LINDA CROCKETT LINGLE
Mayor
TELEPHONE 243-7855

OFFICE OF THE MAYOR
COUNTY OF MAUI
WAILUKU, MAUI, HAWAII 96793

September 16, 1991

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OFC. OF QUALITY

Mr. Brian J. J. Choy, Director
Office of Environmental Quality Control
465 S. King Street, Room 104
Honolulu, HI 96814

Dear Mr. Choy:

Subject: **Lahaina WWRF Additions and Modifications Negative Declaration**

The Department of Public Works, County of Maui, has reviewed the attached Environmental Assessment for the Lahaina WWRF Additions and Modifications, and has determined there are no significant impacts. Therefore, we have found this document to be a negative declaration.

If there are any questions concerning the environmental assessment, please contact Mr. Pedro Foronda of our Wastewater Reclamation Division at 243-7417.

Very truly yours,

Linda Crockett Lingle
Mayor

PF:sv
attachs.

c: Bill Meloy, Brown and Caldwell

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1991-10-08-MA-FEA

County of Maui
Department of Public Works

*Lahaina Wastewater Reclamation Facility Stage 1 Design *

Environmental Assessment and Negative Declaration

September 1991

Brown and Caldwell Consultants

5485163a 8-30-91

County of Maui
Department of Public Works

Lahaina Wastewater Reclamation Facility Stage 1 Design

Environmental Assessment and Negative Declaration

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COUNTY OF MAUI

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Jerry Morgan, Superintendent of Wastewater Treatment Plants
Pedro Foronda, Civil Engineer, Wastewater Reclamation Division
Randy Luat, Plant Supervisor

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CHAPTER 1

EXECUTIVE SUMMARY

The improvements to the Lahaina Wastewater Reclamation Facility (LWRF) pose no significant environmental impacts to the island of Maui. In fact, the new treatment facilities will provide an effluent cleaner than that being produced today. The planned expansion goes beyond state and federal requirements for effluent water quality. This section provides a brief summary of our findings.

As Lahaina's population increases, the County of Maui must increase the capacity of the LWRF to maintain water quality and to meet federal and state environmental regulations. The County has chosen to accomplish this task through a staged approach that will increase treatment capacity gradually while meeting water quality standards. This environmental assessment addresses the first stage of those improvements. We have found that construction of these reclamation facility components will have no adverse impacts on the environment.

Pressure to increase treatment capacity is coming from several directions:

- The State Housing Finance and Development Corporation (HFDC) has proposed building between 3,750 and 4,900 new affordable housing units in the area by 2001.
- The Lahaina Community Plan of December 1983 projected that the population of the area served by the LWRF will increase to 26,400 from its current population of less than 15,000. Although Lahaina residents have chosen to slow growth to a top population of 20,000, even this amount represents a large increase.
- The Community Plan projected significant increases in the number of hotel and condominium units that will be built to accommodate Lahaina's tourist trade.
- About 25 percent of the residences currently use cesspools for wastewater disposal and must be connected to the collection system by the year 2000. Connection of these residences will prevent groundwater quality contamination due to leaching of waste substances (particularly nitrate) into the groundwater.

The Stage 1 improvements will increase the average-flow capacity of LWRF from 6.7 million gallons per day (mgd) to 9 mgd while providing increased treatment reliability and flexibility. In addition, the treatment components will provide a higher level of treatment than currently is being performed.

We have made a careful assessment of the improvements to ensure that there are no detrimental effects to the environment.

Significant findings are as follows:

Land

No new land will be used for the improvements. New injection wells will be drilled through the sedimentary layer and into basalt; however, sedimentary portions of the wells will be cased.

Air

Temporary local construction may increase dust and diesel fumes. In the long-term, air quality will be improved by reducing the amount of spray from the sludge aeration tanks that occurs during high winds.

Odor

The improvements will decrease the potential for odor at the plant.

Biological Resources

No endangered or threatened species live on the plant grounds or nearby.

Water

Enhanced effluent filtration will reduce the amount of suspended solids which may reach the ocean after deep well injection by 19%, even with increased plant capacity.

In response to concerns raised about algal blooms off the coast of Lahaina, we consulted with several local water quality experts. Those consulted believe that the blooms are a natural occurrence and are not related to injection well effluent. A study supporting these findings is presented in Appendix C.

Noise

Noise levels will decrease when new fine-bubble diffusers and blowers are installed to replace existing mechanical aerators although additional noise may occur during construction.

Energy

Energy use will increase due to the higher treatment loads necessitated by increased population; however, all new equipment will be the most energy-efficient available. Fine-bubble aeration will be less energy-intensive than the existing mechanical aeration.

Public Health and Safety

Improvement of chlorination facilities will provide better control over disinfection and ensure a higher-quality effluent. The chlorine storage and handling facility will be enclosed and a chlorine gas scrubbing system will prevent gas leaks to the outside atmosphere if a plant malfunction occurs. In addition, using fine-bubble aerators will reduce the amount of wastewater aerosol that sprays off the site.

As a result of our investigations and the supporting documentation, the Notice of Determination in Chapter 6 together with this Environmental Assessment is filed as a Negative Declaration by the Department of Public Works, County of Maui.

The proposing agency (applicant) is the Wastewater Reclamation Division, Department of Public Works, County of Maui, 200 S. High Street, Wailuku, Maui, Hawaii, 96793. The contact person is Mr. Eassie Miller, P.E., Chief. The approving agency is the Department of Public Works, County of Maui (address above).

The following agencies were consulted in the review of this assessment:

U.S. Army Corps of Engineers, Honolulu District
U.S. Fish and Wildlife Service
Hawaii Department of Land and Natural Resources (DLNR)
Hawaii Office of Environmental Quality Control (OEQC)
Hawaii Office of State Planning, Coastal Zone Management
County of Maui Planning Department
County of Maui Department of Water Supply
West Maui Advisory Committee
West Maui Taxpayers Association

Each of these agencies was notified of the project in a package containing a copy the draft environmental assessment and a letter highlighting the significant project elements. Written comments were received from DLNR, OEQC, County of Maui Department of Water Supply, County of Maui Planning Department, and U.S. Army Corps of Engineers. A copy of these comments is contained in Appendix A of this document. Other agencies consulted in making this assessment are also included in Appendix A.

CHAPTER 2

BACKGROUND AND PROPOSED PROJECT

BACKGROUND

The Lahaina Wastewater Reclamation Facility provides treatment to wastewater in the west Maui area from the region of Lahaina to Kapalua. These facilities are owned and operated by the County of Maui.

Most of the sewer system in Lahaina Town was constructed over 35 years ago. Raw wastewater was collected and pumped to the Ala Moana wastewater pumping station located near Mala Wharf, and this wastewater was discharged offshore through a 1,500-foot ocean outfall into waters 40 feet deep.

In the early 1970's, it was determined that ocean disposal of untreated wastewater created potential public health hazards in an area popular with fishermen and swimmers, threatened valuable aquatic resources in the nearshore discharge zone, and conflicted with state and federal water quality standards.

A wastewater treatment site was selected at Honokowai, a midpoint location for the planned service area extending from Lahaina to Napili. Design work on the Lahaina Water Reclamation Facility was started in 1972; the initial phase of the plant was designed to handle 3.2 million gallons per day (mgd). Flows from south of Hanokowai were pumped to the plant, and ocean discharge of raw sewage was terminated. Flows from the Kaanapali Resort were also pumped to the plant, and the resort's packaged wastewater treatment plant, originally constructed in the early 1960's, was closed. Portions of the Kaanapali Resort collection system were dedicated to the County.

In 1982, it was decided to build a 3.5-mgd expansion to the Lahaina facility, thus raising the total plant design capacity to 6.7 mgd. This expansion was completed in 1985.

Essentially, the 1985 expansion consisted of building an additional treatment plant to operate in parallel with the 1975 Plant. Both plants have similar treatment processes: screening, grit removal, activated sludge biological treatment, secondary clarification, chlorine disinfection, and disposal through injection wells. The 1975 Plant has an effluent filter and an effluent storage reservoir. The 1985 Plant solids processing system - dissolved air flotation thickening and belt filter press dewatering -currently serves both plants.

The LWRF is now nearing capacity and additional flows from residential and tourism-related development are expected.

The 1983 Lahaina Community Plan provides a relatively detailed scheme for implementing the broad objectives and policies delineated in the Maui County General Plan. The community plan documents the desired sequence and pattern of future growth in the area. The current resident population in the area is approximately 14,100. Early population projections for the year 2000 indicated a resident population increase to 26,400, almost doubling the current population over 10 years. However, Lahaina residents prefer to pursue a more controlled growth strategy. To this end, a population guideline of 20,000 residents for the year 2000 was adopted. This is still a very large population increase and will significantly increase the needs for treatment plant facilities.

In addition, it is estimated that only 75 percent of residences currently are connected to the collection system feeding the plant. Most of the unserved residences have on-site cesspools. According to the plan, all residents will be connected to the collection system by the year 2000. Adding these residences will further increase the need for more treatment plant capacity.

The Lahaina area supports a large tourist population in addition to local residents. The tourist population will increase with resort and hotel development. The current tourist population, based on a 65 percent occupancy of condominium and hotel rooms, is approximately 13,300 and is expected to increase. Peak tourist and condominium occupancy can rise as high as 90 percent occupancy of available tourist accommodations. It is clear that demands for treatment plant services will increase substantially in the near future. The current flow is already 81 percent of the original treatment plant design capacity.

DESCRIPTION OF PROPOSED PROJECT

The County of Maui, Hawaii directed the production of the West Maui Master Plan for Wastewater Collection, Treatment, and Disposal, published in June of 1990. The Lahaina facilities and portions of the collection system are nearing capacity and additional flows are expected from tourism-related and residential development. The objectives of this master plan were to:

- Provide a description of the study area, including physical characteristics and current and projected demographics.

- Describe and evaluate the existing condition of the wastewater collection system, noting any current capacity limitation, structural problems, or other needs.

- Identify needed near-term and long-term collection system improvements, including sewer replacement, relief sewer installation, and pumping station replacement or expansion.

- Describe and evaluate the existing Lahaina Water Reclamation Facility. Determine the capacities of the individual unit processes and that of the overall facility.

- Develop and evaluate near-term and long-term alternatives for expanding the Lahaina Wastewater Reclamation Facility and ensuring its operational reliability. Select a recommended plan for implementation.

A three-stage improvement and upgrade plan was developed for the collection system and the treatment plant. The staged approach was chosen to allow improvements to parallel the County's population growth. The following describe each stage briefly below. This environmental assessment addresses only Stage 1.

Stage 1

The Stage 1 improvements will increase average-flow capacity of the reclamation facility to 9.0 mgd and provide significantly increased treatment reliability and flexibility. In addition, the planned upgrade will provide for site selection for off-site solids treatment (anaerobic digestion and dewatering) and include design and construction of urgently needed improvements. The specific recommended Stage 1 treatment improvements are as follows:

- Waste-activated sludge pumps for 1975 Plant
- Diffused aeration for 1985 Plant
- Third secondary clarifier for 1985 Plant
- Effluent filtration
- Additional injection wells
- Additional thickened sludge storage
- Chlorine system upgrade
- Minor improvements
    - Improve influent flow measurement.
    - Increase screening capacity.

- Increase grit removal capacity.
- Provide new system for distributing flow between plants.
- Provide option for wasting from mixed liquor streams in 1975 and 1985 Plants.
- Rehabilitate 1975 Plant dissolved air flotation (DAF) thickener.
- Provide improvements to 1985 Plant process water system and drain system.
- Provide additional emergency power for 1985 Plant aeration system.
- Provide additional work space.
- Provide preliminary treatment for all flow in 1985 Plant.

Stage 2

The Stage 2 improvements will increase the average-flow capacity from 9.0 to 10.7 mgd and combine the two plants into a single facility. Stage 2 also will provide primary sedimentation ahead of the activated sludge process (conversion of 1975 Plant secondary clarifiers) and flow equalization following primary sedimentation (conversion of 1975 Plant aeration tank). Additional units will be provided for the following processes.

- Screening.
- Grit removal.
- Secondary clarification.
- Chlorine contact.
- Injection wells.
- Dissolved air flotation thickening.
- Effluent filtration.

Stage 3

Stage 3 improvements will increase the average-flow capacity from 10.7 to 16 mgd and provide additional units for the following processes.

- Screening.
- Primary sedimentation.
- Secondary clarification.
- Chlorine contact.
- Effluent filtration.
- Injection wells.
- Anaerobic digestion.

This environmental assessment addresses in-plant modifications and improvements included in Stage 1. Facility changes for Stages 2 and 3 will be addressed in a separate environmental review.

REFERENCES

1. Brown and Caldwell, 1990. West Maui Master Plan for Wastewater Collection, Treatment, and Disposal.

CHAPTER 3

EXISTING WASTEWATER TREATMENT AND DISPOSAL FACILITIES

The Lahaina Wastewater Reclamation Facility is actually two plants operating in parallel--the 1975 Plant and the 1985 Plant (which identifies their year of construction). The 1975 Plant has a design average flow capacity of 3.2 million gallons per day (mgd). The 1985 Plant has a design average flow capacity of 3.5 mgd. Both are nitrifying activated sludge plants (no primary treatment); in addition, the 1975 Plant has an effluent gravity filter following secondary clarification and an effluent storage reservoir. The plants currently have a common solids treatment system, and effluent disposal from both plants is to injection wells.

PLANT DESCRIPTIONS

A layout for the Lahaina facility is shown on Figure 3-1. The 1975 Plant is on the north, and the 1985 Plant is on the south. Design data for the facility are shown in Table 3-1 for the liquid stream facilities and Table 3-2 for the solids stream facilities. A combined flow diagram is presented on Figure 3-2. Separate sections are presented below on the 1975 Plant, 1985 Plant, and common facilities. Unit process capacity as discussed in this section is based on the original plant design data as presented in Tables 3-1 and 3-2.

1975 Plant

Flow enters at the 1985 Plant metering structure through the two main interceptors, termed the Napili line and the Lahaina line, which serve the north and south portions of the service area, respectively. After mixing in a small box, the flow is separated into two Parshall flumes, one of which directs flow to the 1975 Plant and the other to the 1985 Plant. After entering the two Parshall flumes, the flows from the two sides do not mix again until just before they enter the disposal wells.

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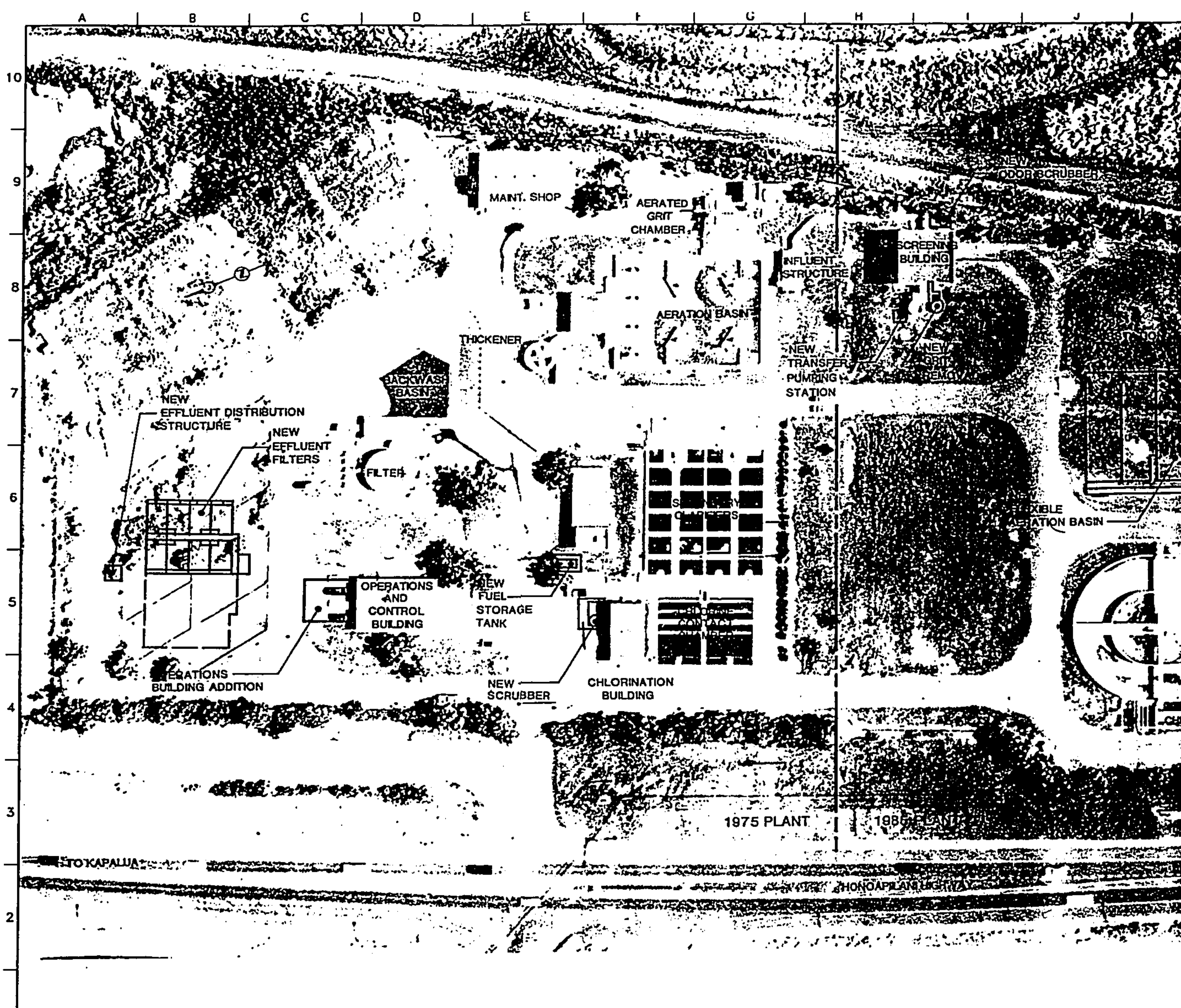

