drainages	Construct 4-6 cross drainage structures to bypass storm flows over main ditch & line approach channel	300,000
9	Stilling Basins	Line 14 stilling & cross drainage sites along ditch	210,000
10	Wahikuli Ditch	Replace Wahikuli Ditch with pipeline, laterals, & control valves	250,000
11	Mahinahina Weir	Reconstruct weir, shelter, and telemetry	50,000
		SUBTOTAL	$4,267,000
		Overhead (15%)	640,000
		Contingency (8%)	341,000
		Profit (10%)	427,000
		State General Excise Tax (4.1667%)	178,000
		SUBTOTAL CONSTRUCTION COST	$5,853,000
		Construction mgmt (20%)	1,171,000
		Contract admin. (10%)	585,000
		Environmental permitting & clearances*	250,000
		Design engineering (15%)	878,000
		Easement acquisition*	175,000
		TOTAL REHABILITATION COST	$8,912,000

*Estimate based on degree of environmental sensitivity.

The table below lists the maintenance projects proposed for the PMIS and breakdown of maintenance costs required with estimated repair costs. The work can be considered fairly simple to be installed by maintenance crew as part of their routine work schedule.

MAINTENANCE COSTS
(PMIS)

No.	Description of Work	Repair Costs
1	Repair tunnel face cavein at Honokoawai siphon outlet site.	$ 250,000
2	Remove silt and sedimentation from bottom of Puukoli, Honokahau ditch sections and six stilling earthen basins.	175,000
3	Replace leaking semi-circular shaped steel flume sections in flume crossing at “B-1” gulch.	36,000
4	Inspect for root intrusion along tunnel sections and initiate periodic root removal program.	10,000
5	Repaint exterior of pipe siphons in Honolua section and conduct interior inspection of pipe siphon to check condition of lining.	150,000
	Subtotal	$ 621,000
	Design Engineering (15%)	93,000
	Environmental Permitting & Clearance*	100,000
	TOTAL MAINTENANCE COST	$ 814,000

*Estimate based on degree of environmental sensitivity.

CRITERIA FOR ESTABLISHING PROJECT PRIORITY

1. Due to the uncertainty facing PMIS’ future, rehabilitation projects which protect the integrity of the system's function is of major importance.

2. As this system does not have a well organized O&M staff, any rehabilitation project that will keep maintenance at a minimum is desirable.

3. This system is critical for maintaining the greenery backdrop on the slopes above the Lahaina-Kapalua visitor destination area, and rehabilitation projects that contribute toward that objective should be given priority.

FIVE-YEAR PROGRAM - PMIS

CAPITAL IMPROVEMENT PROJECTS
(PMIS)

No	Project	Year 1	Year 2	Year 3	Year 4	Year 5	Future Years
1	New Reservoir	▪ acquire rights-of-way or easements	▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances	▪ award design & constr. contract ▪ begin construction		
2	Wahikuli Reservoir	▪ acquire rights-of-way or easements	▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction	
3	Pump “M” (Maui-type shaft)	▪ acquire rights-of-way or easements		▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances		▪ award design & constr. contract ▪ begin construction
4	Pump “K” (booster)	▪ acquire rights-of-way or easements		▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances		▪ award design & constr. contract ▪ begin construction
5	Honokohau Intake	▪ acquire rights-of-way or easements ▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances		▪ award design & constr. contract	▪ begin construction	
6	Reservoir 140	▪ acquire rights-of-way or easements ▪ request approp.	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract ▪ begin construction		
7	Install open ditch lining (gunite)	▪ acquire rights-of-way or easements ▪ request approp.	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction	
8	Construct 4-6 cross drainages	▪ acquire rights-of-way or easements		▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction

No	Project	Year 1	Year 2	Year 3	Year 4	Year 5	Future Years
9	Construct reservoirs at 14 existing stilling basins			▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction
10	Replace Wahikuli Ditch with pipelines, etc.				▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances	▪ award design & constr. contract ▪ begin construction
11	Renovate Mahinahina Weir	▪ acquire rights-of-way or easements ▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances		▪ award design & constr. contract ▪ begin construction		

MAINTENANCE PROJECTS
(PMIS)

No.	Project*	Year 1	Year 2	Year 3	Year 4	Year 5	Future Years
1	Repair tunnel face cavein, etc.	▪ acquire rights-of-way or easements		▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction
2	Remove silt and sedimentation, etc.	▪ acquire rights-of-way or easements ▪ request approp.	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction	
3	Replace leaking semi-circular steel flume, etc.	▪ acquire rights-of-way or easements		▪ request approp.	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract ▪ begin construction
4	Inspect for root intrusion, etc.	▪ acquire rights-of-way or easements	▪ request approp.	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances ▪ award design & constr. contract	▪ begin construction	
5	Repaint exterior of pipe siphons, etc.	▪ acquire rights-of-way or easements	▪ request approp.	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction

*See "Maintenance Cost" in Estimated Costs section of this chapter for a detailed description of work.

LONG-RANGE MANAGEMENT PLAN

The PMIS facilities ownership is divided among many different land owners, which is a major concern for the continuity of the ditch's existence, especially the lower or downstream section (between Mahinahina Weir and Wahikuli Reservoir). The upstream section (between the intakes and Mahinahina Weir) is owned and operated by Maui Land and Pineapple Co. and management is not an issue as it is well maintained. Maui Land & Pineapple Co. has expressed no desire to manage the downstream section at this time.

Presently there is no concerted effort to organize a cooperative among those presently using the system. The system is now managed on an interim basis by the surviving firm of bankrupt Amfac/JMB Hawaii. Much of the system's maintenance work is being deferred until firm commitments are developed by the involved land owners.

The continuation of agricultural use of lands in the region is vital to maintaining the greenery backdrop once provided by sugar cane and to preventing pollution of offshore waters. The current water users are not motivated because the sense of urgency is not yet apparent to them. The initial effort to educate and organize an agricultural water system entity should be taken by the largest land owner, DLNR, which has organizational authority under Chapter 174, HRS, or by the HDOA under Chapter 167, HRS, which provides for the establishment and management of water development projects that have public purpose and public benefit.

The PMIS has multiple-use potential; namely, hydropower generation (the system formerly supported two small hydropower plants), ground water recharge, flood prevention, and recycling treated sewage effluent. However, the major use would still be agriculture and this region could be the test site for selected import replacement. With the region limited to a single highway, limiting the conveyance of goods and services into the area, locally grown diversified agricultural commodities such as eggs, poultry, grass-fed livestock, fresh produce and fruits could offset "imported" items. There needs to be a coordinated effort to bring together farmers and bulk consumer groups (hotels and restaurants) to coordinate supply and demand scheduling, and identifying potential for locally grown agricultural commodities. The long-range management plan should focus on the potential for diversified agricultural farming in the area, rather than on the management of the irrigation system, which will be only a small part of the overall objective of diversified farming for the area. As with the Kokee Ditch Irrigation System, an adhoc committee composed of all existing and potential users of the ditch system should be organized to develop the long-range management plan of the PMIS.

Chapter 8. WAIAHOLE DITCH IRRIGATION SYSTEM

INVENTORY

The Waiahole Ditch Irrigation System (WDIS), started in 1913 by the Waiahole Water Co., developed both surface water and high-level groundwater sources in the eastern (windward) valleys of Oahu for sugar cane irrigation in the leeward part of the island. The system began at the Kahana Intake (790 ft elevation) in Kahana Valley. From Kahana, the system continued south along the windward cliffs and intercepted in succession (via tunnels and intakes) the headwaters of Waikane and Waiahole Valleys. At Waiahole Valley, the system headed west through the Koolau Mountains via a 7 ft x 7 ft, 2.7-mile long trans-Koolau tunnel to its terminus (Reservoir 155) at Honouliuli, a distance of 22 miles (Map 5). The Waiahole Ditch Irrigation System consisted primarily of tunnels from source to central Oahu (25 tunnels connecting the windward sources, the trans-Koolau Tunnel, followed by 13 transmission tunnels in central Oahu). From central Oahu to Reservoir 155, water was conveyed in concrete-lined ditches and across gulches by inverted siphons.

Beginning in 1925, six high-level groundwater development tunnels were constructed over several years with headings directed into the Koolau Mountain (transverse to connecting tunnels). Only four were productive with Uwau and Waikane I Tunnels being the most productive.

EXISTING CONDITIONS

In 1970, the Waiahole Water Company, established in 1913, changed its name to Waiahole Irrigation Company, and later became a wholly-owned subsidiary of Amfac/JMB Hawaii, which also owned Oahu Sugar Company. In 1994, Oahu Sugar Company, which used the bulk of WDIS water, closed its plantation operations. In 1999, the WDIS was purchased by the State of Hawaii and is now managed by the HDOA’s Agribusiness Development Corporation, a State agency governed by an appointed board.

The WDIS currently (2003) is a 22-mile long system of tunnels, ditches, and inverted siphons that takes high-level ground water from four windward development tunnels (Kahana, Waikane I and II, and Uwau) and conveys it to the farm areas in central and leeward Oahu. All of the system's 37 stream intakes have been abandoned, but the four groundwater development tunnels have remained unchanged. The system's approximately 15 miles of tunnels (4 development tunnels, 27 windward connecting tunnels, the trans-Koolau tunnel, and 13 tunnels (3.5 miles) extending from the trans-Koolau tunnel to central Oahu) are all in good condition and have never experienced a major cave-in or blockage. From the last tunnel, WDIS water is carried in cement-lined ditches and siphons to Reservoirs 225 and 155.

There are seven inverted siphons (four metal and three wooden) that move Waiahole water across major gulches. Three are located east and four west of Mililani and they total approximately 7,300 ft in length with the longest being 2,034 ft. All of the siphons are supported above ground on concrete cradles. The three wooden siphons, constructed of 4-inch thick redwood staves to form a 60-inch diameter pipe, were recently replaced with a 36-inch HDPE pipe by the HDOA. The four 72-inch diameter steel siphons (Siphons A, B, C, and D), constructed of riveted 5/8-inch thick steel plates with concrete lining, have been in service for 90 years and show signs of external corrosion of varying degree, especially the rivets. The interior conditions of the steel siphons are unknown.

Reservoir 225 (10 MG) and terminal Reservoir 155 (15 MG) are old, unlined earthen reservoirs which are subject to seepage losses and have diminished storage capacity from years of siltation.

Besides the replacement of the three wooden siphons, other recent improvements to the system include a new HDPE-lined 3-MG reservoir and associated pump station to serve Del Monte pineapple fields. On the windward side of the island in Waikane Valley, two release points were installed to meet the State Water Commission's *Decision and Order* to restore windward streams.

The WDIS now has an average daily flow of 28 mgd, although its transmission capacity is 100 mgd.

ASSESSMENT OF NEEDS

The windward section of the system includes only tunnels: the high-level groundwater development tunnels and connecting transmission tunnels. Access into the transmission tunnels is restricted by a limited number of small openings and a single lane, partially improved access road. Consequently, it is difficult to maintain the windward section of the system.

The Kahana development tunnel, which was bulkheaded about a decade ago by the DLNR in an attempt to restore natural groundwater storage, has the potential of increasing tunnel flow during low-flow periods by releasing high-level ground water stored up during high-flow periods in volcanic dike compartments behind the bulkhead (Figure 1). Further testing is needed to evaluate available storage.

The trans-Koolau tunnel section is in good condition with no reported problems. However, the only means of access through the tunnel is by inflatable raft which has been hampered by lowered water levels due to reduced allocation of windward water.

The open ditch sections (through central and leeward Oahu) that were inspected were in good condition with a few exceptions such as: (1) the roots of trees growing along the ditches have intruded and damaged the side walls, (2) the thin cement lining on the side walls have buckled, cracked, and crumbled, exposing the underlying soil to erosion, and (3) surface runoff from surrounding farm lands have caused heavy siltation and consequent heavy exotic aquatic plant (Amaju) growth along the ditch bottoms, impeding flow.

As the WDIS traverses central and leeward Oahu to its terminus at Reservoir 155 in the Kunia farm area, water is carried across seven moderate to deep gulches via inverted siphons.

Four siphons, consisting of 72-inch diameter pipes constructed of riveted steel panels, cross deep gulches on concrete cradle supports and are badly corroded. Exterior surfaces of the siphons need painting with a protective coating, as most are badly rusted with most, if not all, of the protective coatings gone. One of the concrete cradle supports has been partially undermined by soil erosion (further inspection should be conducted to determine the extent of corrective action needed) and at another, a minor water leak was also observed. Inspection of the siphons' cement lining by a remote-controlled video camera is recommended.

Earthen Reservoirs 225 and 155 have reduced storage capacities due to buildup of sediments and should be cleaned out. Also, lining the reservoirs with HDPE is recommended to eliminate seepage losses. The embankments of both reservoirs are lined with cut stones which need to be re-grouted. The installation of debris catchers and sediment traps at the reservoir inlets are also recommended to prevent debris from entering and silting the reservoirs. Ramps for equipment access into the reservoirs should also be provided.