Brown and Caldwell Consultants

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APPROVED: DATE:

REVISIONS

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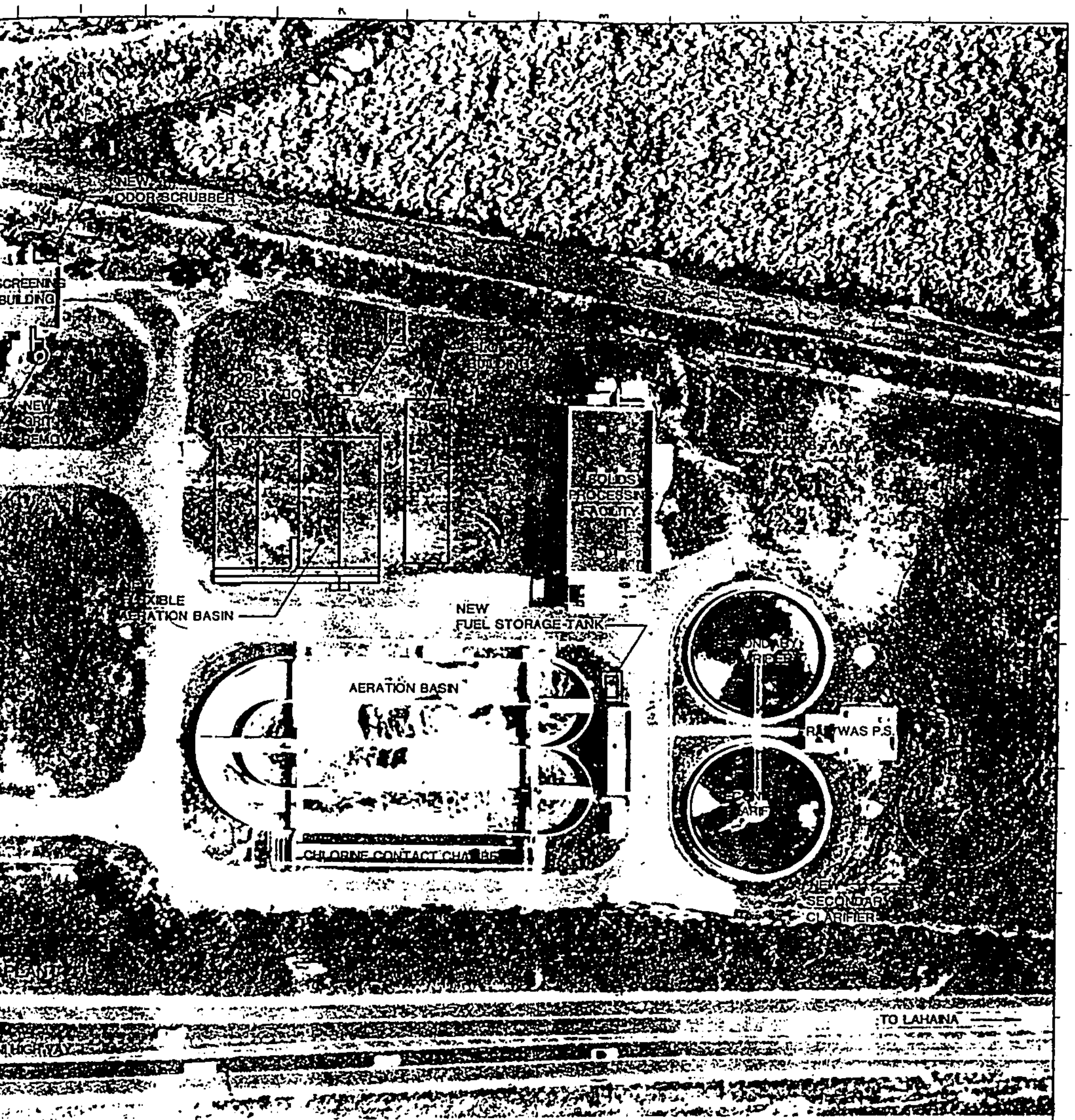

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DEPARTMENT OF PUBLIC WORKS COUNTY OF MAUI, HAWAII	FIGURE 3-1 FACILITY LAYOUT	SCALE 1"=40'
LAHAINA WASTEWATER RECLAMATION FACILITIES ADDITIONS AND MODIFICATIONS		DRAWING NUMBER
		SHEET NUMBER

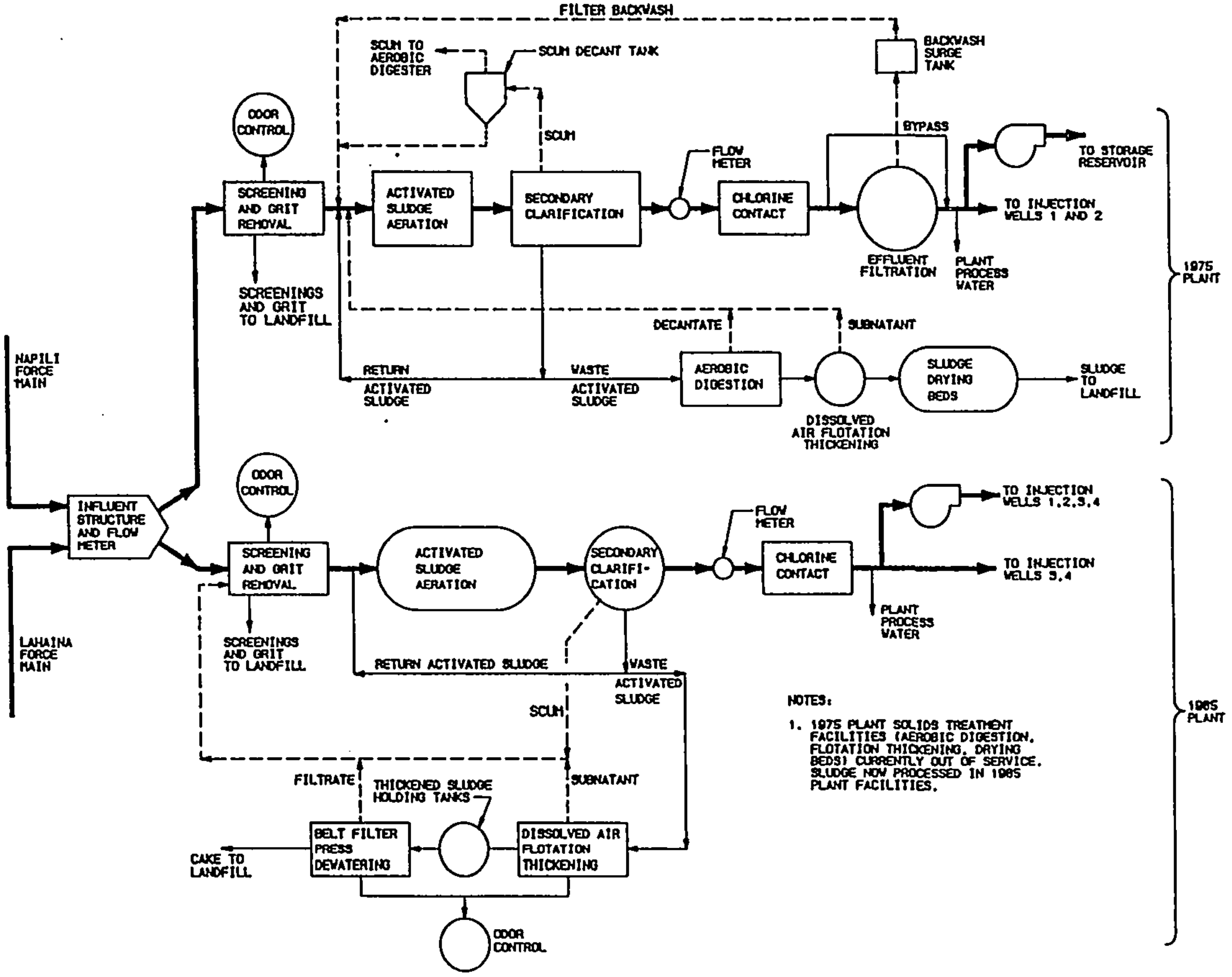


Figure 3-2 Process Flow Schematic Lahaina Water Reclamation Facility

Table 3-1. Lahaina Facility Liquid Stream Design Data

Item	1975 Plant	1985 Plant
Plant flow, mgd		
Average daily	3.2	3.5
Peak	7.1	7.5
Design loadings		
BOD^5, mg/l	240	250
BOD^5, lb/day	6,400	7,300
TSS, mg/l	240	160
TSS, lb/day	6,400	4,670
Headworks		
Parshall flume		
Number	1	1
Throat width, inches	18	18
Traveling screen		
Number	1	1
Width, feet	2.5	3
Capacity, mgd	6.4	7.0
Bar screen		
Number	1	1
Width, feet	2.33	3.0
Grit chamber		
Number	2[a]	1
Type	Aerated	Pista grit
Size, feet	11 x 20	10 dia.
Depth, feet	8	7
Aeration basins		
Number	1	1
Length, feet	82	--[a]
Width, feet	82	--[a]

Table 3-1. Lahaina Facility Liquid Stream Design Data (Continued)

Item	1975 Plant	1985 Plant
Average water depth, feet	20	13
Volume, MG	1.02	2.19
BOD[5] loading, lb/day	6,400	7,300
TSS loading, lb/day	6,400	4,670
MLSS, mg/l	3,200	3,200
Surface aerators, number	4	3
Aerator motor, hp, each	40	125
Secondary clarifiers		
Type	Rectangular	Circular
Number	2	2
Size, feet	40 x 100	75 dia.
Average sidewater depth, feet	14	12
Overflow rate, gpd/sq ft		
Average flow	400	400
Peak flow	888	850
Chlorine contact tanks		
Number	2	2
Length, feet	42	137
Width, feet	34	9
Average water depth, feet	7	8
Volume, each, 1,000 cu ft	10	9.9
Detention time Average, flow, minutes	34[4]	30[4]
Effluent filters		
Design flow, mgd	5.76	-
Solids loading, mg/l	40	-
Percent SS removal	99.5	-
Surface loading, gpm/sq ft	5	-

Table 3-1. Lahaina Facility Liquid Stream Design Data (Continued)

Item	1975 Plant	1985 Plant
Maximum head loss, feet	10	–
Filter run, hr	24	–
Mixed media, depth	12	–
Coal, inches	12	–
Sand, inches	12	–
Effluent pumps		
Number	5	4
Capacity each, gpm	1,000	1,900
Horsepower, each	250	14
Injection wells		
Number	2	2
Diameter, inches	20	20
Depth, feet	200	255
Capacity, mgd		
No. 1	2.0	–
No. 2	7.2	–
No. 3	–	7.6
No. 4	–	7.6

[a]Carrousel aeration tank.

[b]Based on assumed volatile fraction of 0.78.

[c]One unit now converted to a septage receiving station.

[d]Detention time with one unit in service.

Table 3-2. Lahaina Facility Solids Processing Facility Design Data

Item	1975 Plant[a]	1985 Plant
Aerobic digestion		
--Number	4	
--Average water depth, feet	20	
--Length, feet	19	
--Width, feet	23.3	
--Minimum detention time, days	10	
--Aerators, type	Submerged turbine	
Sludge blending tank		
Number	--	1
Volume, gallons	--	20,000
Flotation thickening		
Number	1	1
Thickener loading, lb/hr/sq ft	1.65[b]	2
Surface area, sq ft	254	300
Dry solids loading capacity		
lb/hr	419	600
lb/day	10,060	14,400
Thickened sludge pumps		
Number	--	2
Capacity, each, gpm	--	100
Speeds	--	
Adjustable		
Sludge drying beds		
Number	25	--
Length, feet	60	--
Width, feet	30	--
Depth, inches	8	--
Drying time, days	30	--

Table 3-2. Lahaina Facility Solids Processing Facility Design Data (continued)

Item	1975 Plant[a]	1985 Plant
Thickened sludge storage tank		
Number	–	1
Volume, gallons	–	3,000
Belt filter press		
Number	–	2
Minimum dry solids throughput		
lb/hr	–	700
lb/day	–	16,800

[a]Currently out of service.

[b]Based on 16-hour per day operation.

Preliminary Treatment. Preliminary treatment in the 1975 Plant consists of screening with a Parkson screen and aerated grit removal. The 2.5-foot-wide Parkson screen has 6.0-mm (1/4-inch) openings and is rated at 6.4-mgd peak flow. Screenings are conveyed to a screenings bin located in a building.

The grit removal system consists of an aerated channel with air provided by two small positive displacement blowers. A chain-and-bucket grit remover is operated approximately once per week for 1 to 2 hours to convey the grit to the grit hopper. According to the plant staff, the amount of grit accumulated is less than 0.5 cubic foot per million gallons. Grit and screenings are periodically hauled to landfill.

Aeration Basin. The 1975 Plant aeration basin is a single basin 82 feet square with a 20-foot average water depth. Its volume is 1.02 million gallons (MG). Because of its shape and the use of surface aerators, the basin operates in a complete-mix mode.

The activated sludge process is operated in a nitrifying mode and the mixed liquor suspended solids (MLSS) level is usually in the 2,500- to 3,500-milligrams per liter (mg/l) range.

Secondary Clarifiers. The two rectangular secondary clarifiers are designed for a peak surface loading rate of 888 gallons per day per square foot (gpd/sq ft). Their dimensions are 40 feet wide by 100 feet long with an average water depth of 14 feet. Sludge is withdrawn at the inlet end of the tanks using chain-and-flight sludge removal equipment. A surface skimmer is provided for scum removal.

Chlorination Equipment. The chlorination system for the 1975 Plant is housed in a covered but not enclosed building. Currently, a 200 pound per day (lb/day) chlorinator and a 500 lb/day chlorinator are provided. A single chlorinator is used both for disinfection and for other purposes, such as odor control and activated sludge bulking control.

Chlorine Contact. Two one-pass chlorine contact tanks operate in parallel following secondary clarification. Walls constructed across the tank with transfer ports provide baffling, as the length-to-width ratio is low, 1.25:1. The contact time is 30 minutes at the design peak wet weather flow (PWWF) of 7.1 mgd.

Effluent Filter. A 32-foot diameter, single-valve gravity effluent filter, manufactured by Eimco, is included in the 1975 Plant. The unit has a self-contained backwash system that is automatically activated when head loss through the filter exceeds a predetermined set point.

Effluent Force Main and Reservoir. Originally, effluent irrigation of sugar cane was the principal disposal method. Effluent was pumped through a 20-inch diameter effluent force main to a storage reservoir located approximately 2 miles east of the Lahaina facility. Although irrigation is not currently practiced, effluent is still occasionally pumped to the reservoir for evaporation disposal when the injection wells' capacity is exceeded.

Return and Waste Activated Sludge Pumping. Two return activated sludge (RAS) pumps and one waste activated sludge (WAS) pump are located at the influent end of the clarifier. Sludge from the 1975 Plant must be pumped to the 1985 facilities. The RAS pumps are used for this purpose. This is accomplished by eliminating sludge return for 2 to 4 hours per day while wasting is done.

Aerobic Digester. A four-compartment aerobic digester is provided for sludge stabilization in the 1975 Plant. Each compartment is 66,000 gallons in volume; the design solids retention time is 10 days. Air and mixing is provided by four submerged turbine mixers operating in conjunction with three 50-hp blowers. The motor sizes for the four mixers vary; they are 60, 40, 25, and 15 hp. The digester is currently not used and the sludge is dewatered and hauled to landfill rather than being disposed of on drying beds.

Dissolved Air Flotation Thickeners. A circular DAF thickener (18-foot diameter) is being restored to service after having sat idle for several years. Sludge is currently thickened and dewatered at the 1985 Plant facilities. The 1975 Plant sludge drying beds that formerly received thickened sludge are no longer in service.

1985 Plant

The 1985 Plant liquid treatment system consists of preliminary treatment (screening and grit removal), activated sludge aeration, secondary clarification, and chlorine contact. Sludge thickening and dewatering (for both plants) is provided in the 1985 Plant solids handling facility.

Preliminary Treatment. A Parkson travelling screen is used for screening. It is 3 feet wide with 6-mm (0.25-inch) openings. Its rated hydraulic capacity is 7.0 mgd.

A 10-foot diameter Pista-Grit unit with a rated capacity of 7.0 mgd is used for grit removal. A continuously running drive motor turns a rotor inside the grit chamber, inducing a vortex that causes the grit particles to fall into the grit well at the base of the structure. Grit is pumped from the grit well to a grit separator. Grit and screenings enter a common bin from where they are periodically hauled to landfill.

Activated Sludge Aeration. A 2.19 MG, 13-foot deep Carrousel aeration basin originally with three 125-hp, two-speed, surface-mounted mechanical aerators is used for activated sludge aeration. One of the aerators has recently been replaced by two 75-hp floating aerators. A schematic of the aeration tank is shown on Figure 3-3.

As with the 1975 Plant activated sludge system, a long solids retention time (SRT) is used to maximize treatment efficiency and permit nitrification to occur. SRTs have generally been maintained in the range of 15 to 20 days.

Secondary Clarifiers. Two 75-foot diameter, 12-foot deep secondary clarifiers provide solids separation following activated sludge aeration. The design surface loading rate is 400 gpd/sq ft at average flow and 850 gpd/sq ft at peak wet weather flow (PWWF). Flow is split in a distribution box located between the clarifiers. Draft tubes are used for sludge return, and sludge is wasted directly from a pit in the bottom of the clarifier. Each clarifier is served by a scum collection well connected to a scum collection trough at the periphery of the clarifier.

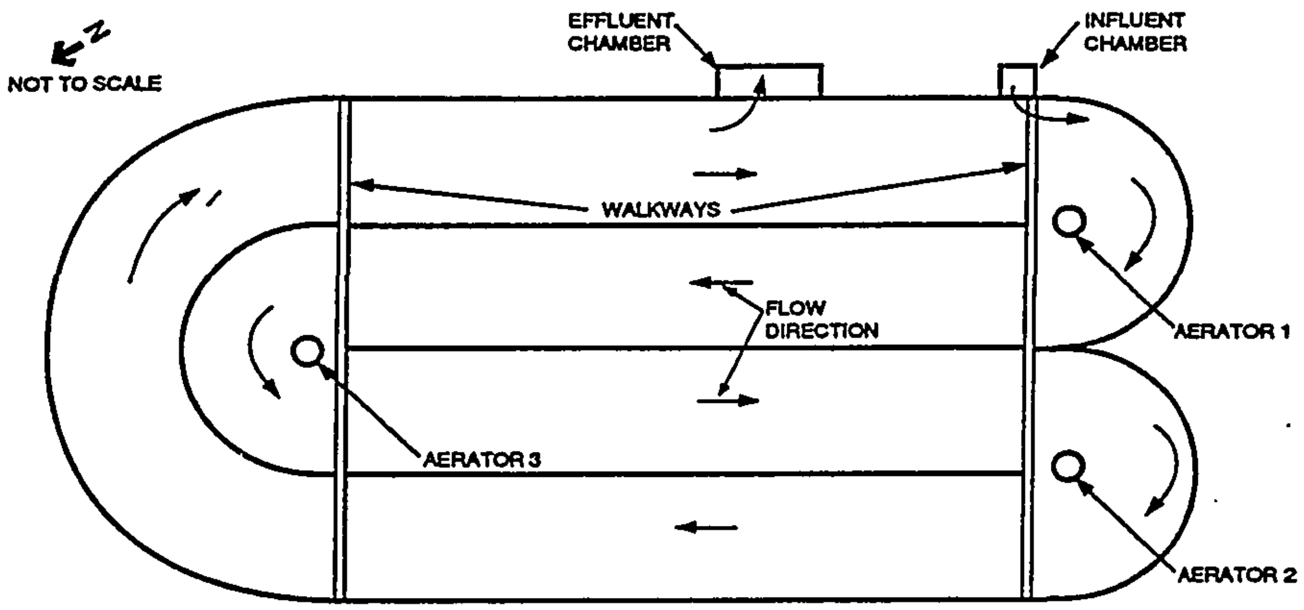


Figure 3-3 1985 Plant Aeration Basin Schematic

Chlorination Equipment. Chlorination for the 1985 Plant is provided with one 1,000-lb/day chlorinator with no backup. The chlorinator is located in the 1975 Plant chlorination building. As with the 1975 Plant, one system is used to provide chlorine for disinfection as well as for other purposes.

Chlorine Contact Channel. Two parallel channels are located adjacent to the aeration basins. Each has a volume of 9,900 cubic feet (or 74,000 gallons) and provides 34 minutes of contact time at average flow. Chlorine is added at the secondary clarifier effluent launders. In addition to providing disinfection, chlorine helps reduce algae growth in the launders.

Common Elements

Common elements serving both plants include the injection wells and solids processing facilities.

Injection Wells. Two injection wells were constructed following completion of the original 1975 Plant in 1979, and two more were added with the 1985 Plant. Wells 3 and 4 are of limited capacity, and much of the effluent from the 1985 Plant is currently pumped to Wells 1 and 2. Flow from the 1985 Plant can be delivered to all four wells, but flow from the 1975 Plant can be delivered only to Wells 1 and 2.

The original rated capacities of Wells 1 and 2 were 2.0 and 7.2 mgd, respectively. These wells were constructed as a backup to the effluent irrigation project and were never intended for long-term disposal. Wells 3 and 4, constructed with the 1985 Plant, were originally both rated at 7.6 mgd.

The capacities of these wells have decreased significantly over the years. Effluent disposal is currently the factor limiting the overall capacity of the Lahaina facility. Additional injection wells are scheduled to be provided as part of the current project.

Solids Processing. Sludge thickening and dewatering for both the 1975 and 1985 Plants are accomplished in the 1985 Plant solids processing facility, which includes a DAF thickener and two belt filter presses. Dewatered sludge is conveyed into sludge bins and hauled by truck to the Central Maui landfill.

The rectangular DAF thickener has a surface area of 300 square feet and is designed for a solids loading of 2 pounds per square foot per hour. The belt filter presses are each rated at 700 lb/hr.

Inflow and Infiltration

As described in the West Maui Master Plan, the Lahaina service area is the oldest part of the collection system and the Lahaina Town area has been the subject of several studies. An infiltration/inflow analysis prepared in 1974 by Park Engineering, Inc., concluded that an average of approximately 0.27 mgd dry-weather infiltration was being discharged through the Ala Moana outfall and that most of this infiltration was occurring along Front Street through sewer lines located below the groundwater table.

In 1979, Wastewater Systems, Inc., conducted a television inspection of portions of the Lahaina Town collection system and found numerous infiltration points at damaged pipes, offset joints, and grade deflections. As a follow-up to this inspection, an "Engineering Report for the Rehabilitation Program of the Lahaina Town Sewer System" (Park Engineering, Inc., January 15, 1980) was issued. This report recommended rehabilitation by sliplining on portions of Front Street (Shaw to Hotel Streets), Shaw Street, Canal Street, Hotel Street, and Kapunakea Street.

In 1985, infiltration was studied as part of the "Kaanapali Odor Study" (M&E Pacific, Inc., September 1985). It was estimated that about 1.3 mgd (or 40 percent of the total flow) at the Lahaina WWTP was attributable to infiltration, of which 1.1 mgd was generated in the Lahaina Service area and 0.2 mgd from the Kaanapali service area.

More recently, sections of gravity pipe downstream of sewage Pumping Station LA02 (fronting Kaanapali) showed marked signs of deterioration at the pipe crown. This pipe is fairly new (operational since 1980), and deterioration is probably due to hydrogen sulfide generation.

System improvements are discussed in the West Maui Master Plan. The Napili Side of the collection system is quite new, and there are no known structural problems.

REFERENCES

1. Lahaina Sewer System and Wastewater Reclamation Plant, Undated (CIRCA 1975). Operation and Maintenance Manual for Injection Well System.

CHAPTER 4

PROPOSED FACILITIES ADDITIONS AND MODIFICATIONS

The proposed upgrade and expansion of the Lahaina Water Reclamation Facility will occur in three stages as the Lahaina community grows. Implementation of this staged growth will culminate in a collection system and treatment plant that can handle peak wastewater flows of 35.0 mgd for the future buildout community in the Lahaina area.

Stage 1 of this three-stage upgrade deals with near-term needs of the wastewater reclamation plant. The improvements will increase the flow capacity of the plant from 6.7 mgd to 9.0 mgd. Critical to current and near-future safe operation of the Lahaina Wastewater Reclamation Facility, these improvements will increase plant reliability and safety and remove system bottlenecks. This environmental assessment addresses design and construction of these Stage 1 facilities.

CURRENT PLANT CAPACITY

The original average flow capacity rating for the Lahaina facility was 6.7 mgd: 3.2 mgd for the 1975 Plant and 3.5 mgd for the 1985 Plant. During preparation of the West Maui Master Plan for Wastewater Collection, Treatment, and Disposal (Brown and Caldwell, 1990), the capacity of existing plants was assessed to determine if the rated treatment plant capacity was necessary.

As a result of the capacity assessment, two capacity ratings have been assigned to the Lahaina facility. The "safe capacity" has been set at 6.2 mgd, 0.5 mgd less than the original design capacity. The "safe capacity" is based on conservative loadings and includes sufficient reliability and redundancy features to ensure treatment under all reasonably expected conditions.

The second rating, "stressed capacity," is the flow at which the plant should be able to operate, given added operator attention, no unusual breakdowns, and occasional special operating techniques. At a plant's "stressed capacity," the risk of process upsets and/or violation of discharge requirements increases. The "stressed capacity" of the Lahaina facility has been set at 8.4 mgd.

Several important limitations regarding the capacity assessment should be noted. First, although the reclamation facility can treat a flow of 6.2 to 8.4 mgd, the injection wells' capacity is much lower. Additional wells should be constructed as soon as possible to accommodate current as well as future peak flows. In addition, several important reliability features, including effluent filters, a backup clarifier, and chlorination system improvements, should be added to the facility. These will ensure that the design flow can be accommodated at all times. In addition, the rated capacities are based on current treatment requirements.

STAGE 1 IMPROVEMENTS

The immediately needed upgrades and improvements in Stage 1 include:

- Waste-activated sludge pumps for 1975 Plant
- Diffused aeration for 1985 Plant
- A third secondary clarifier for 1985 Plant
- Sludge reaeration basin
- Effluent filtration
- Additional injection wells
- Additional thickened sludge storage
- Chlorine system upgrade
- Minor improvements
    - Improve influent flow measurement.
    - Increase screening capacity.
    - Increase grit removal capacity.
    - Provide new system for distributing flow between plants.
    - Provide option for wasting from mixed liquid streams in 1985 Plant.
    - Rehabilitate 1975 Plant dissolved air flotation (DAF) thickener.
    - Provide improvements to 1985 Plant process water system and drain system.
    - Provide emergency power for 1985 Plant aeration system.
    - Provide additional work space.
    - Provide preliminary treatment for all flow in 1985 Plant.

Waste-Activated Sludge Pumps at 1975 Plant

Two return-activated sludge (RAS) pumps and one waste-activated sludge (WAS) pump are located at the influent end of the clarifier. The WAS pump, which is no longer used, originally pumped sludge to either the aerobic digester or circular dissolved air flotation (DAF) thickener at the 1975 plant. With the construction of the 1985 plant, all sludge thickening and dewatering processes were moved from the 1975 plant to the 1985 plant. The RAS pumps currently are used to pump the sludge from the 1975 plant to the 1985 plant. This is accomplished by eliminating sludge return for 2 to 4 hours per day during wasting.

This practice has an adverse effect on treatment. When activated sludge is not being returned, sludge aeration basins receive no seed sludge to keep the activated sludge process going. The existing WAS pump will be rehabilitated or, if necessary, a new WAS pump with sufficient capacity and head to deliver sludge to the 1985 Plant sludge thickening and dewatering facilities will be installed. The new or rehabilitated WAS pump will allow activated sludge wasting 24 hours a day, resulting in more control over the sludge return flow.

Diffused Aeration for the 1985 Plant

A 2.19-million-gallon, 13-foot-deep Carrousel aeration basin originally with three two-speed, surface-mounted mechanical aerators currently is used for activated sludge aeration. These mechanical aerators are much less efficient than diffused air fine-bubble aeration. They also create spray and are potentially more odorous than diffused aeration. More importantly, however, the 1985 Plant aerators have been unreliable, with the shaft of one breaking, cracks occurring in the other two shafts, and gearboxes failing at other times. In one instance, a second aerator failed while repairs on another were pending, causing a process upset. The plant has been able to operate effectively with two of the three aerators in service, but this would become more difficult as flows and loadings increase. Two new floating aerators have been installed to increase treatment reliability.

In addition to the concerns over the reliability of the existing surface aerators, there are issues associated with the spray generated by the aerators. The aeration tank is located next to the Honoapiilani Highway, and sprays can drift over the fence under high wind conditions. The spray has also caused corrosion in the adjacent electrical equipment. The spray may also help to spread odors from the aeration tanks, although the odors generated there are minimal. The Stage 1 upgrade will replace the mechanical aerators in the 1985 Plant with a new diffused aeration system.

Third Secondary Clarifier for 1985 Plant

An additional clarifier is needed for plant reliability. If one unit must be taken out of service for repairs, the remaining clarifiers are highly loaded. Difficulties will increase at design flows. The immediate addition of a standby clarifier will provide design flow treatment at all times.

Effluent Filtration

Effluent total suspended solids concentrations averaged 11.6 mg/l for the 1975 Plant and 9.7 mg/l for the 1985 Plant. This represents excellent performance for the activated sludge process, but lower values would be preferable prior to injection well disposal. Although the EPA allows 30 mg/l, the improvements will reduce suspended solids to less than 5 mg/l. Effluent filtration will be provided at the Lahaina facility to achieve the low suspended solids. Continuous backwashing filters of the upflow type are proposed, as these filters do not have the complex and difficult-to-repair control systems associated with conventional deep-bed, dual-media filters.

Additional Injection Wells

The injection wells are the most critical capacity element in the treatment plant. Additional injection well capacity is needed to accommodate present and future flows and to provide the level of redundancy required by the state (twice the peak dry-weather flow). A single system will be constructed for both plants. Pumping, piping, metering, and valving will provide control and monitoring of flows to each well.

The capacities of the existing wells vary greatly, and it is difficult, perhaps impossible, to predict accurately the capacity of any specific well. Based on an average capacity of 1.7 mgd for the existing wells, 12 additional wells would be needed to provide 27 mgd of capacity for twice the Stage 1 peak dry-weather flow (13.5 mgd).

Additional Thickened Sludge Storage

Currently, there are 23,000 gallons of storage capacity between the DAF thickener and the belt filter presses (one 20,000 gallon tank and one 3,000-gallon tank). This is not adequate to permit 24-hour-per-day, 7-day-per-week operation of the thickener and one shift, 6-day-per-week operation of the belt filter presses.

An additional 50,000 to 75,000 gallons of storage are required. A covered concrete tank will be constructed at grade with internal mixing and air withdrawn to the solids building odor-removal facility.

Chlorine System Upgrade

It has been recommended that additional chlorination be provided at the Lahaina facility. This will permit one chlorinator to be dedicated to disinfection at each of the two plants. Additional chlorinators will be provided for other purposes, principally RAS chlorination for bulking control and odor control.

The major modification recommended for the chlorination storage and handling area is the enclosure of the area and provision of a chlorine gas scrubbing system to prevent any loss of chlorine gas to the outside atmosphere if a chlorine gas leak occurs. This system is required by the 1988 Uniform Fire Code and represents an important safety precaution. The County has adopted the 1985 UFC. If it adopts the 1988 UFC (or later revision) in the future, these modifications will be required.

Minor Improvements

The treatment plant also needs a number of minor modifications to increase efficiency and reliability. Increasing the capacity for screening and grit removal will enhance preliminary treatment. Rehabilitating the DAF thickeners will increase the efficiency of the solids process. Improving flow monitoring, the process water and drain system, and the work space will all add to plant reliability.

REFERENCES

1. Brown and Caldwell, 1990. West Maui Master Plan for Wastewater Collection, Treatment, and Disposal.

CHAPTER 5

DESCRIPTION OF EXISTING ENVIRONMENT

This section characterizes the local environment, area demographics, and governmental regulations pertinent to the wastewater treatment plant.

LOCAL ENVIRONMENT

Physical characteristics of interest include geography and topography, geology and soils, hydrogeology, climate, and biological resources.

Geography and Topography

Maui, the second-largest island of the Hawaiian Archipelago, is 48 miles long and 28 miles across at its widest point, and has a land area of 728 square miles. The Lahaina region, from Honokohau on the north to Olowalu on the south, stretches for about 18 miles along the shore of West Maui. Numerous sand beaches lie along the Lahaina shoreline. The northern and southern ends of this coast are characterized by "palis" or seacliffs; at the northern end, a series of scenic bays highlight the visual qualities of the shoreline environment.

From the shoreline, the land rises eastward gradually to the West Maui Mountains. The region's highest point, Puu Kukui (5,788 feet), lies approximately 6 miles inland (eastward) of the shore. The gradually sloping areas are generally under pineapple or sugar cane cultivation, forming a green backdrop to Lahaina's shoreline communities. Streams and gulches carry runoff across the developed shoreline. The collection system interceptor sewers, which are along the coast, must traverse these streams. A topographic map of the area is shown on Figure 5-1.

The principal town of Lahaina is in the south central portion of the project area. Lahaina has sought to preserve ancient Hawaiian culture by restoring and preserving many significant historical landmarks and structures. Other areas along the coastline from Kaanapali to Honokohau are the scene of expanding resort facilities, which are transforming this region into a more urban setting. New housing units being constructed in Lahaina are a large part of the reason the LWRF is being upgraded.