Ditch water loss, observed during inspection, occurs in the Garst Seed Co.'s 1,300 ft long supply ditch that connects to the WDIS. The unlined supply ditch, approximately 3 ft deep and 10 ft wide, runs parallel to the Waiahole Ditch before entering their reservoir. Although in relatively good condition, this supply ditch should be replaced with a short lateral directly from the main ditch to the Garst Reservoir to eliminate seepage and evaporation losses.

Portions of the Waiahole Ditch and the reservoirs are on private lands. Therefore, before any improvements are made, easements should be obtained.

All of the ditches are concrete-lined, in relatively good condition, and accessible by vehicle for most of their 10-mile length. Besides water for agriculture, the WDIS provides nonpotable water to the Mililani cemetery, the State's Waiawa prison and farm, and the Mililani golf course. The ditch traverses a heavily urbanized area (Mililani), where problems with urban trash (cans, bottles, small appliances, plastic toys, etc.) and storm runoff debris and sediments cause flow restrictions and blockages.

HDOA's Agribusiness Development Corp. operates and maintains the WDIS with operating and maintenance costs, partially offset by water use revenues. Increasing water rates would be counter-productive because existing water users are having a difficult time with existing rates.

PROPOSED CAPITAL IMPROVEMENTS

The Waiahole Ditch Irrigation System is the most established of the systems studied relative to water usage and the means by which delivery and connections are provided. Water users have easy access to water supplies with hookups at their property. The system is well organized and operated by State employees with adequate operational support through water sales revenues. The system's water is limited and strictly regulated due to a contested case ruling by the State Commission on Water Resource Management. The opportunity for expansion of agricultural activity is therefore severely restricted, and must be maximized by improving the system's efficiency to ensure water storage and delivery is achieved with minimal water loss. This is reflected in the needed improvements listed below. This system has the best potential for recycling treated effluent and groundwater recharge. The rehabilitation cost estimates include engineering design and environmental permitting and clearance.

1. Rehabilitate four steel inverted siphons (A, B, C, and D). The siphons are important to the part of the system's transmission of water across central Oahu to the farm lands in Kunia. The 72-inch steel siphons are 90 years old and constructed of riveted steel plates, which typically show exterior rusting and corrosion. The interior concrete lining was not inspected, but a wet, leaking section was noted. The exterior of the siphons need to be restored with paint and a protective coating and HDPE pipe needs to be installed inside the steel siphons.

2. Rehabilitate Reservoirs 155 and 225. The reservoirs are partially silted and the cut stone linings on the embankments are partially damaged. Remove sediments and debris, restore cut stone linings and install HDPE lining to minimize seepage losses. Also, install sediment traps and debris screens at the reservoir inlet.

3. Replace Garst Seed Co. Supply Ditch. Replace and abandon 1,300 ft long, 10 ft wide unlined supply ditch to Garst Seed Company Reservoir with a new lined ditch lateral (with parshall flume) directly from the Waiahole ditch to Garst's reservoir, in order to eliminate evaporation and suspected water losses and provide measured water use.

4. Construct two to three new lined reservoirs located on the leeward side of the WDIS to increase system's storage capacity.

PROPOSED MAINTENANCE IMPROVEMENTS

The system's ability to meet leeward Oahu's irrigation water requirements with dry weather flows has been legally curtailed. Consequently, for system expansion, construction of additional storage capacity will be necessary in order to store excess flows during heavy rain periods.

There is a need to locate ditch water losses or other system leakages and seepages to preserve limited allocations. The improvements needed to meet the above-mentioned concerns include:

1. Survey entire open ditch section. Locate and repair damaged ditch bank linings. Pave or line ditch inverts to stop leakage and prevent aquatic plant "Amaju" growth.

2. Prevent overbank rain runoff and debris from entering open ditches by directing such flows into stilling ponds.

3. Renovate the Kahana bulkhead to control release of stored high-level water during low-flow periods.

4. Use evaporation abatement measures over open ditches and through urbanized section. Consider eliminating selected sections of leeward open ditches with piping, especially near the system terminus.

ESTIMATED COSTS

Estimated costs consist of two types: *Rehabilitation costs,* related to capital improvement projects and *maintenance costs,* related to ordinary operations and maintenance work. Capital improvement projects (CIP), as used in this report, are those which add or improve the value of a system. On the other hand, maintenance costs are for work required for efficient operation of a system on a day-to-day basis.

The table below lists the CIP proposed for the WDIS and their total rehabilitation cost. Capital improvement projects require design engineering, a licensed contractor; and other costs. The total cost is defined as the rehabilitation cost.

CAPITAL IMPROVEMENT COSTS
(WDIS)

No.	Item	Needed Improvements	Construction Cost
1	Reservoir 155	• Remove sediment • Install lining • Repair cut stone wall • Repair overflow channel • Construct sediment trap and floating debris screen at inlet • Remove trees along embankment • General site grading	$ 566,000
2	Reservoir 225	• Remove sediment • Install lining • Replace cut stone wall • Construct sediment trap and floating debris screen at inlet • General site grading	898,000
3	Garst Seed Co. Supply Earthen Ditch	• Seal off earthen ditch connection • Reservoir lateral • Backfill earthen ditch	21,000
4	Siphon A	• Slip line with HDPE pipe • Bypass • Headwork modification	1,054,000
5	Siphon B	• See Siphon A	247,000
6	Siphon C	• See Siphon A	1,538,000
7	Siphon D	• See Siphon A	753,000
8	Reservoir	• Construct 2 to 3 lined reservoirs	600,000
		SUBTOTAL	$ 5,677,000
		Overhead (15%)	852,000
		Contingency (8%)	454,000
		Profit (10%)	568,000
		State general excise tax (4.1667%)	236,000
		CONSTRUCTION COST	$ 7,787,000
		Construction mgmt. (20%)	1,557,000
		Contract admin. (10%)	779,000
		Environmental permitting & clearances*	50,000
		Design engineering (7%)	545,000
		TOTAL REHABILITATION COST	$10,668,000

*Estimate based on degree of environmental sensitivity.

The table below lists the maintenance projects proposed for the WDIS and breakdown of maintenance costs required with estimated repair costs. The work can be considered fairly simple to be installed by maintenance crew as part of their routine work schedule.

MAINTENANCE COSTS
(WDIS)

No.	Description of Work	Repair Costs
1	Inspect and repair damaged ditch sidebanks along entire leeward section from Mililani cemetery to Reservoir 155, pave open ditch inverts and remove aquatic plant growth	$ 250,000
2	Install bank diversion bypass swales of storm flows at open field sites with debris removal basins	55,000
3	Reactivate and renovate existing Kahana bulkhead	50,000
4	Conduct study to eliminate evaporation from open ditches and install piping at high losses section of open ditch and through urbanized section of Mililani and Kunai	150,000
	Subtotal	$ 505,000
	Design Engineering (15%)	76,000
	Environmental Permitting & Clearance*	100,000
	TOTAL MAINTENANCE COST	$ 681,000

*Estimate based on degree of environmental sensitivity.

Annual Maintenance Costs. This system is now composed of a five-man field crew and office staff. They are administratively attached to the HDOA's Agribusiness Development Corporation (ADC). The Board of Directors sets policy and regulates water rates, but the system is managed by the Executive Director of the Corporation. Latest annual maintenance expenditures (FY 2002-2003) show the budget to be $250,000.

CRITERIA FOR ESTABLISHING PROJECT PRIORITY

1. Because the WDIS traverses an urban area, rehabilitation projects that reduce the system's exposure to urban activity should have priority.

2. Those rehabilitation projects that require modest funding and can more readily be installed should be given preference.

3. Preventing and minimizing system water losses is very critical for the WDIS due to mandates limiting water use. Consequently, rehabilitation projects aimed at reducing or preventing losses should have higher priority.

FIVE-YEAR PROGRAM - WDIS

CAPITAL IMPROVEMENTS PROJECTS
(WDIS)

No	Projects	Year 1	Year 2	Year 3	Year 4	Year 5	Future Years
1	Reservoi 155	▪ acquire rights-of-way or easements		▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances ▪ award design & constr. contract	▪ begin construction	
2	Reservoir 225	▪ acquire rights-of-way or easements		▪ request approp. ▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances		▪ award design & constr. contract	▪ begin construction
3	Garst Seed Co. Supply Earthen Ditch	▪ acquire rights-of-way or easements		▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction
4	Siphon A	▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances		▪ award design & constr. contract	▪ begin construction	
5	Siphon B	▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances		▪ award design & constr. contract	▪ begin construction	
6	Siphon C		▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction	
7	Siphon D		▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction	
8	Construct 2 to 3 new lined reservoirs	▪ acquire rights-of-way or easements		▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances		

MAINTENANCE PROJECTS
(WDIS)

No.	Project*	Year 1	Year 2	Year 3	Year 4	Year 5	Future Years
1	Inspect and repair damaged ditch, side banks		▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances	▪ award design & constr. contract ▪ begin construction		
2	Install bank diversion bypass, swales	▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances	▪ award design & constr. contract ▪ begin construction			
3	Reactivate and renovate Kahana bulkhead	▪ acquire rights-of-way or easements		▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances ▪ award design & constr. contract ▪ begin construction		
4	Conduct study to eliminate evaporation, etc.	▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances ▪ award design & constr. contract	▪ begin construction			

*See "Maintenance Cost" in Estimated Costs section of this chapter for a detailed description of work.

LONG-RANGE MANAGEMENT PLAN

The rulings of the State Supreme Court in the Waiahole contested case have placed a precedent-setting water use limitation on the WDIS. The future expansion of the system will not be possible without greater awareness of the benefits of Hawaii's diversified agriculture industry to the State's well being and its need for agricultural water systems. The status quo of the agricultural use and the availability of Waiahole water during drought or low rainfall periods are severely restricted by the water allocations set by the CWRM.

Although the entire WDIS is neither fully owned nor fully encumbered by the State, the ADC can continue to use and provide the necessary management of the system under a memorandum of agreement with other land owners. The current situation of fully funding operations and maintenance of the system through the use of irrigation revenue collected from water users should remain.

This system will need further upgrades such as additional storage reservoirs and other projects to eliminate water losses from the open ditches, because the water allocations do not take into account the water demand of crops during droughts and natural disasters. Such needed capital improvement projects should be funded from a source other than irrigation revenues. Otherwise, water rates would have to be increased, making it uneconomical for farming. A possible alternative would be issuance of special revenue bonds authorized by the Legislature. The ADC has the ability to issue state bonds, which could be used for this purpose, and it should continue as the system's manager for the long term.

Chapter 9. LOWER HAMAKUA DITCH IRRIGATION SYSTEM

INTRODUCTION

This State-owned irrigation system was assessed as part of this study and is fully operational. Because it is an active State-operated system fully funded by HDOA, no inventories of the systems were conducted. The system is managed by the HDOA under authority of Chapter 167, HRS. The system is operated by an irrigation manager and two irrigation system service workers employed by the HDOA. Administrative support is provided by the Department which is governed by the Hawaii Board of Agriculture (HBOA). The HBOA sets policy, approves rules and regulations, and is authorized to establish and enforce water rates. The HBOA is authorized to budget, expend, and contract for capital improvement projects as needed. Operation and maintenance costs of the systems are provided by water use revenues and supplemented with HDOA operating funds; however, capital improvements are financed with State bonds.

EXISTING CONDITIONS

The Lower Hamakua Ditch Irrigation System (LHDIS) was taken over by the HDOA as a result of the closure of Hamakua Sugar Company. The HDOA has a long-term lease with the land owners. Under the HDOA, the LHDIS is being converted from large-scale sugar cane irrigation to small scale diversified crop farming operations. Without an organized cooperative to manage the system, the HDOA entered into a partnership with the USDA Natural Resources Conservation Service (NRCS) and the Hamakua Soil & Water Conservation District to plan system improvements to meet the needs of new small-scale farming operations. Under Public Law 83-566, Watershed Protection and Flood Prevention Act, two studies were undertaken—the first consisted of a crop suitability analysis and the second prepared a watershed plan. These two reports formed the basis for needed improvements to the system. Funding was provided by the HDOA Capital Improvements Program and construction began in 2000. Construction of the Watershed Plan improvements are being carried out incrementally. Presently, the second of four phases is underway. The watershed plan of improvements is estimated to cost $10,592,000 (1997).

The LHDIS (Map 6) originally diverted the headwaters of four streams in Waipio Valley at the 1,000-ft elevation. The system starts at the Kawainui Intake, followed by the Alakahi and Koiawe Intakes. The Waima Intake, currently inactive, is expected to be reactivated. The collection system is gravity fed through a series of transmission tunnels excavated behind the Waipio Valley cliff face. The tunnels are unlined and carved in basalt lava flows. A tunnel section, located close to the cliff, collapsed a decade ago from an overhead landslide, but has now been replaced with a bypass tunnel.

During plantation days, the distribution of water began at the Kukuihaele Weir where the cliff tunnels end and the ditch system begins. The plantation installed service laterals along the entire length of the gravity flow system that extended approximately 14 miles from Kukuihaele to the terminus, Paauilo Reservoir. Most of these service laterals, which consist entirely of buried pipelines, are still being located by the HDOA. Currently, the system is not fully metered.