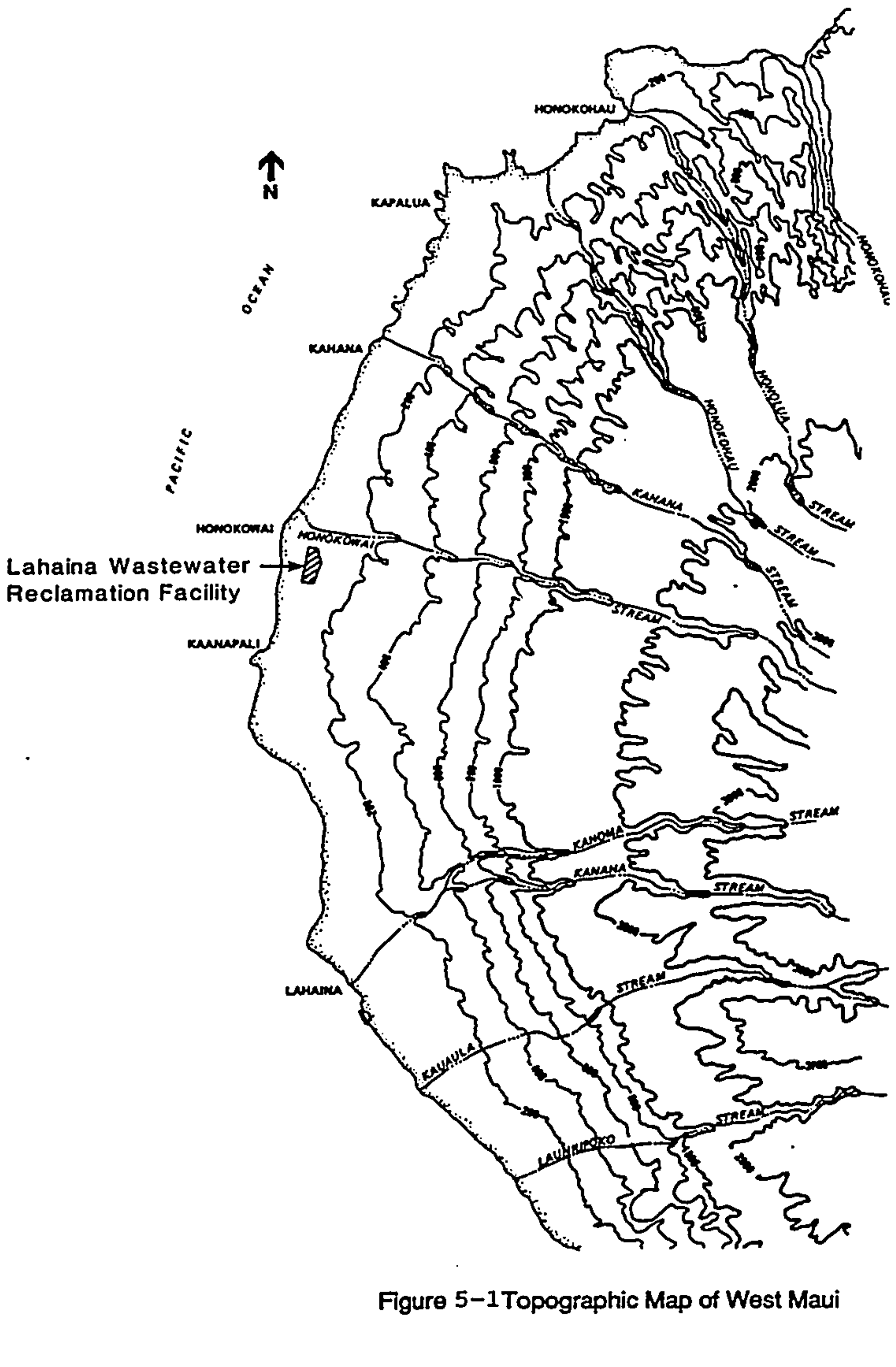


Figure 5-1 Topographic Map of West Maui

Geology and Soils

Geology and soils have a strong influence on sewer construction needs and costs and on effluent disposal capabilities.

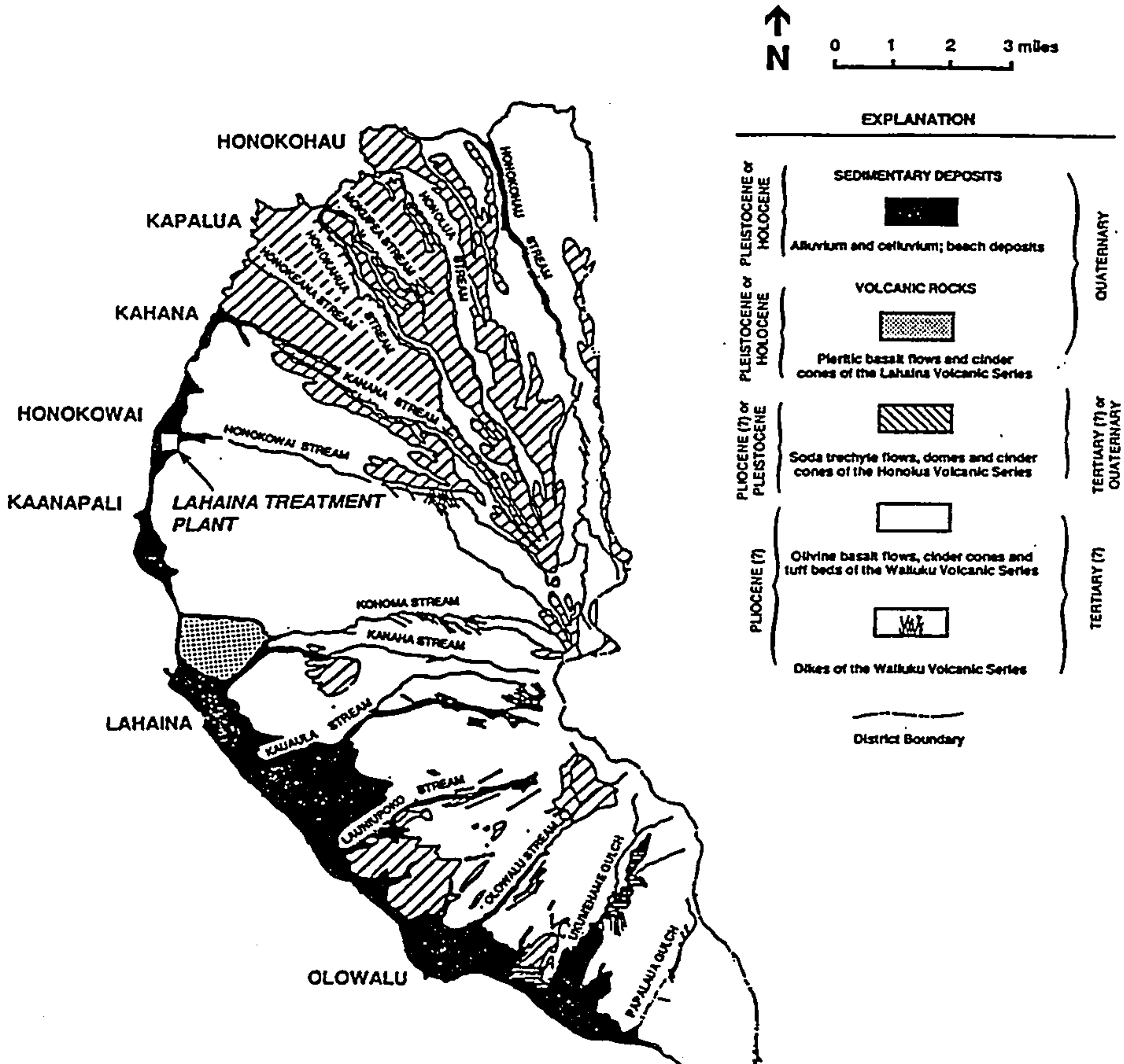
Geology. The geology of West Maui is shown on Figure 5-2. West Maui is a single, separate volcano that emerged above sea level between 1.0 and 1.5 million years ago. The central area of the discharge took place at the head of Iao Valley, leaving a large basin-shaped depression, or caldera, 1.5 to 2 miles in diameter. Pronounced rift or fracture zones radiate northward and southward from the caldera. The rift zones are identified chiefly by the occurrence of dikes, where lavas from below filled the fractures, and pyroclastic materials, which settled into the fractures after being ejected from the former discharge center in the caldera.

A typical shield volcano, West Maui grew by the accumulation of thousands of thin layers of basalt. The original dome was composed of basalt and olivine basalt of the Wailuku volcano series. This is the most widespread rock formation in West Maui and makes up the rocks in the vicinity of the reclamation facility site (Figure 5-2). These basalt sections generally include aa, clinker, and pahoehoe layers about 10 feet thick, which can be highly fractured and porous.

Following the initial extrusive phase of the volcano, a short period of dormancy set in during which some erosion took place and thin soils, up to several feet thick, formed. Eruptions then occurred again and the Honolua volcanic series, consisting of andesites and trachytes, extruded from fissures and local vents and formed a veneer 50 to 500 feet thick over much of West Maui, especially the northern and northeastern sectors which are north of the reclamation facility site.

In their molten state, andesites and trachytes are much more viscous than basalts. They are often restricted to a single massive aa layer whose thickness may reach 100 feet. Thus the Honolua rocks are denser and more massive, and occur in thicker layers than the Wailuku rocks in the vicinity of the plant site. Although the Honolua series accounts for only a few percent of the total rock mass of West Maui, it strongly influences both surface water and ground water hydrology where it forms the surface of the dome.

Long after the fissures and vents responsible for the Honolua series ceased erupting and erosion had deeply incised the West Maui dome, limited volcanic activity recurred in the vicinity of Lahaina approximately four miles south of the facility. A relatively minor volume of lava, called the Lahaina volcanic series, was erupted. The rocks of this series are of such restricted extent that they play no significant role in the region's geology.



SOURCE: Preliminary Report on the Water Resources of the Lahaina District, Maui. Circular C51. Prepared by the U.S. Geological Survey in cooperation with the Dept. of Land and Natural Resources.

Figure 5-2 Geology of West Maui

From the moment the West Maui volcano emerged above the sea, it was subject to erosion, but the rate of rock extrusion far outpaced erosion until nearly final dormancy set in at the close of Honolua time. Deep valleys were carved in the dome and the bulk of the eroded rock was deposited in the lower reaches of the valleys adjacent to the sea to form a wedge of compacted rubble called "old alluvium." Most of the "old alluvium" now lies below the present sea level.

Sea level rose and fell in response to changes in the amount of water contained in the great glaciers during the Pleistocene era. The area of coastal erosion and sedimentation therefore migrated between at least 95 feet above and 300 feet below present sea level. In more recent time, unconsolidated alluvium has accumulated in valley bottoms, and marine erosion and sedimentation have shaped the shoreline.

Soils. The soils of the Lahaina area are chiefly well-drained latasols which were formed in place by weathering of basalt, andesite, and trachyte flows. The latasols include low humic and humic ferruginous varieties in the lower and moderate rainfall regions, and the hydrol humic variety in the high rainfall zone. In the steep headwater drainages and on higher ridges, lithosols are common. Alluvial soils cover valley bottoms near the coast.

In areas between streams where slopes are less than 35 percent and in stream valleys, the normal depth of soil is about 30 inches, while on valley walls and narrow areas between streams, soils are thin and rocky. Those soils derived from the basalts of the Wailuku series are ordinarily dark to red-brown, while those associated with andesite and trachyte of the Honolua series are light brown to light red-brown. Trachyte, in particular, gives rise to light-colored soils.

Geohydrology and Effluent Disposal

The presence of fractured volcanic rocks in the West Maui area permits the use of injection wells for effluent disposal. Flows up to several million gallons per day can be accommodated if the well is favorably located. Capacities can vary significantly, however, and wells located relatively close together (50 to 100 feet) often have greatly different capacities. Further, there are no certain means to identify which locations are best prior to drilling.

The original capacity for Injection Well No. 1 at the Lahaina facility was 2.0 mgd, and the capacity for Well No. 2 was 7.2 mgd. The capacities have decreased over the years. The capacity of Well No. 1 is now 0.5 to 1.0 mgd and for Well No. 2, 3.0 to 5.0 mgd.

Climate

Climatic conditions can affect wastewater treatment systems significantly. For example, air temperature affects wastewater temperature which, in turn, influences biological treatment process rates. Wind is of particular importance because of concern over odors drifting from the treatment plant to nearby resort areas. Rainfall can affect infiltration and inflow to the collection system.

Temperature and Humidity. As it is in the entire Hawaiian Archipelago, the climate of West Maui is mild and pleasant throughout the year, although two distinct seasons occur: winter from October through April and summer from May through September.

The average daily temperature between the two seasons differs by only about 6 degrees F. Along the sea coast during the hottest month of the year (August or September), the average temperature is 78 degrees F. The temperature lapse rate is about 3 to 4 degrees F per 1,000 feet increase in elevation, so that Puu Kukui has an average temperature ranging between 55 and 60 degrees F in the coldest month of the year. Humidity on the windward coast averages 70 to 80 percent, and on the leeward coast, 60 to 70 percent. In the wet mountains it often exceeds 80 percent.

Rainfall. Between the leeward coast at Lahaina and Puu Kukui, a distance of 6.3 miles, the annual average rainfall varies from a meager 10 inches to a bountiful 400 inches annually along a logarithmic gradient of rainfall as a function of distance. At lower elevations, more than 75 percent of total rainfall and practically all effective rainfall falls in winter months during storms. Normally, five to ten storms cross the island each year, one or a few of which may provide nearly the entire annual rainfall at far leeward coasts. These storms are normally caused either by cold fronts or low pressure tropical cyclones (Kona storms) that yield a blanket of rain over large areas.

Where annual average rainfalls exceed about 20 inches, they include a component created through orography of tradewind flow. The moist air mass, lying between sea level and the inversion layer at approximately 6,000 feet, flows over the island from the ocean and cools as it rises above the high land mass, causing water vapor in clouds to condense and fall out as rain. This meteorological phenomenon produces the very high average rainfall in the mountains of West Maui where rainfalls in excess of 10 inches per month are common even during summer months. In Honokohau, the rainfall range from the coast to headwaters is 30 to 400 inches, while in most of the Lahaina district, it ranges from 15 to 300 inches.

Wind. The northeasterly tradewind prevails throughout the year in Hawaii, is more persistent in summer (90 percent) than in winter (50 percent), and tends to be stronger in the afternoon than at night. During winter months, Hawaii may be under the influence of southerly winds from Kona storms or southwesterly winds preceding the northeasterly winds that follow cold fronts.

Terrain has a varied and profound effect on wind. Winds moving over crests, around headlands, or through saddles or narrow gorges become stronger and more turbulent, while areas sheltered by high mountains may be more affected by land and sea breezes or other local winds in the immediate vicinity.

Surface wind circulation in West Maui is very complex because of the alignment of the West Maui mountains and the presence of several major gulches through the range. A 2-year record at Wahikuli, located 5 miles directly downwind from Puu Kukui, shows the existence of a combined land-sea and mountain-valley breeze circulation in that area. Of the 672 days recorded, only 125 days showed a significant departure from the land-sea breeze circulation, and on only 63 days were there tradewinds; yet, nearby unobstructed areas exhibited tradewinds 65 percent of the time. Table 5-1 is a summary of the 2-year wind rose data taken at Wahikuli.

Table 5-1. Wind Rose Data for Wahikuli

Wind direction speed, knots	Fraction of time, percent	Average
North	6	7.0
Northeast	12	6.5
East	39	4.4
Southeast	4	4.8
South	15	6.8
Southwest	13	6.4
West	10	5.4
Northwest	1	4.6
Calm	1	0.0

Figures 5-3 and 5-4 illustrate the general surface wind streamlines for the West Maui area during the day and night hours. At Honokowai, located a few miles to the north of Lahaina, the tradewinds predominate. The Kaanapali resort area lies within the narrow wedge formed by the tradewind limits, and wind in that wedge frequently shifts from the tradewinds (northeast) to sea-breeze (southwest). In the triangular-shaped area downwind of Puu Kukui, a highly persistent land-sea breeze circulation prevails.

Surface Water Hydrology

Approximately a dozen streams and gulches in the study area, as shown previously in Figure 5-1, carry water from the mountain areas to the ocean. The Lahaina Wastewater Reclamation Facility is located adjacent to Honokowai Stream. Flood Insurance Administration maps dated June 1981 show that a portion of the 1975 Plant is within the 100-year flood boundary. This area, shown on Figure 5-5, contains the 1975 Plant sludge drying beds which are no longer in service. In addition, construction of a concrete channel in that reach of Honokowai Stream probably reduced the flood threat significantly. Flood maps have not yet been updated to reflect the new channel, however.

The reclamation facility staff reports that localized flooding on other portions of the site (mainly the maintenance and administration buildings and the injection wells) occurs during intense local storms because of runoff from adjacent cane fields.

Biological Resources

The majority of land in the area is agricultural. The primary crops are pineapple and sugar cane.