There are five reservoirs scattered along the ditch system (Honokaia, Haina, Paauhau, Nobriga, and Paauilo), but two are currently (2003) inactive. In addition, several small ponds serve as fore bays for the service laterals. Due to the length of the system (14 miles) a future requirement would be the construction of additional reservoirs at key locations to increase system storage capacity. The existing reservoirs should be lined and their storage capacity evaluated to meet the needs of new diversified agriculture activity.

Currently, only limited farming activity is taking place along the ditch system as the community is still adjusting to the closure of the Hamakua Sugar Company plantation in 1993. New agricultural activity in the area is still in its infancy due to the State's poor economy, the lack of start-up capital for farming ventures, and the difficulty of farmers to obtain loans or financing without having long-term leases on their farm lands.

ASSESSMENT OF NEEDS AND PROPOSED IMPROVEMENTS

The following is an assessment of proposed improvements for the LHDIS which was taken from the Lower Hamakua Ditch Watershed Plan prepared in September 1999 by the USDA Natural Resources Conservation Service under the Watershed and Flood

Prevention Act, Public Law 83-566. The Watershed Plan has been approved and accepted by the local project sponsors: HDOA and by the respective local Soil & Water Conservation District in which region the project is located.

Flume Replacement and Repair. The elements of the LHDIS that pose the greatest threat of failure are the flumes and support structures. An examination of the 50 flumes between the Main Weir and Paauilo Reservoir indicated that 24 wooden flumes still exist. The wooden flumes are typically constructed of two-inch thick redwood and their support structures are constructed of four inch by four inch and larger redwood. All of the wooden flumes are in need of repair due to dry rot. Emergency repairs to the flumes have been made using plywood and treated Douglas Fir or similar lumber which has proven to be inferior to the original redwood.

Ditch Lining Repair and Sediment Removal. The severely damaged concrete-lined open ditch sections need to be repaired. While cracking of the lining is extensive, only those sections with broken and missing lining, upheaval, intrusion of roots, significant leakage, or open to sediment sources will be repaired. It is estimated that ten percent of the channel lining needs to be repaired. Removal of sediment from the open ditch sections is needed. Sediment in flumes and tunnels will not be removed unless site is accessible. The deposited sediment depth is estimated to average one foot throughout the system.

Reservoirs. Storage of water during nighttime periods will be necessary due to the difficulty in controlling diversion rates during daylight. In short, during the peak demand periods when 14 million gallons per day is needed by farmers and other users, it is expected that most of the demands will take place during the 8 to 12-hour work day. Storage, equivalent to the volume of 12 to 16 hours of ditch flow, will be required if all-day irrigation cycles are to be avoided. At a minimum, 10 MG of storage volume is needed. Additional storage capacity will be needed if a shutdown of the LHDIS for more than a day is needed.

Presently, the four reservoirs of the LHDIS have a combined storage capacity of 31 MG. However, the poor location of the reservoirs on the Paauilo (east) end of the service area leaves much of the project area without water-leveling or storage capability. On the other hand, the farmlots at Honokaia on the west end of the system is a rapidly developing agricultural area without adequate reservoir capacity.

The four existing reservoirs will be used by the LHDIS. A new one-MG reservoir will be installed at Honokaia to serve the new farms. The Paauilo Reservoir will be lined to eliminate seepage losses. Water users will be encouraged to develop reservoir capacity on their farms to ensure adequate water when it is needed.

Lateral Pipeline Systems. Approximately ten lateral distribution systems will be repaired or installed. Many of the lateral systems will incorporate existing pipelines and appurtenances installed during sugarcane cultivation. Sediment ponds and screen filters will be used at each lateral system.

Sixteen lateral systems from the main ditch were used by Hamakua Sugar Co. to irrigate their cane fields. The lateral systems with their filters and screens are still in existence.

Screening and Filtration. A screen filter box or other filtration is needed at each inlet to a lateral system to prevent damaging sediment and floating debris from entering the lateral pipeline system. Some farmers using fine orifice drip systems may need to provide additional filtration on their farms.

Pipeline Systems and Pressure Regulation. Each irrigation subarea will eventually be served by one or more lateral distribution systems which provide water to farmers and ranchers from the LHDIS or one of its reservoirs. Most of the lateral pipeline systems that are currently being used require repair or replacement of components to avoid chronic breakdowns and excessive maintenance. New lateral systems for four subareas will be needed in the short-term future, but other subareas will require more time to be developed and the needed irrigation lateral systems will be installed at a later time. Re-activation of some of the unused lateral systems will also be undertaken.

Water Meters. Water meters will be provided by the LHDIS at the parcel boundary for water users connected to the lateral system and at the ditch takeoff for water users connected directly to the open ditch.

Intakes. Three of the four existing intakes on Waipio Valley streams—Kawainui, Alakahi, and Koiawe—will be reconstructed. The reconstructed intakes will be configured and/or controlled to limit the amount of water diverted to the amount of water demand plus a fraction for seepage, evaporation, and other system losses. System losses are roughly estimated at 3 mgd after the improvements to the system are completed.

The Kawainui Stream diversion will provide operational control over diversion rates for the LHDIS. The Kawainui Stream concrete dam structure will be repaired to fill the structurally threatening void that has developed under the concrete apron. The inlet box will be reconstructed to use a commercially available grating that is angled to be self cleaning. The sand trap will be repaired and fitted with a powered gate that is capable of remote control. The dump gate on the concrete flume will be replaced with a remotely controlled powered gate to control flow in excess of the Hamakua area agricultural water need back into Kawainui Stream.

The intakes at Alakahi and Koiawe Streams will be repaired and reconstructed. Remedial work on access path blockage will also be conducted at each intake to provide adequate visitation access.

Hakalaoa Falls. The construction of a bypass transmission tunnel behind Hakalaoa Falls has been completed and is mentioned for completeness only

SCADA. A Supervisory Control and Data Acquisition (SCADA) system is needed to allow remote data collection and operation of key components of the LHDIS. The data collected by the SCADA system include: flows at the stream diversions, flows at the Main Weir, flows at the lateral systems, storage levels at the reservoirs, and overflow at dump gates. The components that will be controlled by the SCADA system will include the variable diversion gate and sand trap gate at the Kawainui Stream Intake, the dump gate at the Main weir, inlets to the reservoirs, and main gates on the lateral pipeline systems. The use of SCADA to monitor diversion rates at Alakahi and Koiawe Streams will also be considered to comply with the CWRM requirement for water measurement in the system.

The SCADA controls located along the open ditch (for valve actuation and remote terminal unit function) will be connected to the HELCO power supply. Monitoring stations will mainly use solar array and battery unless HECO electrical power is readily available.

The power requirement at the remote Kawainui Stream diversion structure to operate the variable diversion gate, sandtrap gate, flow monitoring gage, and Remote Terminal Unit will be provided by a combination of solar array, and/or micro-hydropower generator and storage batteries. Lack of sufficient sunlight and the variability of stream flows may require both forms of electrical power generation to keep the batteries charged.

A remote relay station will be required for the Kawainui RTU, which does not have line-of-sight access to the Hamakua area. A possible site for the relay station is on the Waipio Valley rim on the ridge between Koiawe and Waima Streams, near the Upper Hamakua Ditch. The site lies within the Conservation District and will be powered by a solar array.

The use of SCADA controls at the Alakahi and Koiawe Intakes was considered, but was not included in the project due to the difficulty of installation and transmission. Manual controls to adjust stream diversion and provide sediment flushing will continue to be used at these intakes.

The Lower Hamakua Ditch Watershed Plan provides for the repair and restoration of LHDIS and effectively addresses the problems of water storage capacity and system reliability. The Plan supports State and County objectives of providing economic opportunities for displaced sugar workers and assisting in the revitalization of the region's economy.

ESTIMATED COSTS

CAPITAL IMPROVEMENT COSTS
(LHDIS)

No.	Item	Improvements	Construction Cost
1	Land Treatment	Conservation Practices	$1,000,000
2	Land Treatment	Technical Assistance	200,000
3	Land Treatment	Waipio Valley Assistance	100,000
4	Ditch	Repair Flume	1,615,000
5	Ditch	Remove Sediment	191,000
6	Ditch	Repair Concrete Lining	700,000
7	Intake	Modify Intakes	200,000
8	System	Install Lateral System	1,000,000
9	Ditch	Install Exclusion Fencing	170,000
10	Intake	Install SCADA System	500,000
11	Waima Intake	Reactivate	250,000
		SUBTOTAL	$5,926,000
		Contingency (20%)	1,185,000
		SUBTOTAL CONSTRUCTION COST	$7,111,000
		Engineering (20%)	1,422,000
		Project Admin. (12%)	853,000
		Land Rights	200,000
		TOTAL REHABILITATION COST	$9,586,000

Source: Modified after *Lower Hamakua Ditch Watershed Plan and Final EIS, September 1999.*

Note: There are no proposed maintenance improvements for the LHDIS, as of this writing.

Presently, the HDOA contracts out the annual maintenance of the system through competitive bidding by qualified firms. Maintenance of the LHDIS will revert back to the HDOA upon completion of the Watershed Project. Administrative and accounting responsibilities are now provided by staff at the main HDOA office. Upon completion of the Watershed Plan, the annual maintenance costs of the LHDIS is estimated in the table below.

ESTIMATED ANNUAL MAINTENANCE COSTS
(LHDIS)

Item	Units needed	Cost
PERSONNEL AND FACILITY		
Manager	1	$ 75,000
Crew	3	105,000
Clerical	1	25,000
Office and yard		30,000
EQUIPMENT (annual cost)		
Pickup Truck	2	8,000
Backhoe	1	10,000
Truck-trailer	1	10,000
Spray truck	1	5,000
Rental		10,000
Maintenance and Repair		10,000
SUPPLIES		
Herbicide		100,000
Office operation		8,000
TOTAL		$ 396,000

Source: Modified after *Lower Hamakua Ditch Watershed Plan and Final EIS, September 1999.*

CRITERIA FOR ESTABLISHING PROJECT PRIORITY

The repair, rehabilitation, and/or replacement of components of the LHDIS are to ensure dependable operation of the system. Those components that are in a condition where failure is imminent and can affect the flow in the ditch system will receive highest priority for action. Next priority will be given to components with high rates of water loss. Third priority will be given to elements that will reduce maintenance costs. Special priority will be given to features providing environmental and social benefits, including restoration of the tunnel at Hakalaoa Falls and modification of the Waipio Valley stream diversion structures to partially release stream flow.

FIVE-YEAR PROGRAM - LHDIS

SEQUENCE OF INSTALLATION AND SCHEDULE OF OBLIGATIONS (LHDIS)

Year	Cost Item	Federal & Other Sources
1	**Land Treatment**	
	Conservation Practices	$ 250,000
	Accelerated Technical Assistance	50,000
	Waipio Valley Assistance	25,000
	Construction	
	Hakalaoa Falls Tunnel	completed
	Engineering Services	
	Hakalaoa Falls Tunnel	completed
	Sediment Removal	23,000
	Flume Repair	194,000
	Intakes Modification	24,000
	Concrete Lining Repair	84,000
	Project Administration	
	Hakalaoa Falls Tunnel	completed
	Land Rights	200,000
	TOTAL YEAR 1	$ 850,000
2	**Land Treatment**	
	Conservation Practices	$ 250,000
	Accelerated Technical Assistance	50,000
	Waipio Valley Assistance	25,000
	Construction	
	Sediment Removal	229,000
	Flume Repair	1,938,000
	Intake Modification	240,000
	Concrete Lining Repair	840,000
	Engineering Services	
	Sediment Removal	23,000
	Flume Repair	194,000
	Intake Modification	24,000
	Concrete Lining Repair	84,000
	Exclusion Fencing	20,000
	SCADA	40,000
	Lateral Systems	79,000
	Project Administration	
	Sediment Removal	28,000
	Flume Repair	232,000
	Intake Modification	29,000
	Concrete Lining Repair	101,000
	TOTAL YEAR 2	$ 4,426,000

Year	Cost Item	Federal & Other Sources
3	**Land Treatment**	
	Conservation Practices	$250,000
	Accelerated Technical Assistance	50,000
	Waipio Valley Assistance	25,000
	Construction	
	Exclusion Fencing	204,000
	SCADA	300,000
	Lateral Systems	600,000
	Engineering Services	
	Exclusion Fencing	20,000
	SCADA	40,000
	Lateral Systems	79,000
	Honokaia Reservoir	completed
	Paauilo Reservoir Lining	completed
	Project Administration	
	Exclusion Fencing	25,000
	SCADA	36,000
	Lateral Systems	72,000
	Land Rights	200,000
	TOTAL YEAR 3	$1,901,000
4	**Land Treatment**	
	Conservation Practices	$ 250,000
	Accelerated Technical Assistance	50,000
	Waipio Valley Assistance	25,000
	Construction	
	SCADA	300,000
	Lateral Systems	600,000
	Honokaia Reservoir	completed
	Paauilo Reservoir Lining	completed
	Engineering Services	
	SCADA	41,000
	Lateral Systems	82,000
	Honokaia Reservoir	completed
	Paauilo Reservoir Lining	completed
	Project Administration	
	SCADA	36,000
	Lateral Systems	72,000
	Honokaia Reservoir	completed
	Paauilo Reservoir Lining	completed
	TOTAL YEAR 4	$ 1,456,000

Source: Modified after *Lower Hamakua Ditch Watershed Plan and Final EIS, September 1999.*

Chapter 10. MOLOKAI IRIGATION SYSTEM

INTRODUCTION

This State-owned irrigation system is assessed as part of this study and is fully operational and because it is an active State-operated system fully funded by HDOA, no inventories of the system was conducted. The Molokai Irrigation System (MIS) is managed by the HDOA under authority of Chapter 167, Hawaii Revised Statutes. The system is operated by an irrigation manager and two irrigation system service workers employed by the HDOA. Administrative support is provided by the Department which is governed by the Hawaii Board of Agriculture (HBOA). The HBOA sets policy, approves rules and regulations, and is authorized to establish and enforce water rates. The HBOA is authorized to budget, expend, and contract for capital improvement projects as needed. Operation and maintenance costs of the systems are provided by water use revenues and supplemented with HDOA operating funds; however, capital improvements are financed with State bonds.

EXISTING CONDITION

The Molokai Irrigation System's (MIS) sole water source is the Waikolu Valley Watershed. Three intakes divert stream flows at the 1,000 ft elevation into the Molokai Tunnel. And a fourth intake with a pump station at the 800 ft elevation lifts stream flows to the Molokai Tunnel inlet portal (Map 7). Five wells, remotely operated from the office, provide supplemental supply of ground water from the valley, during droughts and low-flow periods. The five-mile long Molokai Tunnel, which conveys water through the mountain by gravity to the central Molokai farms, is the only vehicular access into Waikolu Valley, where diversion works are located in a narrow, V-shaped valley. The intakes become clogged and require frequent maintenance. Electric power for the pumps, controls, etc. is provided by a high voltage line installed on the tunnel roof. This power line is plagued with outages, shorts, and electrical leaks due to high humidity and dampness. Future electrical improvements will be required. The pump and motors also experience frequent problems from short circuits and motor failures. Consequently, adequate access through the tunnel is needed for maintenance.

Water exiting the Molokai Tunnel on the leeward side of the island, is gravity fed through a short length of concrete flume into a 30-inch steel pipeline that extends to the system's terminus, the 1.4 billion gallon Kualapuu Reservoir.

The MIS originally served large-scale pineapple operations, but was converted to serve diversified agriculture after pineapple operations closed in the late 1970s. The system also serves the native Hawaiian homesteads in Hoolehua, a large coffee farm, and a seed corn operation. The intensive diversified farming activity on Molokai which reached a peak during the 1990s has stabilized in recent years, due to the availability of new farming opportunities on the lands left vacant on Oahu and Kauai by sugar plantation closures. Water use at the system has remained constant. The distribution system is composed entirely of gravity-fed pipelines except for a small section of land north of Kualapuu Reservoir where a booster pump and a small steel tank provide sufficient hydraulic pressure.

The system's Waikolu Valley water source has experienced severe droughts over the past few years. Shortage of supply and past water use has kept the system in a conservation mode for the past several years. Additional water sources are needed during droughts and possible sources include brackish water wells and the recycling of sewage effluent. The MIS Water Users Advisory Board has developed potential solutions that need to be implemented. The estimated cost for these improvements is $4,009,000. Another problem for the system is the large size of Kualapuu Reservoir. Its 1.4 billion gallon capacity causes major evaporation losses estimated at 1 mgd. Furthermore, with the low reservoir levels experienced during recent droughts, the bottom 3 to 4 ft of reservoir water (estimated at 7-10 million gallons) are unusable. Preliminary studies conducted by HDOA indicate a mitigating solution by possibly dividing the reservoir into two or more compartments.

The system serves approximately 235 customers with annual water use of 1.224 billion gallons (3.35 mgd) on 3,102 acres. The operation and maintenance of the system is funded from water use revenues and supplemented by HDOA operating funds.

The MIS was planned, designed, and constructed under a special Act of Congress (Reclamation Act of 1954) and the BOR's Small Reclamation Projects Act loan program. The loan has been fully repaid from water revenues.

ASSESSMENT OF NEEDS

The MIS has experienced severe drought conditions over the past five years. This has depleted the storage reservoir and source supplies of the system. It has been determined that the size of the system's single reservoir is too large because it is difficult to maintain the reservoir water level due to greater losses from evaporation. A study is needed to determine the optimum reservoir size for the system's current operational needs, which has changed since the project was designed.

The system is approaching its project life and needs to begin replacement of its major components. The first is to install a modern up-to-date telemetry system. The present system was based on technology now outmoded. It must schedule the replacement of its moving parts, i.e., gate valves, pumps, electrical wiring, etc.

In order to meet water users' demand, the system must consider the development of additional water sources other than being dependent on its present sole water source in Waikolu Valley.

PROPOSED CAPITAL IMPROVEMENTS

The HDOA formed an adhoc committee under Chapter 167 to allow water users' input in the development of projects. The committee entitled, "MIS Water Users Advisory Board" assumed the lead in preparing alternatives, accepting input from water users and the public and developing recommendations. The capital improvements discussed below were taken from their report. The purpose of these proposed improvements is to increase water sources to maintain an adequate water level in the 1.4 billion gallon Kualapuu Reservoir.

1. Kawela Stream Diversion. Plans are to capture additional storm flows in Kawela Stream by increasing the height of the dam. Preliminary engineering indicates that a 2 ft high extension of the dam with an 8-inch diameter pipe can divert flows up to 2 mgd. It is estimated that frequent winter storm flows could provide enough additional water supply to justify the estimated construction cost opf $4.3 million
2. Activate unused well. There is an existing, unused 12-inch diameter brackish water well located in the upper part of Kaunakakai Gulch which could be activated as a

brackish water source. The salinity of the well water (1300 ppm) is low enough that if mixed with the fresh water in Kualapuu Reservoir it would increase water supply without adversely impacting the utility of the MIS water supply. The well is located approximately 500 to 600 feet from the MIS'main transmission pipeline. The estimated cost to convert the unused well into a production well is estimated at $0.5 million. However, conversion may involve acquisition of the well site by eminent domain and installation of electrical service to the site, in which case the cost escalates to $1.0 million.

3. Waihanau Stream diversion. Renovate the abandoned diversion dam so that only storm flows (not base flows) are diverted into the existing supply pipeline. Storm flows of up to 0.5 mgd would be captured during the winter months, possibly justifying the estimated $1.8 million construction cost.
4. Install a new modern telemetry system to replace the existing antiquated system.

PROPOSED MAINTENANCE IMPROVEMENTS

1. Convert pumps from electrical to diesel power, except those located in Waikolu Valley. Estimated cost is $0.8 million, however, environmental permitting for diesel fuel storage and handling may increase costs to approximately $1.0 million.
2. Replace mechanical valves, meters, etc., based on an annual schedule of an estimated $100,000 per year for five years.
3. Partition Kualapuu Reservoir (1.4 billion gallons) to an efficient size for current operations.

ESTIMATED COSTS

CAPITAL IMPROVEMENT COSTS
(MIS)

No.	Item	Improvements	Construction Cost
1	Kawela Stream Diversion	Raise existing diversion dam height two ft.	$ 4,300,000
2	Activate Unused Well	Install new well casing. Tap into and extend power line to well site. Install submersible turbine pump & motor. Construct inlet and junction boxes. Install connecting pipeline from well to transmission pipeline.	1,000,000
3	Waihanau Stream Diversion	Renovate Waihanau Stream intake. Construct new inlet box. Install pipeline with junction box to connect onto existing pipeline. Extend pipeline to junction with transmission line.	1,800,000
4	Telemetry System	Install new telemetry system. Connect all system's facility to central control station at office building. Install instruments, computer programs, and appurtenant works. Connect to power sources or install portable power sources.	750,000
		SUBTOTAL	$ 7,850,000
		Overhead (15%)	1,178,000
		Contingency (8%)	628,000
		Profit (10%)	785,000
		State General Excise Tax (4.1667%)	327,000
		SUBTOTAL CONSTRUCTION COST	$10,768,000
		Construction mgmt (20%)	2,154,000
		Contract admin. (10%)	1,077,000
		Environmental permitting & clearances*	1,000,000
		Design engineering (10%)	1,077,000
		Easements acquisition	700,000
		TOTAL REHABILITATION COST	$16,776,000

*Estimate based on degree of environmental sensitivity.

MAINTENANCE COSTS
(MIS)

No.	Description of Work	Repair Costs
1	Remove and dispose of electrical connections and controls. Install new controls, motors, and diesel storage tanks. Convert existing facilities to diesel operation.	1,000,.000
2	Locate and test existing valves, meters, etc. Replace those found defective or outdated. Provide replacement inventory of spare parts and materials. Provide testing equipment and maintenance tools.	100,000
3	Construct concrete "curtain" walls inside Kualapuu Reservoir. Construct junction boxes between cells. Reroute inlet pipeline to serve all cells simultaneously.	1,300,000
	SUBTOTAL	$2,400,000
	Design Engineering (15%)	360,000
	Environmental Permitting & Clearance*	250,000
	TOTAL MAINTENANCE COST	$3,010,000

*Estimate based on degree of environmental sensitivity.

This system is funded from the revolving special fund within the HDOA's operating budget for the program. The Molokai and Waimea Systems are composed of a three-man field crew, whereas the Waimanalo system is composed of a four-man field crew; the entire accounting and bookkeeping function for the systems are centralized at the main office as is the management of the entire program through the Agricultural Resource Management Division Administrator. The latest actual annual expenditure figures (FY 2001-2002) for this program show the budget to be $1,347,000 which provides operational funding for the program. It is difficult to separate out the maintenance costs for individual systems, at this time, due to time constraints.

CRITERIA FOR ESTABLISHING PROJECT PRIORITY

1. The improvement project that provides the quickest relief for filling the Kualapuu Reservoir should have highest priority.

2. The MIS, with its limited revenue potential, needs to be carefully evaluated with respect to the commitment of funds, since major farming activity has declined.

3. Any rehabilitation project that protects against droughts should have higher priority.

FIVE-YEAR PROGRAM – MIS

CAPITAL IMPROVEMENT PROJECTS
(MIS)

No	Project	Year 1	Year 2	Year 3	Year 4	Year 5	Future Years
1	Kawela Stream	▪ acquire rights-of-way or easements	▪ request approp. ▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances		▪ award design & constr. contract		▪ begin construction
2	Monitor Well	▪ request approp.	▪ acquire well site	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract ▪ begin construction	
3	Waihanau Stream	▪ acquire rights-of-way or easements	▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances		▪ award design & constr. contract	▪ begin construction
4	Install new telemetry system	▪ request approp.	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction	

MAINTENANCE PROJECTS
(MIS)

No	Project*	Year 1	Year 2	Year 3	Year 4	Year 5	Future Years
1	Remove and dispose of electrical, etc.		▪ request approp. ▪ conduct prelim. eng. & select consultant		▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction
2	Locate and test existing valves, etc.	▪ request approp.	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction	
3	Construct concrete, etc.	▪ request approp.	▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances		▪ award design & constr. contract		▪ begin construction

*See “Maintenance Cost” in Estimated Costs section of this chapter for a detailed description of work.

Chapter 11. UPCOUNTRY MAUI IRRIGATION SYSTEM

INTRODUCTION

The Upcountry Maui Irrigation System is currently under development by the HDOA in conjunction with Maui Department of Water Supply (MDWS), the USDA Natural Resources Conservation Services, and the Olinda-Kula Soil and Water Conservation District.

The HBOA will own, construct, and administer the system under Chapter 167, HRS. However under an agreement between the HBOA and the MDWS, MDWS will operate and maintain the system and the HBOA will establish rules and regulations governing the setting, enforcement, collection, and control of water rates for the system.

Administrative support is provided by the Department which is governed by the Hawaii Board of Agriculture (HBOA). The HBOA sets policy, approves rules and regulations, and is authorized to establish and enforce water rates. The HBOA is authorized to budget, expend, and contract for capital improvement projects as needed. Operation and maintenance costs of the systems are provided by water use revenues and supplemented with HDOA operating funds; however, capital improvements are financed with State bonds.

INVENTORY

The system was started by Maui County in 1912 to serve the water needs of upland region of Olinda and Kula by diverting stream flows from Haipuaena, Puohokamoa, and Waikamoi Streams and their tributaries. It was originally built as a potable water system, but later developed into a dual water system to meet the needs of farms developing along the upcountry Kula region. The stream diversions consisted of inlet boxes located behind low masonry dams and the water was conveyed by pipes and flumes. At Waikamoi, the diverted flows are merged into storage created instream and offstream. These flows were then transmitted via pipeline to reservoirs at Waikamoi, Olinda, Omaopio, Alae, and numerous small capacity tanks located along the distribution pipeline route. At the twin Waikamoi Reservoirs inflows are piped from 6 streams which are located on the western side of the watershed. The total storage capacity was less than 50 MG, which was inadequate during low-rainfall or high-irrigation periods. The collection system is currently operated and maintained by the Maui Department of Water Supply under agreements between the East Maui Irrigation Co. and the County of Maui.