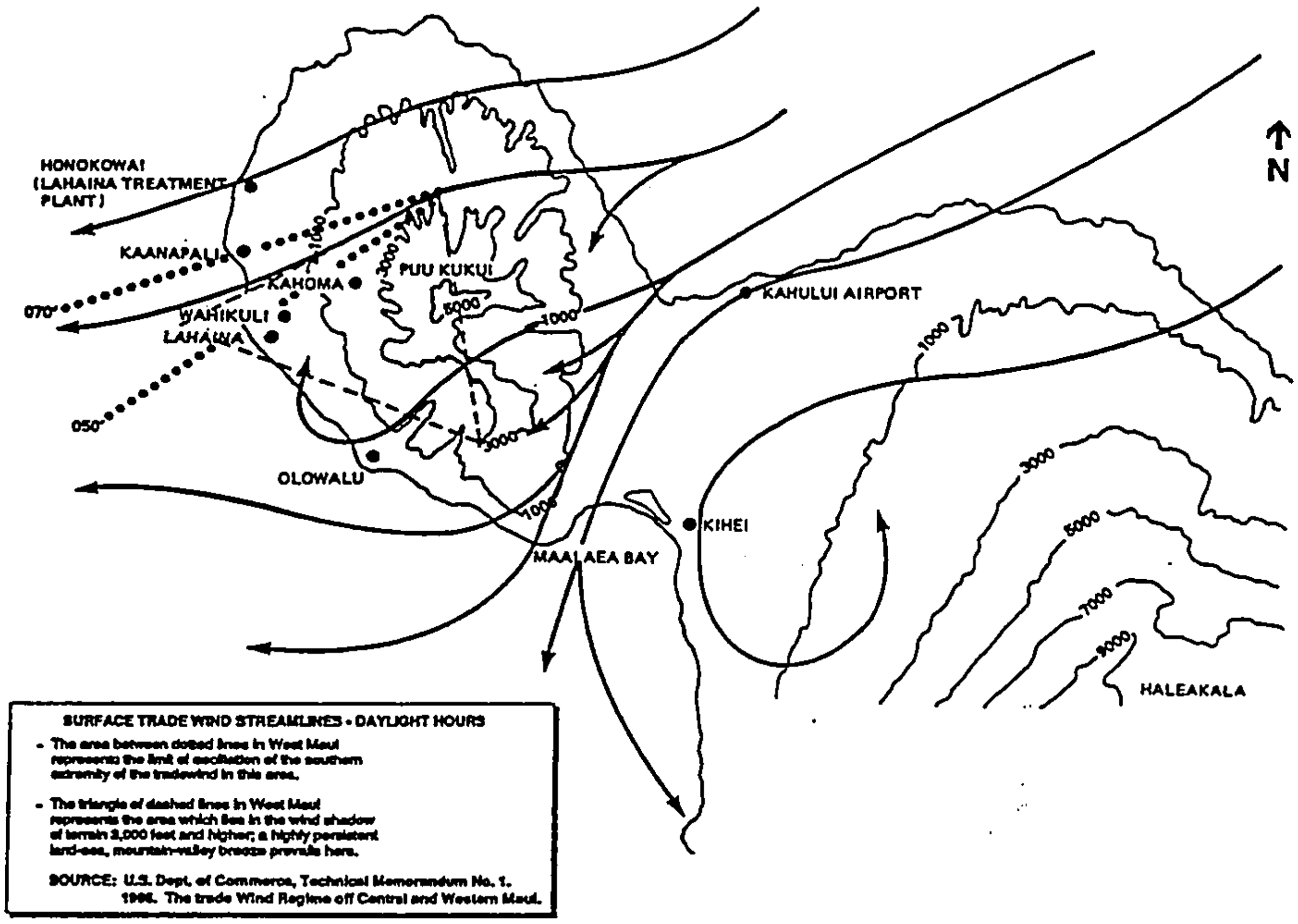


Figure 5-3 Day Wind Regime

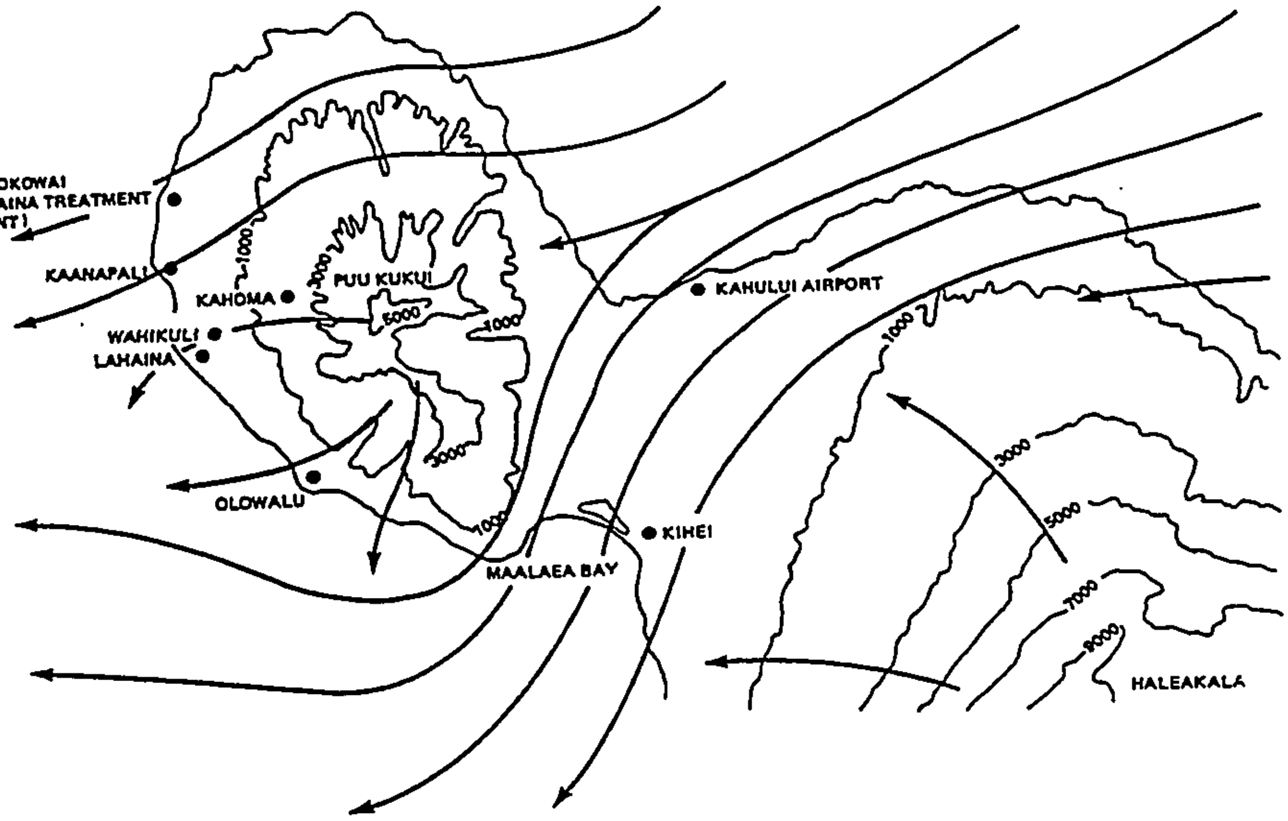


Figure 5-4 Night Wind Regime

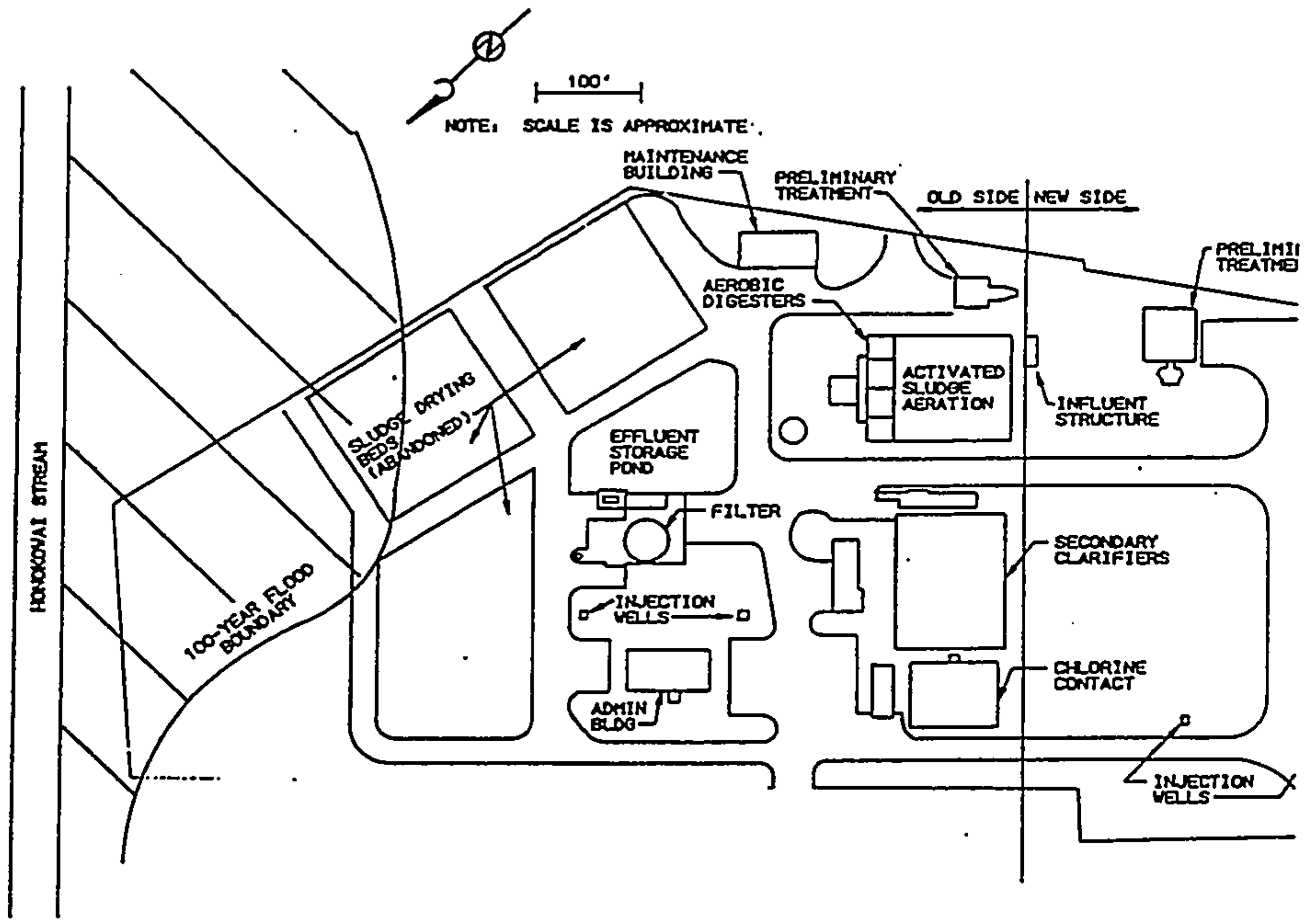


Figure 5-5 100-Year Flood Area

STUDY AREA DEMOGRAPHICS

Development and population growth are important community concerns in the study area. Both the tourist and nontourist populations are increasing rapidly.

Existing Land Use Patterns and Population

The main communities in the Lahaina region are along the shoreline. Residentially oriented communities include Olowalu, Lahaina Town, and the Napili-Honokowai area. Visitor-oriented accommodations are concentrated at the Kapalua and Kaanapali planned resort areas. Most of the inland regions surrounding the urban areas are cultivated intensely for agriculture.

Lahaina Town, with its inland neighborhoods at Kelawea and Wahikuli, is the residential center of the region. The Lahaina Town core is defined by Honoapiilani Highway, Flemming Road, Puamana, and the shore. It contains a mixture of commercial and residential uses as well as important historic structures and civic open spaces. A portion of the town is protected by a County Historic District Ordinance.

Major commercial establishments are concentrated along Front Street and areas immediately behind it. Although frequented by residents and visitors alike, commercial emphasis is visitor-oriented. Resident-oriented commercial services are concentrated along Wainee Street and offer essential professional services and merchandise. Multifamily housing neighborhoods are located adjacent to these commercial areas, interspersed with small, older single-family residential neighborhoods. Major residential areas within the town exist south of Shaw Street, north of Kapunakea Street, and along the shoreline from Baker Street to Puunoa.

Light industrial companies are located in the vicinity of the old cannery site. Other light industrial sites are located east of Honoapiilani Highway along Lahaina Town on both sides of Kahoma Stream. Pioneer Mill and its operating yard just east of the town constitutes the sole heavy industry.

The residential area from Honokowai to Napili is a band along the shoreline served by lower Honoapiilani Road and local streets. A mixture of single-family homes, apartments, and condominiums, as well as some hotels, is found in this area. Vacant lands for potential urbanization are located here.

Between Olowalu and Lahaina Town, Honoapiilani Highway runs close to the shoreline. The lands west of the highway are open. A distinct open space separation also occurs between Lahaina Town and Kaanapali. Lands north of

Kapalua are also open, with scattered residences. These shoreline open space elements, in combination with the agricultural lands, are important open space in the Lahaina region.

Resident population in the Lahaina region increased by 86 percent between 1970 and 1980, from 5,524 to 10,284. The 1990 census indicates that population is 14,574. Of this total, approximately 9,000 reside south of the LWRF, with the remaining 5,100 living north of the plant. It is estimated that 75 percent of the residences are connected to the collection system.

As of June 1989 there were 9,273 visitor units (hotel plus condominium) in the Lahaina district. The estimated population (residents plus visitors) for the island of Maui for 1990 was estimated at 143 percent of the resident population. Due to the seasonal nature of tourism (Figure 5-6), the total population fluctuates throughout the year, probably doubling the resident population during the high season (November through April).

Projected Land Use and Population

The Lahaina Community Plan, dated December 1983, provides a relatively detailed scheme for implementing broad objectives and policies delineated in the Maui County General Plan. Contained in this plan are the desired sequence, patterns, and characteristics of future development for the region, including maps identifying the planned distribution and intensity of land uses and facilities. This Community Plan is a guide for making decisions regarding development in the region until the year 2000, with updates occurring at least every 10 years to incorporate new data and analysis.

Early population projections for the year 2000 indicated a resident population increase to 26,400 (Table 5-2). Lahaina residents chose to pursue a controlled growth strategy to maintain a small town or village character, rather than large-scale expansion around Lahaina Town. To accomplish this, a year 2000 population guideline of 20,000 was adopted.

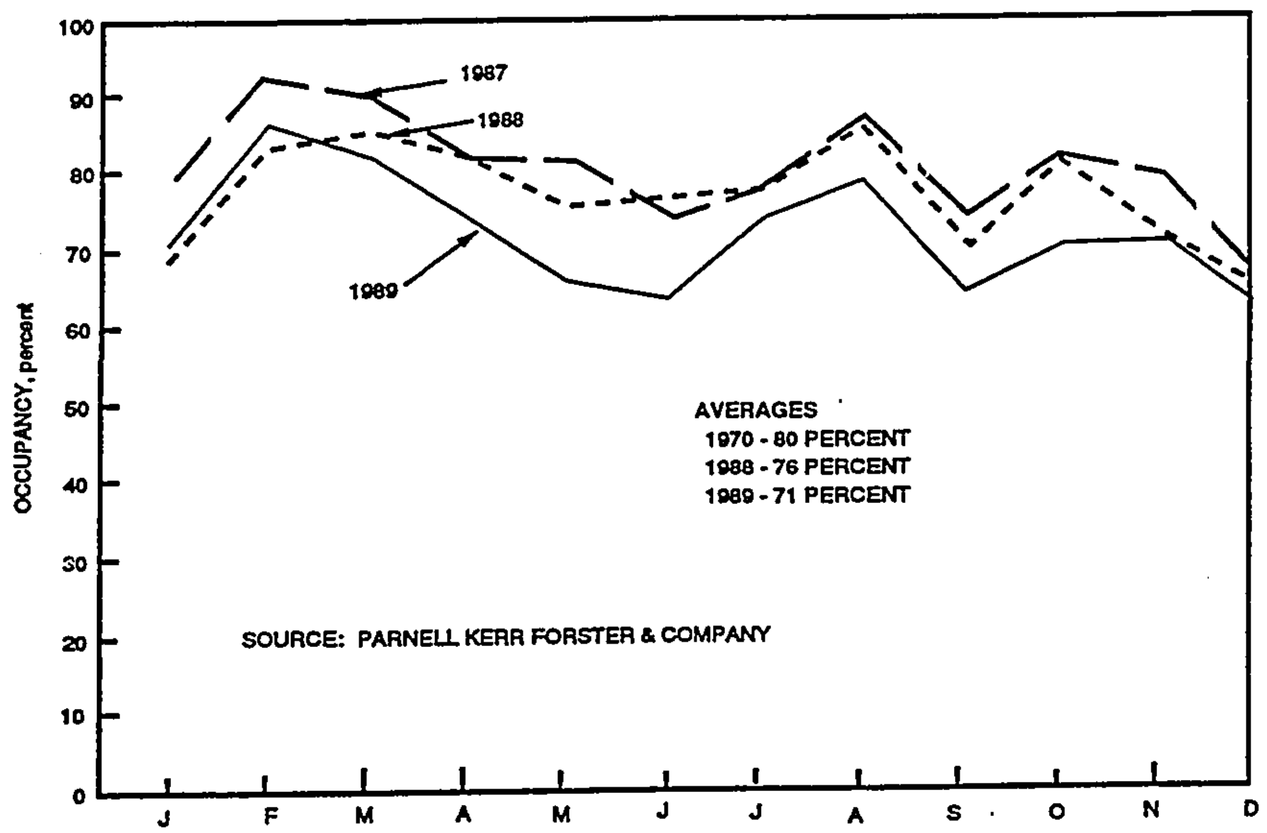


Figure 5-6 Monthly Hotel Occupancy Variations, West Maui (Kapalua to Makena)

Table 5-2. Lahaina Community Plan Projections[a]

Description	Year		
2000	1970	1980	1989
Population, persons, 26,400[b]	5,524	10,284	14,100
Employment, persons, 19,600	--	10,200	--
Housing demand			
Total units, 10,300	1,800	4,200	--
Single-family units, 5,200	--	2,700	--
Multifamily units, 5,100	--	1,500	--
Transient demand			
Total units, 11,000	--	5,800	9,278
Hotel units, 6,000	--	3,300	--
Multifamily units, 5,000	--	2,500	--
Household income, dollars/year, 26,700	--	21,900	--
Retail demand			
Total, square feet, 1,000,000	--	479,000	--
Resident space demand, square feet, 545,000	--	184,000	--
Visitor space demand, square feet, 455,000	--	295,000	--
Office demand, square feet, 584,000	--	257,000	--
Industrial demand, acres 150	--	50	--

[a]Source: Technical Report, Lahaina Community Plan, 1983.

[b]Preliminary Figure. Projected population in adopted Community Plan is 20,000.