The transmission portion of the system was improved by increasing the pipe size which allowed greater capacity for distribution, and by constructing new twin 50 MG reservoirs at Kahakapao which alleviated the problem of inadequate storage capacity. However, current major problems for Kula farmers include: (1) inadequate distribution capacity, (2) inadequate downstream storage capacity, and (3) the high cost of having to use treated potable water.

The Upcountry Maui Irrigation System when completed, will provide Kula farmers with a source of cheaper untreated surface water by bypassing the treated municipal water supply with a parallel pipeline system. The use of untreated water by the Upcountry Maui Irrigation System will result in greatly reduced water rates for farmers. The gravity-fed system, a project authorized under Public Law 83-566, will tap into the Kahakapao Reservoir located upstream of the County's Olinda Water Treatment Plant (Map 8). The system will serve farm lands well known for growing world-famous Maui onions, beautiful protea flowers, giant carnations, persimmons, and wine grapes.

Approximately 2 miles of the planned 10-mile long 24-inch pipeline has been installed and the next construction phase is expected to start in summer 2003.

When completed, the Upcountry Maui Irrigation System will serve existing truck crop farms and possibly some large acreage of pineapple. However, because the surface water sources are susceptible to droughts, additional storage capacity or alternate supplemental sources, i.e., recycled or reuse of water, needs to be studied. The adequacy of the system's reservoir capacity, especially along its downstream end, also should be further evaluated.

ASSESSMENT OF NEEDS

The assessment of needs presented below was taken from the Upcountry Maui Watershed Final Plan prepared in 1997 by the USDA Natural Resources Conservation Service under the Watershed and Flood Prevention Act, Public Law 83-566. The Watershed Plan has been approved and accepted by the local project sponsors, the HDOA and the respective local Soil & Water Conservation District in which region the project is located.

The Watershed Plan has been developed to meet the Federal and Sponsors' objectives of developing viable agricultural industry by providing adequate and consistent agricultural water supply.

The major concern is that the existing system cannot provide adequate supply to meet water demands during low rainfall periods. The system is unable to make optimum use of the water resources available in the region because portions of the collection system, transmission, and storage components are not adequately sized to permit capture, storage, and conservation of storm flows during abundant periods of rainfall. The existing system was built in a piece-meal fashion as both municipal and agricultural water users increased over the years, resulting in the current system.

The existing system utilizes surface water sources; and, therefore, it must conform with the federal Clean Water Act, which increases the cost of providing potable water for municipal users, but unnecessarily so for agricultural users. The system’s transmission pipelines are inadequate to meet the irrigation needs of farmers on the downstream end of the system. Also, storage capacity is inadequate to meet peak irrigation demands.

The Watershed Plan meets national and state objectives of developing viable agricultural businesses by providing adequate and reliable water supply for farming use.

PROPOSED CAPITAL IMPROVEMENTS

The Upcountry Maui Irrigation System will include a total of 49,500 ft or 9.4 miles of distribution pipeline that will be installed from the Olinda Water Treatment Plant to Keokea. The pipeline will begin at the 4,120 ft elevation at the Maui County Water Treatment Plant and drop to the 3,100 ft elevation at its terminus. The ductile iron or high density polyethylene distribution pipeline will vary in diameter from 18 inches to eight inches, as shown in the following table, “Proposed Pipeline.” Approximately 12 acres of easements across private parcels will be acquired. The pipeline will be buried along most of its length. Thirteen crossings of gulches are identified. Most crossings will be designed as elevated trestles. This pipeline will be dedicated to nonpotable water use.

An unpaved, 10 ft wide access road will be installed along the distribution pipeline alignment. The access road will join existing gulch crossings located closely, or otherwise will be constructed as grade crossings across dry gulches. Measures will be taken to minimize erosion potential due to the roadway. Upon completion, there will be two separate water systems, both sharing the same water source.

Nine lateral systems for the service areas of Olinda, Kimo Road, Crater Road, Pulehuiki/Kamehameiki, Kealahou, Waiakoa, Kaonoulu, Waiohuli, and DHHL/Keokea will be installed (see following table, “Capital Improvement Costs”). Lateral pipeline lengths will vary from 3,800 ft to 19,850 ft. High density polyethylene pipe sizes will vary from eight inches to two inches in diameter. The pipelines will be buried within the existing road rights-of-way where possible. Approximately 4.8 acres of private land easements will be acquired. Sublateral pipelines will connect the water system to farmer-supplied meters at the farm boundaries.

PROPOSED PIPELINE*
Upcountry Maui Irrigation System, Hawaii

Pipeline Segment	Nominal Diameter (in.)	Segment Length (ft.)	Flow Cap. (gpm)**
Main Distribution Pipeline			
0+00 to 165+00	18	16,500	2,660
165=00 to 257+00	16	9,200	2,100
257+00 to 287+00	14	2,900	1,600
286+00 to 323+00	12	3,700	1,330
323+00 to 387+00	10	6,400	950
387+00 to 495+00	8	10,800	610
Olinda Road Lateral			
0+00 to 98+00	3	9,800	100
Kimo Road Lateral			
0+00 to 198+50	8	19,850	610
Crater Road Lateral			
0+00 to 124+00	4	12,400	170
Pulehuiki/Kamehameiki Lateral			
0+00 to 86+00	3	8,600	100
Sub Lateral			
87+00 to 152+50	2	6,650	50
Kealahou Lateral			
0+00 to 86+86+80	8	8,680	610
Waiakoa Lateral			
0+00 to 47+00	6	4,700	360
Kaonoulu Lateral			
0+00 to 75+00	6	7,500	360
Waiohuli Lateral			
0+00 to 32+80	4	3,280	170
Keokea/DHHL Lateral			
0+00 to 164+00	6	16,400	360

* All pipe is High Density Polyethylene, 160 psi, SDR 11. March 1997

**5 feet per second flow velocity.

Source: Modified after *Final Watershed Plan, Environmental Impact Statement, Upcountry Maui Watershed, March 1997.*

PROPOSED MAINTENANCE IMPROVEMENTS

The Upcountry Maui Irrigation System is currently under development and no infrastructure has been installed yet, except for 12,000 ft of 36" pipeline (Map 8). No maintenance improvements are contemplated for at least the next four to five years and consequently no cost estimate for maintenance is provided.

An irrigation district will be established under Chapter 167, HRS, to operate the system. The policy, regulations, and water-rate control will be set by the HDOA. However, the County of Maui's Department of Water Supply will maintain the system under a maintenance agreement to be entered into upon completion of all the improvements under the watershed plan.

ESTIMATED COSTS

This project began construction in 2000 and approximately 12,000 ft. of 36" D.I. pipeline of the main transmission line has already been installed.

CAPITAL IMPROVEMENT COSTS
Upcountry Maui Irrigation System (Revised March 1997)

No.	Improvement	Total Cost
1	Mobilization	$ 53,000
2	Main Pipeline (HDPE)	2,365,000
3	Lateral Pipeline (HDPE)	1,849,000
4	Sublateral Pipeline (HDPE)	89,000
5	Road Crossings	32,000
6	Gulch Crossings	137,000
7	Access Road	1,274,000
	SUBTOTAL	$ 5,799,000
	Contingency (20%)	1,160,000
	TOTAL CONSTRUCTION	$ 6,959,000
	Engineering Services (15%)	1,044,000
	Project Administration (15%)	1,044,000
	Real Property	227,000
	TOTAL REHABILITATION COST	$ 9,274,000

Source: Modified after *Final Watershed Plan, Environmental Impact Statement, Upcountry Maui Watershed, March 1997.*

CRITERIA FOR ESTABLISHING PROJECT PRIORITY

Although the priorities have been enumerated and adopted in the watershed plan there is some flexibility to alter the order of installation based on the availability of revenue producing potential. Any improvement that can provide revenue on a timely basis should be given consideration.

FIVE-YEAR PROGRAM

Attached is a table showing a 3-year installation program with funding. However, funds are subject to availability of legislative appropriations (both State and Federal).

SCHEDULE OF WATERSHED IMPROVEMENTS INSTALLATION*
Upcountry Maui Irrigation System

Year	Item	Total
1	Main Pipeline	$ 552,000
	Gulch Crossings	25,000
	Access Road	115,000
	Total	$ 692,000
2	Mobilization	$ 41,000
	Main Pipeline	3,264,000
	Lateral Pipelines	383,000
	Sublateral Pipelines	16,000
	Gulch Crossings	189,000
	Access Road	1,377,000
	Paved Road Crossings	5,000
	Total	$5,275,000
3	Demobilization	$ 41,000
	Lateral Pipelines	2,552,000
	Sublateral Pipelines	122,000
	Access Road	497,000
	Paved Road Crossings	45,000
	Total	$3,257,000
	TOTAL	$9,224,000

*Price Base 1996 March 1997
Source: Modified after *Final Watershed Plan, Environmental Impact Statement, Upcountry Maui Watershed, March 1997*

Chapter 12. WAIMANALO IRRIGATION SYSTEM

INTRODUCTION

The Waimanalo Irrigation System, a State-owned and operated system that is fully operational, is included as part of this report. Because the system is an active State-operated system fully funded by HDOA, no inventory of the system was conducted. The system is managed by the HDOA under authority of Chapter 167, Hawaii Revised Statutes. The system is operated by an irrigation manager and two irrigation system service workers employed by the HDOA. Administrative support is provided by the Department which is governed by the Hawaii Board of Agriculture (HBOA). The HBOA sets policy, approves rules and regulations, and is authorized to establish and enforce water rates. The HBOA is authorized to budget, expend, and contract for capital improvement projects as needed. Operation and maintenance costs of the systems are provided by water use revenues and supplemented with HDOA operating funds; however, capital improvements are financed with State bonds.

EXISTING CONDITIONS

The Waimanalo Irrigation System's water source is located in the Maunawili Valley watershed with intakes located on Maunawili, Ainoni, and Makawao Streams (Map 9). The collection system within the valley is composed mainly of open unlined ditches, pipe siphons, and tunnels which are susceptible to heavy siltation, tree root intrusion, and heavy vegetative growth due to high rainfall (approximately 100 inches a year). Because access to most of the collection system is by four wheel drive vehicles, system maintenance is labor intensive.

The proposed improvements below were taken from the Waimanalo Watershed Final Plan prepared in 1981 by the USDA Natural Resources Conservation Service under the Watershed and Flood Prevention Act, Public Law 83-566. The Watershed Plan has been approved and accepted by the local project sponsors, the HDOA, and the respective local Soil & Water Conservation District in which region the project is located.

The Waimanalo Irrigation System is in fairly good condition and is presently undergoing improvements based on the Waimanalo Watershed Plan, prepared by the USDA NRCS.

The system's gravity-fed ditch flows are transported from Maunawili Valley to Waimanalo Valley through a short unlined tunnel (Aniani Nui Tunnel). A short ditch directs water from the Aniani Nui Tunnel exit into a network of pipelines which connect to the Waimanalo farming community and a 60 MG earthen reservoir lined with HDPE. This new 60 MG reservoir replaces several small reservoirs and serves as the distribution point for the system and was constructed with federal assistance under the watershed project

The original ditch distribution system was recently replaced with ductile iron pipe and water meters, under the watershed project. However, many of the system's distribution laterals are inactive due to family farm closures in which the younger generation does not continue farming. On the other hand, since the Vietnam War, southeastern Asian immigrants with farming backgrounds have taken over many vacated farming operations. Currently (2003), the Waimanalo Irrigation System has 164 accounts with an annual water use of 146,226,964 gallons (0.4 mgd) over 1,170 acres.

The plan will improve agricultural water management through modernizing the antiquated irrigation water delivery system; recycle treated sewage effluent for irrigation; preserve and enhance environmental quality of Waimanalo valley by retaining prime and important farmland in agriculture; protecting and preserving historic value of the ditch; and improve health and aesthetics by providing adequate solid waste collection sites. Also part of the local sponsors' action was to acquire the fee water rights and to upgrade the water collection system in Maunawili Valley.

PROPOSED CAPITAL IMPROVEMENTS

The Watershed Plan has the objective of accelerating assistance to all system water users. The Plan's improvements include a storage reservoir, 15.7 miles of distribution pipeline, a separate treated sewage effluent lift pump and reservoir, and a transmission pipeline. Accelerated technical assistance would be provided to water users in converting from sprinkler and drip irrigation and in designing cultivation practices to minimize nematode problems. Bananas would be irrigated at 50 percent of the computed water requirement for June to September, and the number of acres irrigated would be maximized.

Water from the Maunawili watershed would be taken from the tunnel outlet at Aniani Nui Ridge and piped to the reservoir near the mauka end of Mahailua Street. The reservoir would be a deep, off-channel, 60 MG excavated structure with an embankment 40 feet high. A gravity-fed pipeline (with some supplementary pumping required) would deliver water from the reservoir to water users. The treated sewage effluent would be pumped from the Waimanalo sewage treatment plant to a storage reservoir at the site of the existing Wing-King Reservoir.