Consistent with a policy of slow population growth, the following phases were included in the Community Plan (see Maps 6-1 through 6-7 in Chapter 6 of the Community Plan):

- Phase I (short term, first 5 years):
  - Infill at Napili-Honokowai.
  - Minor expansion inland from Honoapiilani Highway at Napilihau.
  - Infill at Lahaina.
  - Residential development at Kapunakea.
  - Residential development in the vicinity of Wainee Village.
  - Residential development around Crater Reservoir.
  - Residential development adjacent to the Lahaina Civic Center.
  - Residential development within Project District IA
- Phase II (medium-term, 10-year growth, if more accommodation is needed):
  - Napilihau extension.
  - Contributions to residential housing at Kaanapali North.
  - Contributions to residential housing north of the Lahaina Civic Center.
  - Contributions to residential housing within Project District 1A.
- Phase III (long-term, 20-year growth, if further accommodation is needed):
  - Continued residential expansion at Kaanapali North.
  - Continued residential expansion north of the Lahaina Civic Center.
  - Continued residential expansion within Project District 1A.

In addition to proposed developments delineated in the Lahaina Community Plan, several new proposals have been made. The State Housing Finance and Development Corporation (HFDC) has proposed a major affordable housing project of approximately 3,750 to 4,900 units in the agricultural uplands between Lahaina and Honokowai. This project is scheduled to be completed by 2001. Additional development also has been proposed between Puamana and Olowalu (at Ukumehame, Launiupoko, and Olowalu). These proposals were removed from the earlier deliberations in the formulation of the Lahaina Community Plan.

REGULATORY REQUIREMENTS

The basic regulatory framework for wastewater treatment and disposal in Hawaii is contained in Title 11, Chapter 62 of the Hawaii Administrative Rules. Chapter 62 covers both publicly and privately owned wastewater treatment plants and individual wastewater systems. Title 11, Chapter 23 defines the Underground Injection Control (UIC) Program, developed to protect ground water supplies from contamination by wastewater disposal.

Wastewater Treatment Plants

Chapter 62 contains several provisions applicable to the Lahaina facility. These pertain to both treatment level and disposal requirements.

Treatment. Chapter 62 specifies effluent requirements for all treatment plants. In addition, the Lahaina facility has an NPDES permit for discharges to Honokowai Stream. The permit specifies, however, that discharge to Honokowai Stream shall not be permitted "except for reasons such as an act of God, war, strike, or for any other cause outside the control of the permits." Effluent limits are summarized in Table 5-3.

Although the EPA and state limit for suspended solids is 30 mg/l, the LWRF will produce an effluent with less than 5 mg/l suspended solids. Removing the solids through effluent filtration will reduce nutrient loads as well as extend the injection wells' useful life.

The requirements for effluent irrigation specified in Table 5-3 are currently being re-examined. More comprehensive, and more stringent, regulations may be developed as a result.

Table 5-3. Lahaina Effluent Requirements

Constituent	Requirement
BOD_5	30 mg/l, 30-day average[a,b]
	45 mg/l, 7-day average[b]
	60 mg/l, maximum, grab sample[b]
Suspended solids[a,b]	30 mg/l, 30-day average[a,b]
	45 mg/l, 7-day average[b]
	60 mg/l, maximum, grab sample[b]
Disinfection	
Injection wells[a]	0.1 mg/l minimum chlorine residual
Surface discharge[b]	200 MPN fecal coliforms/100 ml, 30-day
Geometric mean	400 MPN fecal coliforms/100 ml, 7-day
Geometric mean	23 MPN total coliforms/100 ml, 30-day
Effluent irrigation[a] median (five samples)	240 MPN total coliforms/100 ml, maximum

[a] Title 11, Chapter 62, Hawaii Administrative Rules, December 1988.

[b] NPDES Permit HI 0020184, August 1986.

Disposal. Policy decisions by the County government in the early 1970s ruled out offshore outfalls as a means of disposal for treated wastewater. In current practice, most effluent is disposed of by injection wells, although a small percentage is used for irrigation. Chapter 62 requires that a backup disposal system with 100 percent of the peak dry-weather flow capacity be available. This requirement affects the number of injection wells required.

The UIC Program regulates the location and conditions of injection well discharge in Hawaii. A UIC permit must be obtained for each injection well. In general, all injection wells must be located on the seaward side of the UIC line, which is generally defined as being 1,000 feet inland or at 100 feet elevation, whichever is greater from the shore. The UIC line in the vicinity of the Lahaina facility is shown on Figure 5-7.

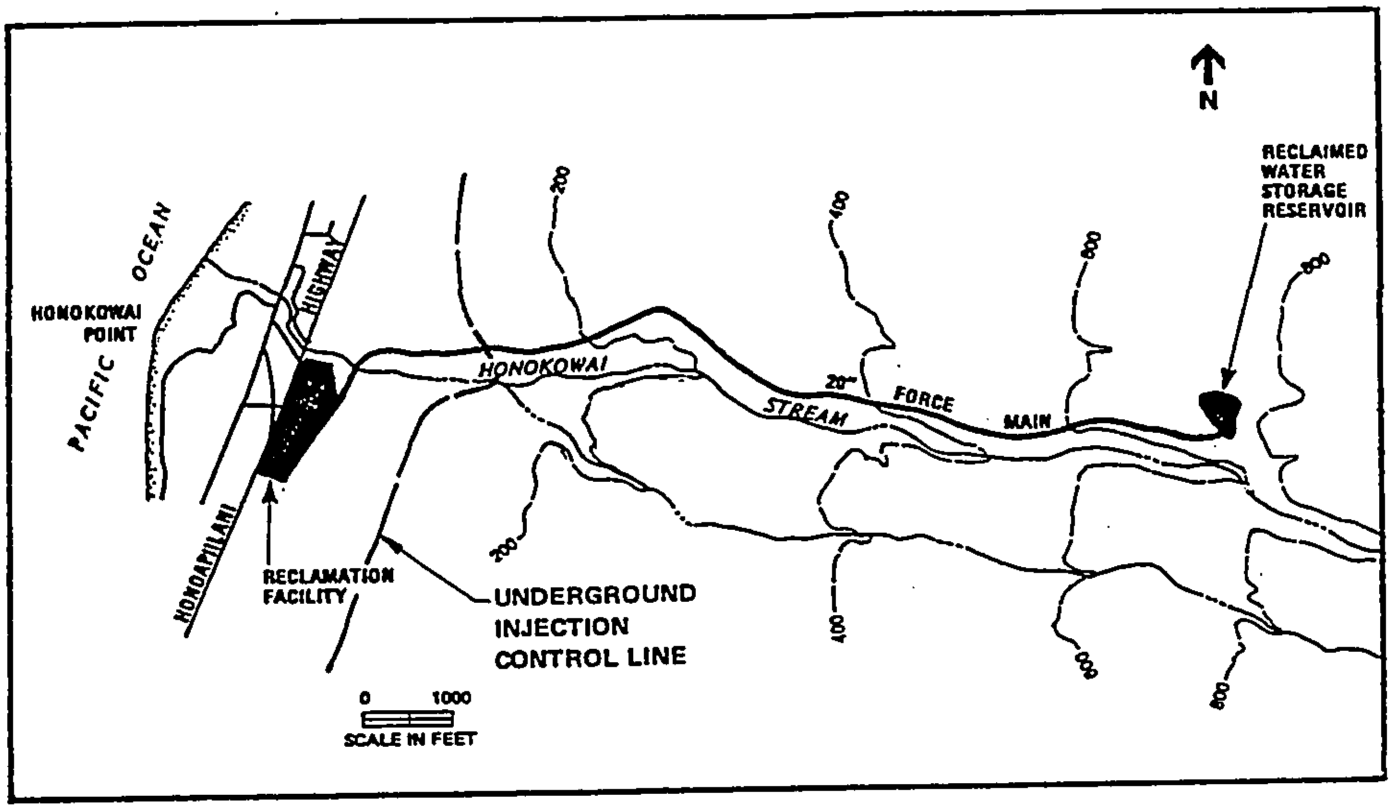


Figure 5-7 Underground Injection Control (UIC) Line

The State of Hawaii is also in the process of designating Critical Wastewater Disposal Areas (CWDAs) to protect underground drinking water and surface waters. In November 1989, the County of Maui Wastewater Advisory Committee (MWAC) recommended that both the inland and coastal areas of West Maui (Lahaina District) be designated a CDWA.

Sludge Disposal. Chapter 62 specifies that the State Director of Health must approve each wastewater sludge disposal plan, including treatment and transport. Acceptable sludge disposal methods identified in Chapter 62 are: (1) a duly permitted solid waste facility; (2) agricultural land application for beneficial use purposes (meeting the federal requirements specified in 40 Code of Federal Regulations [CFR] Part 257); (3) incineration; and (4) another wastewater system that has been given specific authorization to accept and dispose of sludge.

Individual On-Site Systems

Cesspools are the most common individual on-site systems. Chapter 62 recognizes that individual systems are sometimes appropriate as a treatment and disposal system in remote areas or a temporary solution until sewage collection systems are built. The goal cited in Chapter 62, however, is to move toward regional wastewater collection, treatment, and disposal systems that are consistent with state and county planning policies. Individual systems would still be permitted in remote areas.

It is estimated that approximately 75 to 80 percent of residents in the study area are currently served by the collection system. It is assumed for the purposes of this Environmental Assessment that all residents in the study area will be connected to the sewer system by the year 2000.

REFERENCES

1. U.S. Geological Survey and Hawaii Department of Land and Natural Resources. Preliminary Report on the Water Resources of the Lahaina District, Maui.

2. U.S. Department of Commerce, Technical Memorandum No. 1, 1966. The Trade Wind Regime of Central and Western Maui.

CHAPTER 6

ENVIRONMENTAL IMPACTS ASSOCIATED WITH THE UPGRADE OF THE LAHAINA WASTEWATER RECLAMATION FACILITY

This section describes possible environmental impacts of the Lahaina Wastewater Reclamation Facility upgrade and explains efforts included in the project to alleviate or eliminate adverse effects. Overall, the treatment plant upgrade is beneficial to the environment because it enables effective treatment of increased wastewater flows and provides for greater treatment plant reliability. In addition, the total amount of suspended solids in the effluent is reduced by 19%, even though plant capacity is expanded.

IMPACTS

Direct Environmental Impacts

Land. Impacts to the land from the Lahaina Wastewater Reclamation Facility upgrade will be minimal. The size and location of the site will not be altered and no new facilities will be located off the existing site. Addition of new facilities will require a more intense utilization of the site. Clearing and grading of the site will be the only impact except for construction of new effluent injection wells to provide 100 percent backup of effluent disposal capability as required by the Department of Health.

Construction of the injection wells will require on-site drilling. The existing effluent injection wells are 20 inches in diameter, but smaller-diameter wells are believed to be as effective, and wells of approximately 14-inch diameter are planned. The wells will be drilled through upper sedimentary material, which is approximately 100 feet thick, and down into the fractured basalt below. The sedimentary reach of the well and some of the upper basalt layer will be cased and grouted to prevent effluent from entering the sedimentary layer. The wells will extend from 150 to 300 feet below grade. The last 100 to 200 feet will not be cased.

Air. The Lahaina facilities upgrade will not result in any permanent adverse impacts to air quality. Local air quality may be affected temporarily by dust and diesel fumes from construction activities. Where possible, the ground will be wetted to reduce the dust.

Overall, air quality at and adjacent to the wastewater plant will be improved by the facilities upgrade. The activated sludge aeration basin is located next to the Honoapiilani Highway. Under high wind conditions, spray from the tanks can drift over the fence. This spray has caused corrosion to the adjacent electrical building and may spread odors from the plant. The substitution of diffused-air fine-bubble aeration for the existing surface-mounted mechanical aerators will significantly reduce the amount of aerosols produced.

Odor. The treatment plant has no recent history of odor problems. However, substitution of the diffused-air fine-bubble aeration for the existing surface-mounted mechanical aerators will reduce the potential for odor generation.

With treatment plants, odor can emanate from the process unit where incoming sewage is first exposed. In the Lahaina plant, this is the preliminary treatment building and the open pretreatment area. This project will eliminate those odors by removing the outdoor pretreatment area. The preliminary treatment building already has odor scrubbers for the air removed from the building. The existing system will be improved by this project by increasing the amount of air removed as well as the odor-scrubbing capacity. Odor control will also be improved by increasing the air change rate in the building to over 20 air changes per hour. The design changes will pay particular attention to removing potentially odorous air at its source so that the environment inside the building is comfortable for plant staff. Other changes include improvements to prevent air from leaking from the building without going through the odor scrubber. In addition, odor control facilities are being upgraded for the solids handling building.

Chlorine is used at the Wastewater Reclamation Facility for disinfection and for odor control. Upgrades proposed for the chlorine system will improve odor control.

Biological Resources. It is unknown at this time how much land will need to be cleared. However, only land which has been cleared and grown back will be cleared for this project. No endangered or threatened species of fish, wildlife or plants are present within or immediately adjacent to the treatment plant, according to the United States Fish and Wildlife Service Pacific Islands Office of Environmental Services (Appendix A).

Water. Effluent from the Lahaina Wastewater Reclamation Facility currently is discharged via injection wells to fractures in the underlying basalt. This effluent, via gravity and the pressure from up-gradient groundwater, flows toward the ocean.

Treatment plant effluent contributes various constituents, including but not limited to, suspended solids, dissolved oxygen, and nutrients such as nitrogen and phosphorus to the ocean. Improving effluent filtering will reduce the amount of suspended solids and nutrients entering marine waters. The treatment plant effluent will contain less than 5 mg/l suspended solids, less than that being discharged now and significantly less than the requirement of 30 mg/l.

Unique and Sensitive Environmental Areas.

Streams and Wetlands. There are no surface waters or wetlands located on the Lahaina Plant site. The Honokowai stream flows adjacent to the site. This stream flows heavily during rainstorms and may act as a conduit transporting fertilizer nutrients from agricultural runoff to the ocean. This stream has been channelized to prevent flooding. Flood Insurance Administration maps dated June 1981 show that a portion of the 1975 Plant is within the boundary of the 100-year flood plain of this stream. This area contains sludge drying beds that are no longer in service. The plant upgrade will not impact this stream.

Agriculture. There will be no changes to the boundaries of the plant. These upgrades will not impact the amount or quality of adjacent agricultural lands.

Wild and Scenic Rivers. There are no Wild and Scenic Rivers in the project area.

Sole Source Aquifer and Recharge Area. This property is not located on a sole source aquifer or recharge area.

Well Head Protection Area. No drinking water wells are located in close proximity to the site. This site is located shoreward of the underground injection control line. Highly regulated injection wells are permitted shoreward of this line for the disposal of effluent.

Aesthetics. All treatment plant modifications will occur within the treatment plant boundary. Improved odor control will enhance the overall aesthetics of the plant. The present architectural theme of the newer part of the plant will be carried to the new structures.

Noise. Modifications and upgrades will not change the level of noise at the plant. Noise levels may be increased temporarily, due to construction. Construction will be limited to normal working hours, 8AM to 6PM, on week days and will end at project completion. Replacing existing mechanical aerators with fine bubble diffusers and blowers housed in a building will decrease noise.

Energy. Energy use will increase temporarily as a result of construction, and long-term, as a result of higher treatment levels and greater treatment loads required for population increases. These increases will be offset by the use of energy-efficient equipment. Fine-bubble aeration will be used, largely because of its energy efficiency.

Water Supply and Use. There will be no increase in the treatment plant's demand for potable water supplied by the City's water utility. Where suitable, the plant will use effluent to water the landscaping. The State and the Maui County Department of Water Supply encourage water conservation and the use of restricted-flow faucets and shower heads. The State of Hawaii is considering enacting legislation requiring water conserving plumbing fixtures in all new construction.

Public Health and Safety. Improvements at the Lahaina Plant will increase public safety and protect public health. The upgrade of the chlorine system will provide a chlorinator for each of the two plants for disinfection, chlorination of the currently return activated sludge (RAS), and odor control. This system will provide better control over disinfection and ensure a higher-quality effluent. The major modification planned for the chlorine storage and handling facility is enclosure of the area. In addition, a chlorine-gas-scrubbing system will prevent any loss of chlorine gas to the outside atmosphere, should a leak occur. This system is required by the 1988 Uniform Fire Code and represents an important safety precaution.

The replacement of the surface-mounted mechanical mixers with diffused-air fine-bubble aerators will significantly reduce wastewater aerosol that can be transported off-site as spray.

Historical or Cultural Resources. There are no cultural or historic resources that will be impacted by this project. To reduce the possibility of destroying historic material or archaeological artifacts, the contractor will be instructed to stop construction if cultural evidence is observed. The contractor will notify the County prior to further action.

Indirect Environmental Impacts

The upgrade of the Lahaina Wastewater Reclamation Facility will not affect land use patterns or the area population. These improvements and additions will be implemented to provide safe and reliable wastewater treatment for existing wastewater flows and increased flows inevitable with a growing area.

Economic Impacts

One of the primary pressures for increasing the wastewater treatment capacity of the Lahaina facility is to accommodate new affordable housing units proposed by the State Housing Finance and Development Corporation (HFDC). This development will be a benefit to the community at large providing affordable housing in an area with relatively high housing costs. The rise in residential housing will also spur economic growth through an increased exchange of goods and services and increased property and excise tax revenues. Over time, the increased wastewater treatment capacity will facilitate residential and commercial development consistent with the Lahaina Community Plan. Expanded employment opportunities stemming from projected resort and commercial development will furthermore constitute a positive economic impact to the community.

The estimated capital cost for the design and construction of Stage 1 Lahaina Facilities upgrade is approximately 24 million dollars. The construction of the project will require a substantial labor force and will be a stimulus to the building industry for the life of the construction period (approximately 30 months).

Funding sources available to finance the project are State Housing Finance Development Corporation (HFDC), State Revolving Fund, private interests, and impact fees (development connection fee).

Irreversible and Irretrievable Commitment of Resources

Commitment of land, energy, and materials will be made to construct operate and maintain the upgraded treatment plant facilities.

Short-term Use of the Environment versus Maintenance of Long-term Productivity

Short-term adverse construction impacts of noise, dust, fumes, and traffic disruptions will be offset by significant improvement in long-term water quality and health conditions.

HYDROGEOLOGY

In the Hawaiian Islands, particularly on Maui, sewage effluent has been disposed of by injection into relatively deep disposal wells. The wells are located shoreward of the underground injection control line to prevent contamination of groundwater aquifers, as required by government regulations. Using a higher level of treatment combined with injection well disposal has prevented beach closures in tourist areas and other problems associated with using deep ocean outfalls for effluent disposal. To date, there is no indication that injection well disposal is detrimental to water quality near the shoreline.

Effluent water from the Lahaina Wastewater Reclamation Facility is highly treated to remove sediments, pathogens, and volatile organic matter and far exceeds what is mandated by federal, state, and local regulations. Following treatment, the effluent from the 1975 plant passes through effluent filters designed to greatly reduce any remaining sediment. The highly treated and filtered effluent and highly treated water from the 1985 plant are presently disposed of into four injection wells located at the Lahaina Wastewater Reclamation Facility.

The wells are drilled through the upper sedimentary deposits and into the underlying fractured basalt. Effluent is injected into brackish or saline water that underlies what is known as a Ghyben-Hertzberg freshwater lens. The upper sections of each well are sealed as they pass through the sedimentary layer and down part way through the basalt. This prevents the injected effluent from entering fresh groundwater in the sedimentary layer.

At the Lahaina Wastewater Reclamation Facility, the direction of groundwater flow is generally perpendicular to the coast and down gradient of the slopes of Puu Kukui. The profile underlying the Lahaina Wastewater Reclamation Facility is composed of an upper sedimentary layer, probably varying in thickness from 50 to 100 feet which is underlain by basalt layers from a few feet to several hundred feet thick. Layers and cracks in the basalt act as conduits for the flow of water and effluent through the lava sequence.

A modeling study zone for the Kahului Wastewater Reclamation Facility, located only 25 miles north of the Lahaina Facility, indicated that the effluent spreads radially as it rises, probably forming a conical plume (Appendix D from that report is included in this report as Appendix B.). The top of this plume is displaced seaward. The extent of the effluent spread from its point of injection is unknown but it likely spreads in all directions.

Several factors control where the effluent enters the ocean. Because effluent is less dense than saltwater, it tends to rise. However, the depth and westward extent of the sedimentary layer, which prevents or dramatically slows upward migration of the effluent, will affect where it actually enters the ocean. The down gradient flow of groundwater also affects effluent movement. Combined with these variables are other factors such as nonuniform-density water and tidal action, which, in part, determine where the saline and effluent waters mix.

To our knowledge there are no studies which clearly show how the effluent flows from this point on. It is likely that buoyant forces cause it to travel upward, intercept the unconfined groundwater at some point above, and flow seaward.

Ultimately, the flow probably enters the ocean with the fresh groundwater. It is not clear at what distance from shore this occurs. At Kahului this effluent is thought to enter seawater at a distance of 2,000 to 3,000 feet from shore.

In 1989, an algal bloom of Cladophora occurred off the shore of Lahaina. Dr. Richard Brock, a marine biologist at the University of Hawaii, said that the bloom occurred in many areas around Maui as well as around the island of Hawaii. Dr. Brock also noted that following rain-storms there was considerably more nitrogen, phosphorus, and turbidity in the near shore waters off of Lahaina. He did not think that the treatment plant effluent was responsible for the bloom. (Personal communication, February 27, 1991)

The Maui Times published an article on May 1, 1991, discussing another possible algal bloom. Several experts were interviewed and provided information. These researchers were interviewed again by Brown and Caldwell for the County of Maui Wastewater Reclamation Department.

Dr. Fredric Martini, a faculty member at the Cornell University Marine Laboratory presently working at the University of Hawaii, noted that there was not a great deal of hard information about algal blooms. He said that he felt these blooms were nutrient-related but was unable to pin point the source of the nutrients. However, Dr. Martini indicated that the blooms were generally preceded by a heavy rain and high surf. When this happens, nutrient runoff is immediately incorporated into the water. The heavy surf breaks up the algal communities at the ocean floor and vertical mixing occurs bringing the algae in contact with the nutrients. He also noted that much of the unpleasantness associated with the algal bloom was not the algae itself but actually dead algae and zoo plankton that is feeding on it. (Personal communication, May 13, 1991)

Dr. Isabella Abbott, a botanist at the University of Hawaii, was also contacted. She noted that the bloom referred to in the Maui News was not considered a bloom at this point. She noted algal blooms begin to occur in April when the temperatures are warm and the water is clear. What is unusual about the current algal population increase is that it is a species of Cladophora but not the same one that occurred in 1989. This species is Cladophora sericea. Algal blooms are common occurrences, but Cladophora usually is not a major contributor. Dr. Abbott emphasized that there could be as many as several dozen genus and species contributing to the bloom. Cladophora blooms may have occurred regularly in unobserved areas. Algal blooms of various species occur regularly in the waters off Maui. (Personal communication, May 13, 1991).

Skippy Hau, who works with the Department of Land and Natural Resources in the Division of Aquatic Resources, works with Dr. Abott and collects samples for her the indicated that one of the unusual aspects of 1989 Cladophora bloom and the current population increase was its Filamentous nature. Cladophora is usually a vine algae. The filaments can be up to a foot long and are very annoying to swimmers and drivers. He emphasized, however, that algae blooms are a common seasonal occurrence and the only difference between the 1989 bloom and the algal population growth now versus other blooms is the species and growth form, not the occurrence itself. (Personal communication, May 14, 1991)

Dr. Steve Dollar, a researcher at the University of Hawaii Institute of Marine biology, performed a rigorous study last year of water samples taken off the coast of Maui, including near the Lahaina Wastewater Reclamation Facility. While there was no Cladophora bloom last year, his study failed to show any nutrient enrichment from the injection wells at the plant. (Personal communication, May 13, 1991)

Based on these investigations, it appears unlikely that the Lahaina Reclamation Facility is contributing significantly to outbreaks of algal blooms off the Lahaina coast.

Impacts Expected From Additional Effluent Injection Wells

Increasing the number of injection wells from 4 to 16 will provide several benefits. The Lahaina wastewater treatment plant capacity will be increased by 34 percent from 6.7 to 9.0 mgd. Well capacity will allow more efficient use of the effluent wells as well as spreading the effluent over a larger receiving area. Each of the 16 wells will be receiving only a small portion of the effluent generated. Wells can be maintained and flushed more often, improving the capability of the wells to accept effluent. The injection capacity at the Lahaina Wastewater Reclamation Facility is the factor limiting plant capacity. Addition of these wells will eliminate the possibility of plant overflow.

MITIGATION

This section addresses various measures which will be incorporated into the design or required of contractors to reduce the extent of environmental degradation. Mitigation measures are included for each impacted element of the environment.

The proposed project benefits the environment because it:

- Enables effective treatment of increased wastewater flows;
- Improves the reliability of the facility, thus reducing the possibility of a plant upset;
- Reduces the risk of damage caused by a chlorine gas leak;
- Reduces the potential for odors.

To reduce the potential for noise impacts during construction, use of noisy equipment will be confined to normal working hours, avoiding early mornings, nights, and weekends.

Dust from construction will be reduced through normal construction measures, such as regular sprinkling.

Energy conservation will be a primary design criteria for all improvements and new facilities.

To mitigate concerns regarding use and handling of chlorine for wastewater disinfection and odor control, the chlorine-handling and storage facility will be enclosed in a building with chlorine-scrubbing equipment. Alarms and safety equipment will also be installed.

In the event that water quality impacts are identified in the future, there are several potential mitigating measures that can be implemented. They are:

1. Reclaim a portion of the plant effluent by applying it to adjacent golf courses, layers in the new HFDC housing project, parks, traffic median strips, and/or agricultural lands.
2. Remove biostimulating nutrients (nitrogen and/or phosphorus) from the effluent.

The County is in the process of developing an effluent reuse program. A study is presently being commissioned to examine the reuse alternatives. The County envisions a time in the future when reuse will be the primary method of disposal of effluent and the injection wells will be used only as backup to handle flows that are not needed for another beneficial use.

Compliance With Government Statutes, Ordinances, and Rules

The proposed LWRF modifications and additions conform to goals set forth in the *Maui County General Plan and* the Lahaina Community Plan. The upgrade prevents pollution of nearshore areas, protection of shoreline resources, and the ability to reliably and safely treat current and future wastewater flows.

It is anticipated that the following permits will be needed for this proposed project:

- An Underground Injection Control (UIC) permit for additional wells to dispose of treated effluent.

- A building permit, a grading permit, an electrical permit, and a plumbing permit, in compliance with Chapters 16.24, 20.08, and 16.16 or the Maui County Code and Maui County Ordinance No. 1213.

A Conservation District Use Application (CDUA) will not be required. The area surrounding the treatment plant is in a State Land Use Commission-designated Conservation District; however, the plant site was set aside under Governor's Executive Order No. 3006.

RECEIVING WATER QUALITY

This section presents available receiving water quality for the area immediately off the coast of the Lahaina Wastewater Reclamation Facility. This information is presented in a study by Dr. Steven Dollar entitled, "An Assessment of Nonpoint Source of Pollution of the Marine Environment off of Kaanapali, Maui, Hawaii" (the entire report is presented in Appendix C). Dr. Dollar concludes that "the region directly downslope from the Lahaina Sewage Treatment Plant, which utilizes injection wells for effluent disposal, no substantial nutrient or salinity gradients were encountered. As a result, it does not appear that effluent materials are leaching into groundwater and entering the ocean near the shoreline in the area surveyed."

Tables 6-1, 6-2, and 6-3 presents the nutrient values from water samples collected off the coast in the vicinity of the Lahaina Wastewater Reclamation Facility during June, July, and November 1990, respectively. In neither June nor July were the Hawaii Department of Health (HDOH) water quality standards exceeded. Standards were selected for a "dry coastline" and for values not to be exceeded more than 10% of the time. These are relatively stringent standards. Only in the November sampling period were water quality standards exceeded. Six out of 17 samples had elevated NH_4. From Table 6-1 it can be seen that the Lahaina effluent contains little NH_4. This suggests that the higher NH_4 values found only in the November sampling may have source other than plant effluent.

Table 6-1. Water chemistry constituents in samples collected off the coast from the Lahaina Wastewater Reclamation Facility during June 1990. Values in boxes exceed the Hawaii Department of Health (HDOH) water quality standards for the 10% criteria for dry conditions. All units are expressed in micromoles per liter. This information is taken from Dollar (1991). See Appendix C.

Sample Location	PO_4 (μM)	DOP (μM)	TP (μM)	NO_3 (μM)	NH_4 (μM)	DON (μM)	TN (μM)	Si (μM)	Salinity (0/00)
Lahaina Wastewater Reclamation Facility									
Sewage Effluent	45.52	0.99	46.51	280.85	2.50	24.21	307.56	597.39	1.06
Ocean 1	0.14			0.13	0.04			2.94	34.42
Ocean 2	0.17	0.21	0.38	0.08	0.15	4.98	5.21	3.92	34.33
Ocean 3	0.14	0.19	0.33	0.40	0.11	4.83	5.34	4.11	34.36
Ocean 4	0.17	0.17	0.34	0.19	0.09	4.53	4.81	3.33	34.35
Ocean 5	0.16			0.16	0.13			3.33	34.35
Ocean 6	0.16	0.19	0.35	0.16	0.11	5.07	5.34	3.33	34.36
Ocean 7	0.13	0.17	0.30	0.16	0.28	5.43	5.87	2.74	34.38
Ocean 8	0.14	0.17	0.31	0.13	0.15	4.13	4.41	2.74	34.40
Ocean 9	0.16	0.15	0.31	0.13	@bFSuP; 0.11	4.70	4.94	2.74	34.38
Ocean 10	0.16	0.11	0.27	0.13	0.24	4.18	4.55	2.74	34.39
Ocean 11	0.16	0.14	0.30	0.13	0.15	5.20	5.48	1.57	34.46
Ocean 12	0.14	0.16	0.30	0.08	0.13	4.34	4.55	2.74	34.38
Ocean 13	0.17	0.16	0.33	0.13	0.19	4.23	4.55	2.74	34.40
Ocean 14	0.17	0.16	0.33	0.08	0.17	6.97	6.22	2.94	34.38
Ocean 15	0.21	0.16	0.37	0.24	0.17	5.94	6.35	3.33	34.36
Ocean 16	0.17	0.17	0.34	0.48	0.11	5.55	6.14	5.29	34.26
Ocean 17	0.16	0.14	0.30	0.11	0.15	5.48	5.74	2.55	34.38

DOP = Dissolved organic phosphorus
DON = Dissolved organic nitrogen
TN = Total nitrogen
PO_4 = Orthophosphate
TP = Total phosphate
NO_3 = Nitrate
Si = Silica
NH_4 = Ammonium

Table 6-2. Water chemistry constituents in samples collected off the coast from the Lahaina Wastewater Reclamation Facility during July 1990. Values in boxes exceed the Hawaii Department of Health (HDOH) water quality standards for the 10% criteria for dry conditions. All units are expressed in micromoles per liter. This information is taken from Dollar (1991). See Appendix C. (continued)

Sample Location	PO_4 (µM)	DOP (µM)	TP (µM)	NO_3 (µM)	NH_4 (µM)	DON (µM)	TN (µM)	Si (µM)	Salinity (0/00)	CHLa (µg/L)	Turbidity (n.t.u)
Lahaina Wastewater Reclamation Facilities											
Drainage Channel	3.06	0.55	3.61	41.01	57.73	1.83	100.57	435.59	7.16	0.38	0.98
Drainage Channel	1.84	0.37	2.21	27.87	49.03	2.66	79.58	341.19	13.29	0.48	0.91
Ocean 1	0.10	0.16	0.26	0.13	0.06	6.01	6.22	11.48	33.92	0.02	0.22
Ocean 2	0.09	0.15	0.24	0.08	BDL	5.24	5.32	9.93	34.01	0.20	0.21
Ocean 3	0.10			0.05	0.05			5.64	34.30	0.38	0.20
Ocean 4	0.11	0.15	0.26	0.13	0.10	5.06	5.29	6.81	34.23	0.13	0.20
Ocean 5	0.11			0.18	BDL			5.06	34.35	0.14	0.23
Ocean 6	0.11	0.13	0.24	0.24	0.10	4.55	4.89	4.87	34.38	0.13	0.21
Ocean 7	0.11			0.29	0.05			4.67	34.39	0.14	0.18
Ocean 8	0.13	0.11	0.24	0.29	0.08	4.58	4.95	4.48	34.37	0.10	0.18
Ocean 9	0.13			0.26	BDL			5.06	34.34	0.19	0.17
Ocean 10	0.13	0.11	0.24	0.42	0.13	4.00	4.55	4.28	34.41	0.09	0.14
Ocean 11	0.11			0.29	0.08			4.48	34.41	0.11	0.17
Ocean 12	0.13	0.11	0.24	0.48	BDL	3.40	3.88	3.11	34.46	0.08	0.11
Ocean 13	0.11			0.32	0.29			4.28	34.38	0.08	0.14
Ocean 14	0.13	0.11	0.24	0.48	0.03	3.24	3.75	3.11	34.47	0.09	0.11
Ocean 15	0.11			0.11	0.18			5.26	34.28	0.24	0.26
Ocean 16	0.10	0.14	0.24	0.05	0.10	3.68	3.83	4.87	34.26	0.22	0.33
Ocean 17	0.09	0.15	0.24	0.21	0.03	4.26	4.50	2.92	34.46	0.26	0.09
Ocean 18	0.10			0.21	0.03			2.53	34.48	0.12	0.15
Ocean 19	0.10	0.16	0.26	0.11	0.03	4.41	4.55	3.11	34.44	0.11	0.21
Ocean 20	0.10			0.11	0.03			3.31	34.42	0.13	0.18
Ocean 21	0.10	0.17	0.27	0.11	0.03	4.54	4.68	3.50	34.43	0.14	0.26
Ocean 22	0.11			0.13	BDL			3.11	34.43	0.16	0.29
Ocean 23	0.11	0.15	0.26	0.11	0.05	5.05	5.21	3.70	34.39	0.17	0.48
Ocean 24	0.11			0.05	0.03			3.50	34.41	0.14	0.24
Ocean 25	0.11	0.15	0.26	0.05	0.05	5.19	5.29	3.50	34.41	0.13	0.51

Table 6-2. Water chemistry constituents in samples collected off the coast from the Lahaina Wastewater Reclamation Facility during July 1990. Values in boxes exceed the Hawaii Department of Health (HDOH) water quality standards for the 10% criteria for dry conditions. All units are expressed in micromoles per liter. This information is taken from Dollar (1991). See Appendix C. (continued)

Sample Location	PO_4 (μM)	DOP (μM)	TP (μM)	NO_3 (μM)	NH_4 (μM)	DON (μM)	TN (μM)	Si (μM)	Salinity (0/00)	CHLa (μg/L)	Turbidity (n.t.u)
Ocean 26	0.13			BDL	0.05			3.70	34.40	0.22	0.47
Ocean 27	0.13	0.13	0.26	0.03	0.26	5.46	5.75	3.70	34.40	0.17	0.24
Ocean 28	0.13	0.14	0.27	0.05	0.05	4.87	4.97	3.60	34.41	0.15	0.37
Ocean 29	0.13	0.14	0.27	0.05	0.42	5.51	5.98	3.50	34.40	0.24	0.59
Ocean 30	0.13	0.16	0.29	0.05	0.23	4.88	5.16	3.70	34.37	0.16	0.48

DOP = Dissolved organic phosphorus
DON = Dissolved organic nitrogen
TN = Total nitrogen
PO_4 = Orthophosphate
TP = Total phosphate
NO_3 = Nitrate
Si = Silica
NH_4 = Ammonium

Table 6-3. Water chemistry constituents in samples collected off the coast from the Lahaina Wastewater Reclamation Facility during November 1990. Values in boxes exceed the Hawaii Department of Health (HDOH) Water Quality Standards for the 10% criteria for dry conditions. All units are expressed in micromoles per liter. This information is taken from Dollar (1991). See Appendix C.