Installation of improvements would provide high quality Waimanalo Irrigation System water under pressure to 1,134 acres, including 79 acres previously irrigated with municipal system water. An additional 68 acres would be supplied with treated sewage effluent. The Waimanalo Agricultural Park will also be provided an irrigation system. As a result, the agricultural productivity and the rural character of Waimanalo Valley could be strengthened. The agricultural use of important Waimanalo farmland will be able to continue, by irrigating with treated sewage effluent. Problems with solid waste disposal may continue to be a problem.

Note: At this writing, most of the improvements in the Watershed Plan have been installed with the remaining improvements pending, due to financial constraints.

PROPOSED MAINTENANCE IMPROVEMENTS

1. Routine replacement of slide gates on reservoir and control structures, pumps and motors, trash/debris racks, valves, vents, pressure relief valves, meters, flow control devices are required at 25-year increments.

2. Routine maintenance of Aniani Nui Tunnel, i.e., remove root intrusion and debris and line tunnel entrances.

3. Abandoned open ditches should be sealed and returned to original condition and subsequently release easement rights to owners.

ESTIMATED COSTS

CAPITAL IMPROVEMENT COSTS
Waimanalo Irrigation System

No.	Item	Improvements	Construction Cost*
1		Land Treatment	$ 616,000
2	Maunawili Source	Improve Water Collection System	500,000
3	Reservoir	Install Irrigation Pipeline System	completed
4	Ditch	Install Irrigation Pipeline System	completed
5	Ditch	Modify Old Irrigation Ditch	50,000
6	Sewage	Construct Sewage Effluent Pumps, Pipeline System and Storage Reservoir	410,000
7	Waste Mgmt	Install Solid Waste Collection Sites	completed
8	Reservoirs	Restore three abandoned reservoirs	750,000
		SUBTOTAL	$ 2,326,000
		Overhead (15%)	349,000
		Contingency (8%)	186,000
		Profit (10%)	233,000
		State General Excise Tax (4.1667%)	97,000
		SUBTOTAL CONSTRUCTION COST	$ 3,191,000
		Construction mgmt (20%)	638,000
		Contract admin. (10%)	319,000
		Environmental permitting & clearances**	1,000,000
		Design engineering (10%)	319,000
		Easements acquisition	25,000
		TOTAL REHABILITATION COST	$ 5,492,000

* Price base 1981.
**Estimate based on degree of environmental sensitivity.
Source: Modified after *Final Watershed Plan and Environmental Impact Statement, Waimanalo Watershed, December 1981*

The Waimanalo Watershed project began construction in 1992 and several structural measures outlined in the watershed agreement have been installed and are operational. These completed projects include: The 60 MG Waimanalo Reservoir, pipeline connecting Aniani

Nui Tunnel to the reservoir, pipeline (replacing open water distribution ditches), and improvements to limited sections of the Maunawili collection systems.

Due to financial constraints and higher priorities of other more critical watershed projects, construction activity for this project is currently pending. Furthermore, due to community and public concerns raised, some improvements may need to be processed through environmental clearance again.

MAINTENANCE COSTS
Waimanalo Irrigation System

No.	Description of Work	Repair Costs
1	Replace reservoir gate's control structure, pumps, motors, valves, racks, flow controls, etc., annually	$ 50,000
2	Routine maintenance Aniani Nui Tunnel	100,000
3	Distribution ditches now abandoned in service areas returned to original condition and cancel easements	150,000
	SUBTOTAL	$ 300,000
	Design Engineering (15%)	45,000
	Environmental Permitting & Clearance*	1,000,000
	TOTAL MAINTENANCE COST	$ 1,345,000

*Estimate based on degree of environmental sensitivity.

The annual maintenance costs of the system are funded from a revolving special fund within the HDOA's operating budget and are not individually earmarked. The Molokai and Waimea systems each has a three-man field crew, whereas the Waimanalo system has a four-man field crew; and the entire accounting and bookkeeping function for the systems are centralized at the main office as is the management of the entire program through the Agricultural Resource Management Division Administrator. The latest actual annual expenditure figures (FY 2001-2002) for this program show the budget to be $1,347,000, which provides operational funding for the program. Due to time constraints, individual maintenance costs were not separated out.

CRITERIA FOR ESTABLISHING PROJECT PRIORITY

1. For the Waimanalo Irrigation System, most of the watershed improvements have been constructed, but the remaining projects need consideration in order to complete the plan.

2. The capital improvement projects that can result in increasing the revenue stream should have higher priority.

FIVE-YEAR PROGRAM

The planned sequence for installing the structural improvements during the first year includes: (1) design and construction of the pipeline from Aniani Nui Ridge Tunnel to the 60 MG storage reservoir, (2) construction of the 60 MG Reservoir, (3) construction of the 1.5 MG sewage effluent reservoir, and (4) initial construction of the delivery systems. Construction during the second year will include construction of the delivery systems and the solid waste disposal sites. Of the above list, only (3) remains.

The planned sequence for installing land treatment would be phased over several years with the first two years concentrating on preparation of those lands now being developed for agricultural use. The conversion from sprinkler to drip irrigation and development of contour furrow irrigation for the sewage effluent will be delayed until the new delivery systems are near completion. This sequence should provide the least disruption of the cropping operations and farm production. The table below presents the five-year planned project installation and funding needed. The schedule is subject to availability of appropriations from the State and Federal governments. This watershed project is in its final stages of installation.

FIVE-YEAR REPAIR PROGRAM
Waimanalo Irrigation System

Year	Measure	Total Funds
1	Reservoirs & Pipelines	completed
	Water Collection System	$ 500,000
	Land Treatment	160,000
2	Complete Reservoirs, Pipelines & Solid Waste Sites	completed
	Land Treatment	160,000
3	Contracted Technical Assistance	20,000
	Land Treatment	160,000
4	Land Treatment	153,000
	TOTAL	$ 1,153,000

Source: Modified after *Final Watershed Plan and Environmental Impact Statement, Waimanalo Watershed, December 1981*

MAINTENANCE PROJECTS
Waimanalo Irrigation System

No	Project*	Year 1	Year 2	Year 3	Year 4	Year 5	Future Years
1	Replace reservoir gate's control, etc.		▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances	▪ award design & constr. contract		▪ begin construction	▪ ongoing
2	Restore abandoned reservoirs, etc.		▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract		▪ begin construction
3	Clean and clear Maunawili, etc.		▪ request approp.		▪ conduct prelim. eng. & select consultant ▪ obtain environ. permits & clearances		▪ award design & constr. contract ▪ begin construction
4	Reoutine maintenance, etc.	▪ request approp.	▪ conduct prelim. eng. & select consultant		▪ begin construction		
5	Distribution ditches now abandoned, etc.	▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances ▪ award design & constr. contract	▪ begin construction	▪ cancel easements	▪ return land to owners	

*See "Maintenance Cost" in Estimated Costs section of this chapter for a detailed description of work.

Chapter 13. WAIMEA IRRIGATION SYSTEM

INTRODUCTION

The Waimea Irrigation is a State-owned (HDOA) system. Because it is an active, fully operational State-operated system, no inventory of the system was conducted. The system is managed and fully funded by the HDOA under authority of Chapter 167, Hawaii Revised Statutes. The system is operated by an irrigation manager and two irrigation system service workers employed by the HDOA. Administrative support is provided by the HDOA which is governed by the Hawaii Board of Agriculture (HBOA). The HBOA sets policy, approves rules and regulations, and is authorized to establish and enforce water rates. The HBOA is authorized to budget, expend, and contract for capital improvement projects as needed. Operation and maintenance costs of the systems are provided by water use revenues and supplemented with HDOA operating funds; however, capital improvements are financed with State bonds.

EXISTING CONDITIONS

The Waimea Irrigation System serves the farmers in Lalamilo and Puukapu. The system's water sources are the summit watersheds of Kohala Mountain starting with Kawainui and followed by Kawaiki, Alakahi, and Koiawe Streams (Map 10). The diverted flows from intakes on these streams are channeled into a series of open ditches and tunnels, called the Upper Hamakua Ditch, which was originally constructed to collect Kohala Mountain water for use along the Hamakua coast. However, in 1948, the ditch system was returned to the then Territory of Hawaii. Later, the lower end of the collection system was re-aligned and diverted into a new concrete-lined 60 MG reservoir at Waimea.

The Waimea Reservoir is supplemented by the 100 MG Puu Pulehu Reservoir, recently rehabilitated with HDPE lining by the HDOA. This is a twin-celled reservoir that collects the excess flows from the Upper Hamakua Ditch for use during drought periods. The region is prone to droughts lasting 3 to 5 months. Puu Pulehu Reservoir water can be transferred to the Waimea Reservoir via a booster pump and connecting pipeline. There is sufficient storage to maintain an average service flow in the system for approximately 100 irrigation days.

The system distributes water from Waimea Reservoir, via pipelines, to serve farm lands up to 6.5 miles away. The distribution system is pressurized and completely metered at each service lateral. Currently (2003), the system has 117 water service accounts drawing 330,847,000 gallons annually (0.906 mgd) on 587 acres. The distribution pipelines vary in size from 6 to 24 inches and passes through several populated areas, impacting maintenance work. The Waimea Irrigation System has been operational since the early 1970s and supports a stable agricultural community and has been continuously improved under the HDOA's capital improvements program.

ASSESSMENT OF NEEDS

A study conducted several years ago to assess the needs of the system forms the basis for proposed capital improvements by the HDOA (1989). System improvements have also been planned under authority of Public Law 83-566, with an approved watershed plan awaiting appropriations. The planned improvements presented under the project title, "Waimea-Paauilo Watershed Plan," will increase the storage capacity of the system and allow for expansion of water uses. This assessment below was taken from the Watershed Plan prepared by the USDA Natural Resources Conservation Service. The Watershed Plan has been approved and accepted by the local project sponsors: The HDOA and the respective local Soil & Water Conservation District in which region the project is located.

The plan's objectives are to: (1) provide improved water conveyance efficiency of the existing transmission ditch system, (2) add another major storage reservoir for increase capacity, and (3) expand service to provide livestock drinking water by installing new distribution pipelines.

The efficiency of the transmission system will be achieved by eliminating seepage losses along sections of the ditch by installing bypass pipelines. The storage capacity of the entire system needs to be increased by lining existing reservoirs to eliminate water losses through leakages and add one new reservoir. The plan calls for constructing delivery systems for livestock water through a series of new pipelines that will distribute water to remote pasture lands. This will increase domestic water availability in the system and reduce the need to develop new domestic water sources.

The watershed plan was developed to meet both the national objective of increasing the economic value of national output of goods and services and achieving the Sponsors' objective to improve agricultural water management.

The major problem of the Waimea Irrigation System is insufficient agricultural water caused by inadequate collection, storage and distribution facilities. Excessive seepage losses occurring along the existing transmission ditches cause deterioration of the linings, tunnels and flumes.

The system's existing storage capacity is inadequate for meeting irrigation water demand during frequent dry periods and for effective application of water to diversified crops. Furthermore, the region served by the Waimea Irrigation System is the heart of the cattle industry, but the system lacks a supplemental livestock water system for low or drought periods.

PROPOSED CAPITAL IMPROVEMENTS

The Watershed Plan selected by the Sponsors includes livestock water. It will complement the ongoing land treatment program of the Conservation District and provides improved water conveyance efficiency of the Upper Hamakua Ditch, reservoir storage for irrigation and livestock water, and irrigation and livestock water distribution systems.

Capital improvements proposed in the Watershed Plan include:

1. A 133 MG storage reservoir (Waimea II Reservoir) to supplement the existing two reservoirs,

2. A 30-inch diameter supply pipeline to convey water from the existing Upper Hamakua Ditch collection system to the proposed 133 MG reservoir, and

3. Improvements to the upper reaches of the Ditch system.

The collection system which presently uses sections of natural stream channels will be improved with 8,000 ft of by-pass pipeline segments. Required right-of-way for the by-pass pipeline amounts to 5.5 acres. The 30-inch supply pipeline, most of which is located adjacent to an existing road, will require an additional 1.8 acres for use of the road.

The proposed 133 MG Waimea II Reservoir will be constructed on Department of Hawaiian Home Lands pasture land. A compacted earthfill dam with maximum height of 65 ft and crest length of 1,450 ft is to be constructed using fill material excavated from the reservoir and adjacent area. The reservoir will be lined with high density polyethylene plastic. A geofabric and polyethylene drainage grid under the liner is proposed. The embankment will include a chimney drain and principal and emergency spillways. The reservoir will be filled by the supply pipeline from the Upper Hamakua Ditch. The principal spillway inlet structure is an SCS standard covered riser and the outlet structure is an impact basin. A 30-inch diameter reinforced concrete cylinder pipe is considered to convey flows from inlet to outlet structure. The emergency spillway will be grassed with a reinforced concrete crest control structure. Maximum reservoir storage during passage of this storm is 136.5 MG. Minor clearing of brush and small trees will be required within the 34.7 acres of pasture land for which land rights will be required. A total of two acres clearing is estimated.

The existing Lalamilo irrigation delivery system will be expanded with 21,800 ft of pipeline. Pumps will be installed to supplement gravity pressure as needed during peak demand periods. Approximately 900 ft of 24-inch diameter ductile iron pipe and 20,900 ft of polyvinyl chloride pipe, 14-inch to 4-inch diameter, will be installed. Required right-of-way is 4.8 acres.

A separate livestock water distribution system will be constructed. Total length of the livestock water pipeline is 184,400 ft. Use of high-density polyethylene (HDPE) pipe ranging in diameter from 6-inch to ¾-inch is proposed. Electric and diesel pumps will be used to provide water to elevations beyond the reach of gravity. Storage tanks and ponds will satisfy demand fluctuation and will limit hours of pumping required. This will allow for periods of electrical failure, repairs and other shutdowns. A sequential control system will automate pump operation. Total required right-of-way is 174.1 acres including temporary right-of-way of 84.5 acres. Estimated capital costs are shown in the following table.

PROPOSED MAINTENANCE IMPROVEMENTS

The Waimea Irrigation System was converted from the remnants of the Upper Hamakua Ditch Irrigation System to serve the Lalamilo Farm Lots in Kamuela. The system is rapidly approaching its project life and should begin replacement of its valves, meters, equipment, and the 60 MG reservoir should be cleared of accumulated sediments. A system assessment conducted in 1986 recommended several improvements (Division of Water & Land Development, DLNR, Report R77). Estimated maintenance costs are shown in the *Maintenance Costs* table.

1. Replace valves, meters, pumps, and other equipment. These should be phased in over a period of several years at $50,000 per year.

2. Convert two existing pumps from electrical to diesel power.

3. Install a new telemetry system to control and monitor water flows within the system.

4. Clean and remove sediment from 60 MG Waimea Reservoir and install automated gauging recorder and weather station.

ESTIMATED COSTS

CAPITAL IMPROVEMENT COSTS
Waimea Irrigation System

No.	Item	Improvements	Construction Cost
1	Upper Hamakua Ditch Improvement	UHD By-pass Pipelines	$ 517,000
		UHD to Waimea II Reservoir Supply Pipeline	747,000
2	Waimea II Reservoir	Construct Lined Reservoir	6,019,000
3	Irrigation Water Distribution System	Lalamilo Addition	249,000
		DHHL Additions	622,000
		Waimea II to Existing Mainline	159,000
4	Livestock Water Distribution System	Main, Group 2, E, E-1	540,000
		Group 1	37,000
		Group 3	318,000
		Group 5	298,000
		Group 7	36,000
		Group 9	107,000
5	Pumps	Convert two elect. pumps to diesel	100,000
6	Telemetry System	Install new system to control & monitor flows	500,000
	SUBTOTAL		$10,249,000
	Overhead (15%)		1,537,000
	Contingency (8%)		820,000
	Profit (10%)		1,025,000
	State general excise tax (4.1667%)		427,000
	SUBTOTAL CONSTRUCTION COST		$14,058,000
	Construction mgmt (20%)		2,812,000
	Contract admin. (10%)		1,406,000
	Environmental permitting & clearances*		1,000,000
	Design engineering (12%)		1,687,000
	TOTAL REHABILITATION COST		$20,963,000

*Estimate based on degree of environmental sensitivity. The cost has been revised to reflect additional costs from original NRCS' estimates.

Source: Modified after *Watershed Plan and Environmental Assessment, Waimea-Paauilo Watershed, September 1989*

MAINTENANCE COSTS
Waimea Irrigation System

No.	Description of Work	Repair Costs
1	Replacement of valves, meters, pumps and other equipment phased in over five years at annual increments	$ 50,000
2	Clean and remove sediment from 60 MG Waimea Reservoir and install automated gauging recorder and weather station	250,000
	SUBTOTAL	$ 300,000
	Design Engineering (15%)	45,000
	TOTAL MAINTENANCE COST	$ 345,000

*Estimate based on degree of environmental sensitivity.

The operation and maintenance costs of the Waimea Irrigation System are funded from the revolving special fund within the HDOA's operating budget for all of its systems. Individual system expenditures are not available for this report. The system has a four-man field crew and is administered from the main office through the Agricultural Resource Management Division Administrator. The latest annual expenditure figures (FY 2001-2002) for all five HDOA systems was $1,347,000. Upon completion of the watershed plan improvements, the estimated annual additional maintenance costs are as shown in the table below.

ESTIMATED ANNUAL ADDITIONAL MAINTENANCE COST*
Waimea Irrigation System

Item	Operation & Maintenance
Upper Hamakua Ditch Improvement	
UHD By-pass Pipelines	$ 4,000
UHD to Waimea II Reservoir Supply Pipeline	6,000
SUBTOTAL	10,000
Storage	
Waimea II Reservoir	24,000
Irrigation Water Distribution System	
Lalamilo Addition	9,000
DHHL Additions	28,000
Waimea II to Existing Mainline	1,000
SUBTOTAL	38,000
Livestock Water Distribution System	
Main, Group 2, E, E-1	5,000
Group 1	1,000
Group 3	4,000
Group 5	4,000
Group 7	1,000
Group 9	1,000
SUBTOTAL	16,000
GRAND TOTAL	$ 88,000

*Price Base: 1987
Source: Modified after *Watershed Plan and Environmental Assessment, Waimea-Paauilo Watershed, September 1989*

CRITERIA FOR ESTABLISHING PROJECT PRIORITY

1. The priority for the capital improvements have been determined and agreed by the parties to the watershed plan.

2. Certain capital improvement projects that deal with providing adequate storage should have higher priority because without the extra storage the effectiveness of the plan's objective will be difficult to implement.

3. Any improvements that will increase revenues from increased water sales, should have higher priority.

FIVE-YEAR PROGRAM

The table below shows the schedule of improvements to be installed under the Waimea-Paauilo Watershed Plan, together with funding obligations, and is subject to availability of future legislative appropriations (both State and Federal).

SCHEDULE OF WATERSHED IMPROVEMENTS INSTALLATION
Waimea Irrigation System

Year	Item	Total
1	TECHNICAL ASSISTANCE	
	Engineering	
	UHD By-Pass Pipelines	$ 40,000
	UHD-Waimea II Res. Sup. PL	58,000
	Waimea II Reservoir	60,000
	Project Administration	
	UHD By-Pass Pipelines	3,000
	UHD-Waimea II Res. Sup. PL	5,000
	Waimea II Reservoir	7,000
	SUBTOTAL	173,000
2	TECHNICAL ASSISTANCE	
	Engineering	
	Waimea II Reservoir	60,000
	UHD By-Pass Pipelines	10,000
	UHD-Waimea II Res. Sup. PL	10,000
	Project Administration	
	UHD By-Pass Pipelines	7,000
	UHD-Waimea II Res. Sup. PL	10,000
	Waimea II Reservoir	77,000
	LAND RIGHTS	
	UHD By-Pass Pipelines	1,000
	UHD-Waimea II Res. Sup. PL	3,000
	Waimea II Reservoir	34,000
	SUBTOTAL	212,000
3	TECHNICAL ASSISTANCE	
	Engineering	
	UHD By-Pass Pipelines	17,000
	UHD-Waimea II Res. Sup. PL	28,000
	Waimea II Reservoir	343,000
	Project Administration	
	UHD By-Pass Pipelines	20,000
	UHD-Waimea II Res. Sup. PL	29,000
	Waimea II Reservoir	39,000
	Irrigation Dist. System	13,000
	FINANCIAL ASSISTANCE	
	UHD By-Pass Pipelines	416,000
	UHD-Waimea II Res. Sup. PL	600,000
	LAND RIGHTS	
	Irrigation Dist. System	7,000
	SUBTOTAL	1,512,000

Year	Item	Total
4	TECHNICAL ASSISTANCE	
	Engineering	
	Waimea II Reservoir	$ 309,000
	Irrigation Dist. System	112,000
	Project Administration	
	UHD By-Pass Pipelines	3,000
	UHD-Waimea II Res. Sup. PL	5,000
	Waimea II Reservoir	225,000
	Irrigation Dist. System	7,000
	FINANCIAL ASSISTANCE	
	Waimea II Reservoir	4,827,000
	SUBTOTAL	5,488,000
5	TECHNICAL ASSISTANCE	
	Engineering	
	Irrigation Distribution System	20,000
	Livestock Water Distribution System	5,000
	Project Administration	
	Waimea II Reservoir	39,000
	Irrigation Distribution System	40,000
	Livestock Water Distribution System	15,000
	FINANCIAL ASSISTANCE	
	Irrigation Distribution System	824,000
	LAND RIGHTS	
	Livestock Water Distribution System	157,000
	SUBTOTAL	1,100,000
Future Year 6	TECHNICAL ASSISTANCE	
	Engineering	
	Livestock Water Distribution System	132,000
	Project Administration	
	Irrigation Distribution System	7,000
	Livestock Water Distribution System	8,000
	SUBTOTAL	147,000
Future Year 7	TECHNICAL ASSISTANCE	
	Engineering	
	Livestock Water Distribution System	10,000
	Project Administration	
	Livestock Water Distribution System	31,000
	FINANCIAL ASSISTANCE	
	Livestock Water Distribution System, Main, E, E-1, Groups 1,3	650,000
	SUBTOTAL	691,000

Year	Item	Total
Future Year 8	TECHNICAL ASSISTANCE	
	Engineering	
	Livestock Water Distribution System	5,000
	Project Administration	
	Livestock Water Distribution System	20,000
	FINANCIAL ASSISTANCE	
	Livestock Water Distribution System, Groups 5,7,9	301,000
	SUBTOTAL	326,000
Future Year 9	TECHNICAL ASSISTANCE	
	Project Administration	
	Livestock Water Distribution System	2,000
	SUBTOTAL	2,000
	GRAND TOTAL	$ 9,651,000

*Price Base: 1988
Source: Modified after *Watershed Plan and Environmental Assessment, Waimea-Paauilo Watershed, September 1989*

MAINTENANCE PROJECTS
Waimea Irrigation System

No	Project*	Year 1	Year 2	Year 3	Year 4	Year 5	Future Years
1	Replacement of valves, etc.	▪ request approp.	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction	▪ ongoing
2	Convert two existing pumps, etc.		▪ request approp. ▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction	
3	Install a new telemetry system, etc.		▪ request approp.	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances		▪ award design & constr. contract ▪ begin construction
4	Clean and remove sediment from , etc.	▪ request approp.	▪ conduct prelim. eng. & select consultant	▪ obtain environ. permits & clearances	▪ award design & constr. contract	▪ begin construction	

*See “Maintenance Cost” in Estimated Costs section of this chapter for a detailed description of work.

Chapter 14. EAST MAUI IRRIGATION SYSTEM

INVENTORY

The East Maui Irrigation System remains intact and continues to supply irrigation water for Hawaiian Commercial & Sugar Co. (HC&S) agricultural operations in central Maui. The East Maui Irrigation Co, Ltd operates the system with 18 employees. The company maintains and repairs 74 miles of 355 stream diversions, 50 miles of tunnels, 16 steel siphons, and 7 storage reservoirs and 62 miles of unpaved access roads.

There are four main transmission ditches: Wailoa Ditch, 195 mgd capacity, New Hamakua Ditch, 100 mgd capacity, Lowrie Ditch, 70 mgd capacity, and Haiku Ditch, 70 mgd capacity.

In 1898, immediately after acquiring HC&S, Alexander & Baldwin started the Lowrie Ditch, which started in the rain forest of Kailua in Makawao district. The ditch had two sources. The first source was a reservoir at Papaaea that was fed by two 5 to 6-mile ditches and the second source was Kailua stream where the diversion intercepted the source of the older Haiku Ditch and ran parallel to that ditch. The Lowrie Ditch, a 22-mile system with a capacity of 60 mgd, was three-fourths open ditch and included these elements: 74 tunnels for a total of 20,850 ft, the longest being 1955 ft; 19 flumes for a total length of 1965 ft; and 12 siphons with a total length of 4,760 ft, the biggest being 250 feet deep at Halehaku gulch. The Lowrie Ditch, by means of inverted siphons, ended at the 475-ft elevation, 257 ft above the Haiku Ditch.

The Koolau Ditch was the next big project built in 1904-1905. The Koolau Ditch extended the water collection system another 10 miles eastward toward Hana, around the Koolau Range to Makapipi, in 1904. This ditch traveled through more difficult terrain than most other systems and it presented greater logistical problems. In all, ten mountain streams were intercepted. There were 7.5 miles of tunnel and 2.5 miles of open ditch and flume. The 38 tunnels, all dug out of solid rock, were 8 ft wide and 7 ft high. In length they averaged 1,000 ft: the shortest was 300 ft and the longest 2,710 ft.

The New Haiku Ditch was completed in 1914 with a capacity of 100 mgd. It was mostly tunnel, partially lined, with a length of 54,044 ft. Kauhikoa Ditch was completed in 1915 with a capacity of 110 mgd and a length of 29,910 ft. Wailoa Ditch was started in 1918 and finished in 1923. Mostly tunnel, all lined, with a length of 51,256 ft, Wailoa Ditch had an original capacity of 160 mgd, later increased to 195 mgd.

East Maui Irrigation System's water collection system originally had 388 intakes, 24 miles of ditch, 50 miles of tunnels, and 12 inverted siphons as well as numerous small feeders, dams, intakes, pipes, and flumes. The water source was primarily surface runoff from a total watershed area of 56,000 acres. Of this watershed, East Maui Irrigation Co. owned 18,000 acres—the 38,000-acre balance belonged to the State of Hawaii.

The East Maui Irrigation Co. controlled all the surface water to HC&S supplied through the East Maui Irrigation System. Ground waters were controlled by HC&S itself.

By 1931, HC&S was able to pump 144 mgd of ground water. HC&S also received water from the West Maui Irrigation System through the Waihee Canal and Spreckels Ditch through agreements with Wailuku Sugar Co.

EXISTING CONDITIONS

Ownership & Management:	The East Maui Irrigation System is owned and managed by the East Maui Irrigation Co., Ltd., a wholly owned subsidiary of Alexander & Baldwin, Inc.
Employment:	18 full-time employees
Average Delivery:	165 million gallons per day (mgd)
Delivery Capacity:	• Wailoa Ditch 195 mgd • New Hamakua Ditch 100 mgd • Lowrie Ditch 70 mgd • Haiku Ditch 70 mgd Total Capacity 435 mgd
Miles of Ditches:	74 miles of aqueduct of which 50 miles are tunnel.
Miles of Roads:	62 miles of private four-wheel drive jeep access roads to facilitate maintenance and repair of ditch system.
Reservoirs:	Seven reservoirs with a total capacity of 274 million gallons.

Intakes:	355 registered stream diversions ranging from 1” diameter pipes to permanent concrete structures that can divert up to 75 mgd.
Siphons:	13 steel siphons ranging from 42 to 72 inches in diameter.
Watershed Area:	50,000 acres of which 33,000 acres are leased from the State of Hawaii.
Water Users:	• Hawaiian Commercial & Sugar Co. • Maui County Department of Water Supply • Maui Pineapple Company

ASSESSMENT OF NEEDS

For this report, no assessment of the needs and concerns were conducted due to time constraints and limited funds. No proposed improvements are included for the same reason. Future studies will be directed toward a detailed evaluation of this system.

The staff of employees conduct normal maintenance which consists of road and trail maintenance, ditch and tunnel cleaning, brush and tree removal, and minor repairs to stream intakes, etc. Storm damage repairs require special or urgent attention because storms usually threaten the physical integrity of system, although they occur infrequently (over a period of several years). No estimates of costs for maintenance or capital improvement were prepared for this report due to time constraints and limited funds.

Chapter 15. KAUAI COFFEE IRRIGATION SYSTEM

INVENTORY

The original plantation irrigation system was conceived and constructed by McBryde Sugar Co. over a period extending from the early 1900s to the 1930s. The plantation acreage extended from Hanapepe eastward through Eleele, Kalaheo, Lawai and into Koloa covering 20,000 acres. Due to its leeward location the McBryde plantation did not have access to sufficient surface water, so it developed ground water sources near Hanapepe River and numerous storage reservoirs (estimated at 800 MG) to augment system water supply. In order to economically pump water to storage reservoirs and fields, McBryde plantation needed a cheap electric power source. A massive undertaking built the Wainiha Hydropower Plant, 35 miles away tapping into northern Kauai's abundant windward surface water sources in the Wainiha watershed. McBryde's Wainiha Power Plant is the earliest hydroelectric power plant of any significant size built in Hawaii—and to this day remains the largest in annual power production. Power from Wainiha plant was transmitted the 35-mile distance to Hanapepe by means of a power line that traversed across Wainiha, Lumahai, and Hanalei Valleys; up the ridge mauka of Kalihiwai to the mountain divide between Kalihiwai and Wailua; onward toward Lihue; and passing between Haiku and Lawai to Hanapepe. At its peak, the Wainiha hydropower plant provided up to 57,000 volts, more than adequate for plantation needs. The plant had three generators, pelton wheels with exciters, transformers and a switchboard.

McBryde plantation had access to the Wahiawa watershed, which includes the Kanaele Swamp. Determined to build a reservoir to capture the runoff from this watershed, McBryde started the Alexander Reservoir in 1928, although conditions for water storage were not generally ideal in Hawaii. The only Hawaii plantations that developed any substantial water storage capacity were McBryde and Koloa plantations on Kauai and Wailua Sugar Co. on Oahu.

A second hydropower plant was built by McBryde when the Alexander Dam and Reservoir were built, storing water from Wahiawa Stream. The dam was 120 ft high and 620 ft long and it provided adequate hydraulic differential to power 1100 kW generator at Kalaheo. All this hydroelectric power, together with steam power from burning mill bagasse waste combined, resulted in excess power which was sold.

Pump 3 was one of four pump stations that tapped both in and under the Hanapepe River (three of them have since been abandoned). Pump 3 was uniquely successful in water production. At Pump 3, a vertical shaft descends 90 ft to a pump room. Forty feet below that, a network of skimming tunnels was built, beginning in 1908. The tunnel essentially intercepted an underground river. Pump 3 is recharged by surface water diverted from Hanapepe River. The main pump at No. 3 tapped surface flows of Hanapepe River and the underlying groundwater aquifer. A vertical shaft descends 130 ft below river bed with skimming tunnels, one of these skimming tunnels intercepted a huge "underground river." Although there were four pump stations originally, only Pump 3 could sustain adequate capacity. When McBryde's cost of running its coal-burning steam pumps proved prohibitive, the company turned to cheaper energy sources—specifically hydroelectric power and burning bagasse for fuel. The center of the power grid was at Pump 3.

After plantation closure, the Kauai Coffee Irrigation System presently consists of Pump 3 Ditch and Alexander Dam Ditch. The system is composed of tunnels, siphons, flumes and open ditches. System water flows southward from Alexander Reservoir, fives miles to the junction of Pump 3 Ditch near Umi Reservoir; and also eight miles eastward from Hanapepe Valley floor to the storage reservoir (Luawai near Lawai). Still surviving are eight storage reservoirs (Elua 80 MG, Mau 26 MG, Elma 27 MG, Hukiwai 16 MG, Kapa 18 MG, Ioleau 39 MG, Umi 7 MG, and Luawai 9 MG). The system is operated and maintained by a crew from McBryde Sugar Co.

EXISTING CONDITIONS

Ownership: McBryde Sugar Co., a wholly owned subsidiary of Alexander & Baldwin, Inc.

Management: Kauai Coffee Company, Inc.

Ditches:
- Alexander Dam ditch system, owned in entirety by McBryde Sugar Co.
- Pump 3 ditch system, owned in entirety by McBryde Sugar Co.

Average Delivery: 27 million gallons per day (mgd)

Delivery Capacity:	• Alexander Dam –	15 mgd
	• Pump 3 Ditch –	18 mgd
	Total Capacity	33 mgd

Miles of Ditches: (infrastructure include tunnels, siphons, aqueducts, etc.)

- Alexander dam: from Alexander dam to Pump 3 ditch - 5 miles
- Pump 3: from Hanapepe Valley to Luawai Reservoir (Lawai) 8 miles

Total 13 miles

No. of Major Intakes: Two

Area of Watershed: 8,000 acres

Water Users:

- Kauai Coffee Co.
- National Tropical Botanical Gardens
- Syngenta Seed Co.
- Dekalb Seed Co.
- Pioneer Seed Co.
- Hanapepe Valley Taro Growers use 5 mgd not included in the 27 mgd average delivery

Reservoirs:

- Alexander Dam: 810 MG (services Kalaheo Hydroelectric)
- Elua Reservoir: 80 MG
- Mau Reservoir: 26 MG
- Elima Reservoir: 27 MG
- Hukiwai Reservoir: 16 MG
- Kapa Reservoir: 18 MG
- Ioleau Reservoir: 39 MG
- Umi Reservoir: 7 MG
- Luawai Reservoir: 9 MG

■ Total Maximum Storage Capacity: 1,032 MG

ASSESSMENT OF NEEDS

Due to time constraints and limited funds, no assessment of the system's needs was conducted. Future studies will include a detailed evaluation of this system, including an assessment of improvements needed. Consequently, no cost estimates for improvements or maintenance were prepared for this report.

Chapter 16. WEST MAUI IRRIGATION SYSTEM

INVENTORY

Subsequent to plantation closure, the original system has been down-sized to two operational ditches: Waihee Ditch, 70 mgd capacity, and Spreckels Ditch, 50 mgd capacity. The ownership of these two ditches are shared by Wailuku Agribusiness Co. Inc. (successor to Wailuku Sugar Co.) and Alexander & Baldwin, Inc. Now called the West Maui Irrigation System, the system is operated and maintained jointly by Wailuku Agribusiness Co. and Hawaiian Commercial & Sugar Co. There are seven surface water diversions and approximately 17 miles of ditches which support agricultural operations on the western side (Iao Valley) of the Maui isthmus.

The former Wailuku Sugar Co. took over Waihee Plantation in 1895, at which time Spreckels' 1882 Waihee Ditch became the source of conflict and legal action between Wailuku Sugar Co. and Mr. Spreckels of HC&S.

Subsequently, but before legal resolution, HC&S was acquired by new owners who shared a common interest with Wailuku Sugar Co. in a proposal to construct a second ditch to divert Waihee Stream flows at a higher elevation. The terms of the agreement (made permanent with exchanges of fee title almost 25 years later) were that HC&S would get five-twelfths of the new upper-level " Waihee Canal" water and one-half of the older Waihee Ditch (Spreckels) water. With these issues resolved, Wailuku Sugar Co. undertook the construction of Waihee Canal.

The Waihee Canal (also called Waihee Ditch) was started in 1905 and completed in 1907. This 50-mgd capacity ditch tapped Waihee Stream at the 650 ft elevation, just below Aliele Falls. Its 10.62 mile length included 22 tunnels, totaling 16,539 ft; 39 flumes totaling 2,764 ft; 35,549 ft of open, cement-lined ditch; and a 1,253 ft long, 3 ft diameter siphon across Iao Valley. Ditch grade averaged 2.5 ft per 1,000 ft. The longest tunnel (2,246 ft) was especially challenging because much of it penetrated through hard close-grained rock.

The old Wailuku Sugar Co. ditch names, it must be noted, are particularly confusing. In recent times, the newer ditch (formerly Waihee Canal) is now referred to as the Waihee Ditch, whereas the older ditch is now called the Spreckels Ditch (formerly Waihee Ditch).

Adding confusion is another Spreckels Ditch (formerly Haiku Ditch) belonging to the East Maui Irrigation System.

By 1913, Wailuku Sugar Co. was irrigating entirely from mountain sources. Besides the major ditches mentioned herein, the company had nine other smaller ditches; two on Waiehu Stream, five on Wailuku Stream in Iao Valley (the largest was Maniania Ditch), and two on Waikapu Stream (South Side and Palolo Ditches). Some of these ditches have been abandoned or consolidated. Wailuku Sugar Co. ended sugar production in 1988.

EXISTING CONDITIONS

Ownership:
- Wailuku Agribusiness Co., Inc. (WAB)
- Alexander & Baldwin, Inc. (A&B)

Management: Wailuku Agribusiness and Hawaiian Commercial & Sugar Co. A maintenance crew of 4 to 5 persons maintains the West Maui Irrigation System.

Ditches: sections.
- Waihee—owned in fee by WAB with perpetual easements in some.
- Spreckels—owned in fee by WAB with perpetual easements in some sections from Waihee Stream to South Waiehu Stream. A&B owns in fee from South Waiehu Stream to HC&S reservoirs 73 and 74.

Average Delivery: 45 million gallons per day (mgd)

Delivery Capacity:

• Waihee Ditch –	70 mgd
• Spreckels Ditch –	50 mgd
Total Capacity	100 mgd

Miles of Ditches:

	Miles
• Waihee Ditch (from Waihee Valley to Hopoi Chute)	6.06
• Waihee Ditch (from Hopoi Chute to WAB Reservoir 99)	4.47
Total …………………………………...........	10.53
• Spreckels Ditch (from Waihee Valley to South Waiehu intake)	3.30
• Spreckels Ditch (from South Waiehu intake to HC&S Res. 73/74)	3.44
Total ……………………………………	6.74
■ Total Waihee and Spreckels ………………………………..	17.27

No. of Major Intakes:	Seven
Watershed Area:	13,500 acres
Water Users:	Hawaiian Commercial & Sugar Co. Sandalwood Golf Course Maui Tropical Plantation Maui Pineapple Company Maui Department of Water Supply Various landowners for agricultural purposes Kuleanas (4.5 mgd of uses not included in the 45 mgd average delivery)
Allocation of Water:	Per June 23, 1924 Agreement: • Waihee Ditch—5/12 HC&S, 7/12 WAB from Waihee Stream to Hopoi Chute Ditch • Spreckels Ditch—50/50 HC&S and WAB from Waihee Stream to South Waiehu Stream, 100% HC&S from South Waiehu Stream to Reservoirs 73 and 74

ASSESSMENT OF NEEDS

Due to time constraints and limited funds, no assessment of the system's needs was conducted. Future studies will include a detailed evaluation of this system, including an assessment of improvements needed. Consequently, no cost estimates for improvements or maintenance of the system were prepared for this report.