Sample Location	PO_4 (μM)	DOP (μM)	TP (μM)	NO_3 (μM)	NH_4 (μM)	DON (μM)	TN (μM)	Si (μM)	Salinity (0/00)
Lahaina Wastewater Reclamation Facility									
Drainage Channel	0.12	0.46	0.58	0.93	1.10	21.12	23.15	153.98	25.20
Ocean 1	0.12			BDL	0.44			3.74	35.00
Ocean 2	0.13	0.15	0.28	0.07	0.23	6.80	7.10	2.95	35.00
Ocean 3	0.13			0.05	0.18			2.75	35.00
Ocean 4	0.10	0.17	0.27	0.00	0.13	5.63	5.76	3.15	34.99
Ocean 5	0.10			0.02	0.44			3.15	34.99
Ocean 6	0.09	0.19	0.28	0.12	0.18	6.99	7.29	3.15	34.97
Ocean 7	0.13			0.21	0.31			2.75	34.99
Ocean 8	0.12	0.16	0.28	0.19	0.10	5.98	6.27	3.74	34.94
Ocean 9	0.10			0.19	0.39			2.56	34.99
Ocean 10	0.10	0.20	0.30	0.05	0.21	6.57	6.83	3.54	34.94
Ocean 11	0.10			0.26	0.21			2.56	34.99
Ocean 12	0.10	0.21	0.31	0.02	0.21	6.45	6.68	3.15	34.95
Ocean 13	0.07			0.16	0.63			2.56	34.98
Ocean 14	0.10	0.20	0.30	0.16	0.57	6.10	6.83	5.11	34.88
Ocean 15	0.15			0.12	0.31			4.72	34.80
Ocean 16	0.09	0.18	0.27	BDL	0.26	5.86	6.12	3.15	34.94
Ocean 17	0.12			BDL	0.44			3.34	34.93
Ocean 18	0.12	0.15	0.27	BDL	0.23	6.80	7.03	3.54	34.87

DOP = Dissolved organic phosphorus
DON = Dissolved organic nitrogen
TN = Total nitrogen
PO_4 = Orthophosphate
TP = Total phosphate
NO_3 = Nitrate
Si = Silica
NH_4 = Ammonium

DETERMINATION

The proposed expansion of the Lahaina Wastewater Reclamation Facilities (LWRF) is not expected to result in any significant unmitigable adverse environmental impacts and is expected to have long-term beneficial effects. The criteria used to determine whether an impact is significant are defined in Title 11, Chapter 200, Section 12 of Hawaii Administrative Rules.

The proposed project consists of modifications and improvements to existing facilities. Additions to the treatment plant included in the project are another secondary clarifier, an effluent filter, approximately 12 new underground injection wells, modifications to the aeration tank, a new sludge reaeration tank, a new blower building, and enclosure of the chlorine storage area. The intent of the project is to improve treatment reliability and capacity, increase safety, improve energy efficiency, and reduce odor. The proposed project will be confined within the existing plant site boundaries and will not cause an increase in building height. The completed project will not substantially alter the appearance of the existing LWRF.

Although not expected, the only potentially significant impact of the project would be on the near-shore marine waters, resulting from the deep-well injection of effluent. Although the assessment report by Steven Dollar noted above and in Appendix C indicates no current identifiable impacts, mitigation measures have been identified which could be implemented if adverse impacts occur. One of these measures, reclamation of the effluent, is currently under study.

This Notice of Determination, together with this Environmental Assessment, is filed as a Negative Declaration by the Department of Public Works, County of Maui. Contact person for the Department of Public Works is:

Mr. Eassie Miller, P.E., Chief
Wastewater Reclamation Division
Department of Public Works
County of Maui
200 South High Street
Maui, Hawaii 96793

REFERENCES

1. Heutmaker, Duane; Petersen, Frank; and Wheatcraft, Stephen. A Laboratory Study of Waste Injection into a Ghyben-Herzberg Groundwater System Under Dynamic Conditions. Water Resources Research Center. University of Hawaii. March 1977

APPENDIX A
AGENCY CONTACTS

PHONE CONTACTS FOR LAHAINA ENVIRONMENTAL ASSESSMENT

Dr. Hams Krock, University of Hawaii .... (808) 533-4612

Dr. Richard Brock, Hawaiian Research Institute of Marine Biology .... (808) 956-2859

Mr. Chauncy Hew, County of Maui Health Department Drinking Water Wells .... (808) 543-8309

Mr. Eugene Akazawa, Clean Water Branch, County of Maui Health Department .... (808) 543-8309

Mr. Marlin Atkensen, University of Hawaii Environmental Center .... (808) 948-7361

Housing, Finance and Development Corporation - Department of Business and Economic Development .... (808) 453-2987

US Department of Housing and Urban Development .... (808) 541-1326

Mr. Eugene Asakawa, Clean Water Marine Water Quality .... (808) 543-8309

Dr. Ed Lau, Institute of Marine Biology .... (808) 247-6613

Mr. Paul Dienfang, Oceanic Institute .... (808) 259-6951

Ms. Wendy Folks, Oceanic Institute .... (808) 259-6951

US Fish and Wildlife Service, Hawaii .... (808) 541-2749

Hawaii Division of Aquatic Resources .... (808) 548-5920

Hawaii Conservation and Environmental Affairs Office .... (808) 548-7837

Historic Sites Preservation Office - Department of Land Use and Natural Resources .... (808) 548-6408

JOHN WAIHEE
GOVERNOR

RECEIVED
1991 JUL 23 PM 4:01
WASTEWATER
RECLAMATION DIVISION
COUNTY OF MAUI

(2)

COUNTY OF MAUI
PUBLIC WORKS
1991 JUL 22 PM 1:48

BRIAN J. J. CHOY
Director

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
220 SOUTH KING STREET
FOURTH FLOOR
HONOLULU, HAWAII 96813

DEPT OF PUBLIC WORKS	Info	Action	Rem	See Me	Comments	Copy	File
DIRECTOR							
DEP. DIR.							
PERS.							
STAFF CE							
LUCA							
WW RECL.							
SOLID W.							
ENGR.							
HWYS.							
SECTY.							

Return to: ________
By ________ Date ________

July 19, 1991

Mr. George N. Kaya
Director of Public Works
County of Maui
Department of Public Works
200 South High Street
Wailuku, Maui, Hawaii 96793

Dear Mr. Kaya,

SUBJECT: Lahaina Wastewater Reclamation Facility
Stage 1 Design Environmental Assessment

We have reviewed the Lahaina Wastewater Reclamation Facility Stage 1 Design Environmental Assessment and have the following comments to offer:

1. Please identify the agencies that were consulted during the environmental assessment preparation process.

2. Please describe the economic impacts of the project on the immediate community as well as on the community at large.

Enclosed is a document that provides guidance for the preparation of environmental assessments. Please call Jeyan Thirugnanam at 586-4185 if you have any questions. Thank you.

Sincerely,

Brian J.J. Choy
Director

Enclosure

WASTE WATER RECLAMATION DIVISION	Info	Action	See Me	Comments	File	Return to	Copy
EASSIE							
ALEX							
PEDRO							
RON							
TRACY							
JERRY							
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SIGNED					Date		

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO ATTENTION OF
Operations Division

22 JUL 1991

Mr. George N. Kaya
Director
Department of Public Works
County of Maui
200 South High Street
Wailuku, Maui, Hawaii 96793

Dear Mr. Kaya:

In response to your June 19, 1991 and June 21, 1991 letters, we have reviewed the May 1991 Draft Environmental Assessment (EA) for Improvements to the Lahaina Wastewater Reclamation Facility, Lahaina, Maui, Hawaii, and the Land Use Commission Special Use Permit Application for the Proposed Lahaina Baseyard at Honokowai. The two projects are located on adjacent properties, mauka of Honoapiilani Highway, just south of Honokowai Stream. Based on the EA and the Special Use Permit Application, the projects do not involve any work in surface waters or adjacent wetlands; therefore, a Department of the Army permit is not required for either project.

We appreciate the opportunity to review these documents. If there are any questions on this determination or if the project plans change, please contact the Operations Division at 438-9258.

Sincerely,

Stanley T. Arakaki
Stanley T. Arakaki
Chief, Operations Division

WASTE WATER RECLAMATION DIVISION	Info	Action	[illegible]	Comments	File	Return to	Copy
EASSIE							
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[illegible] EM				Date			

B&C FAX ✓ Bill Mel 7/26

LINDA CROCKETT LINGLE
Mayor

BRIAN MISKAE
Planning Director
GUY A. HAYWOOD
Deputy Planning Director

COUNTY OF MAUI
PLANNING DEPARTMENT
250 S. HIGH STREET
WAILUKU, MAUI, HAWAII 96793

August 7, 1991

MEMORANDUM

TO: Mr. George Kaya, Director of Public Works

FROM: Brian Miskae, Planning Director

RE: Lahaina Wastewater Reclamation Facility Stage 1 Design Envrironmental Assessment

In response to your memorandum of July 18, 1991, regarding our comments on the above referenced matter, enclosed is a copy of our response dated July 23, 1991.

Should you require further information, please feel free to contact my office.

a:PWEA.jas

WASTE WATER RECLAMATION DIVISION	Info	Action	See Me	Comments	File	Return to	Copy
EASSIE							
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ALEX							
PEDRO	✓	✓			✓		
RON							
TRACY							
JERRY							
ALMA							

Date 8/11

A CROCKETT LINGLE
Mayor

BRIAN MISKAE
Planning Director
GUY A. HAYWOOD
Deputy Planning Director

COUNTY OF MAUI
PLANNING DEPARTMENT
250 S. HIGH STREET
WAILUKU, MAUI, HAWAII 96793

July 23, 1991

Mr. George Kaya
Director of Public Works
County of Maui
200 South High Street
Wailuku, Hawaii 86763

Dear Mr. Kaya:

Re: LAHAINA WASTEWATER RECLAMATION FACILITY
STAGE 1 DESIGN ENVIRONMENTAL ASSESSMENT

We have reviewed the Environmental Assessment and have the following comments to offer:

1. **Demographics.** The scope of this Environmental Assessment covers the implementation of Stage 1 of an improvement and upgrade plan that was developed in the West Maui Master Plan for Wastewater Collection, Treatment, and Disposal, published in June, 1990. The three stages of the improvement and upgrade plan were based primarily on population projections developed from the Lahaina Community Plan.

We would like to point out that the Planning Department has recently hired the firm of Community Resources, Inc. to conduct a socio-economic study for Maui County as part of the upcoming Community Plan Review process. The socio-economic study will include population and economic forecasts for each community plan area. Wilson Okimoto Associates has been hired to conduct infrastructural assessments and projections of future requirements based on the socio-economic study. The projections together with the results of the Community Plan Update process may differ from the assumptions made by your Department in developing the West Maui Master Plan.

Please be advised that we will be seeking active involvement and participation from your department throughout the Community Plan Update process.

2. **INJECTION WELLS.** We have concerns regarding total reliance on injection wells for effluent disposal. As noted in the Environmental Assessment the capacity of the wells currently in use have diminished over time. Twelve new wells are proposed to augment the existing four. Will it be feasible to continue relying

on the injection wells for effluent disposal for peak flows of 35 mgd as envisioned after completion of the Stage 3 improvements?

The County should actively pursue an effluent reuse program in order to lessen the reliance on injection wells.

Thank you for the opportunity to provide comments on this matter.

Yours truly,

BRIAN MISKAE
Planning Director

JOHN WAIHEE
GOVERNOR OF HAWAII

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES

KEITH W. AHUE
MANABU TAGOMORI
Dan T. Kochi

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND ENVIRONMENTAL AFFAIRS
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION PROGRAM
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

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1991 JUL 30 AM 10:08

'91 JUL 29 P2:03

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

OCEA:SL:SKK

JUL 26 1991

FILE NO.: 91-556
DOC. NO.: 1195E

The Honorable George N. Kaya, Director
Department of Public Works
County of Maui
200 South High Street
Wailuku, Maui, Hawaii 96793

Dear Mr. Kaya:

SUBJECT: Lahaina Wastewater Reclamation Facility State 1 Design Environmental Assessment

Thank you for giving our Department the opportunity to comment on this matter. We have reviewed the materials you submitted and have the following comments.

HISTORIC PRESERVATION PROGRAM CONCERNS:

We concur with the EA's determination that the proposed improvements will have "no effect" on significant historic sites. The proposed improvements will be located within the existing reclamation facility boundaries. There are no known historic sites on this property, and it is highly unlikely that they are present because of previous ground disturbance related to the construction of the facility. However, we recommend revision of the last sentence on page 6-4. The State Historic Preservation Division, pursuant to Chapter 6E, must be notified when historic sites are encountered during construction work.

Should you have any questions, please contact Ms Annie Griffin at 587-0013.

WASTE WATER RECLAMATION DIVISION	Info	Action	See Me	Comments	File	Return	Copy
EASSIE							
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Date

Our Department's Land Management Division comments that Executive Order 3155 was set aside to the County of Maui for a Sewage Pump Station Site and Wastewater Reclamation Plant and Reservoir Site, TMK 2nd/4-4-02: 29. Executive Order 3206 was set aside to the County of Maui for an addition to the Lahaina Wastewater Reclamation Plant. The submitted Environmental Assessment is compatible with the set aside purposes of each Executive Order.

Please feel free to contact me or Sam Lemmo at our Office of Conservation and Environmental Affairs, at 548-7837, should you have any questions.

Very truly yours,

Kirk W. [signature]

WILLIAM W. PATY

DEPARTMENT OF WATER SUPPLY
COUNTY OF MAUI
P.O. BOX 1109
WAILUKU, MAUI, HAWAII 96793-7109

'91 AUG -5 P1:40
COUNTY OF MAUI
PUBLIC WORKS

July 31, 1991

Mr. George N. Kaya
County of Maui
Department of Public Works
200 S. High Street
Wailuku, Hawaii 96793

Dear Mr. Kaya:

Subject: **LAHAINA WASTEWATER RECLAMATION FACILITY**
STAGE 1 DESIGN ENVIRONMENTAL ASSESSMENT

Thank you for the opportunity to review the draft environmental assessment for the subject project.

As with all projects that are reviewed by our Department, we have concerns on the potential of contamination of the ground water resource. We have no objections to the Lahaina Wastewater Reclamation Facility project if it does not pose a threat to the ground water resource.

Sincerely,

Rae M. Shikuma
Director

hc

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RECLAMATION DIVISION
COUNTY OF MAUI

WASTE WATER RECLAMATION DIVISION	Info	Action	See Me	Comments			
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ALEX							
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ALMA							
YVONNE							
SIGNED					Date		

"By Water All Things Find Life"

United States Department of the Interior
FISH AND WILDLIFE SERVICE
PACIFIC ISLANDS OFFICE
P.O. BOX 50167
HONOLULU, HAWAII 96850

RECEIVED

March 15, 1991

Ms. Molly Bigger
Brown and Caldwell
100 W. Harrison Street
Seattle, WA 98119

Dear Ms. Bigger:

Re: Telephone Conversation of March 8, 1991

As requested in our telephone conversation of March 8, 1991, I have reviewed the map sent of the location of the Lahina treatment plant upgrade. There are no known endangered plants or animals within the proposed project site. Please contact me if I can be of further assistance.

Sincerely yours,

Derral Herbst

Derral Herbst
Botanist

APPENDIX B
HYDROGEOLOGY

APPENDIX D

INJECTION WELL HYDROGEOLOGY

This appendix is a summary of available information on the hydrogeology of the effluent injection wells at the Wailuku-Kahului Wastewater Reclamation Facilities (WWRF).

References

The primary reference for this appendix is a study of the WWRF injection wells[1], prepared by the USGS and published in 1977. As a condition for approval of the EIS for the original project, this work was done before operation of the plant, to verify that the existing injection wells would not have an adverse impact on Kanaha Pond. The study included field investigations and computer modeling of the lava rock aquifer, used to study the distribution of injected wastewater.

Other references include a report[2] describing investigations made in 1970 of a pilot injection well drilled at the plant site. This pilot well is one of the four existing wells now used for effluent disposal. An analysis of deep well injection[3] was also prepared as part of the EIS for the original project.

Existing wells

Currently there are four injection wells used to dispose of effluent from the WWRF. The existing injection wells are located in the north-west portion of the plant site, 75 to 150 feet from the beach, aligned approximately parallel with the shoreline, and approximately 450 feet from the northern boundary of the Kanaha Pond Wildlife Sanctuary. The wells are located approximately 200 feet from each other. Each existing well has a bore diameter of 17 inches and is approximately 380 feet deep. The upper 180 feet of the wells are cased and cemented, preventing release of effluent into the upper strata. The treated wastewater is discharged into the open basaltic zone through the lower 200 feet of the well.

Each well is routinely rehabilitated to maintain its injection capacity. The most common rehabilitation method is to discharge air into a small pipe extending approximately 150 feet within the well. This release of air acts as an air lift pump, reversing the direction of flow within the well and dislodging wastewater solids that reduce injection capacity. Backwash water is diverted to a holding pond located on the plant site, and eventually pumped to the head of the plant. Alternatively, caustic soda is directed into the wells, to breakdown solids impeding the discharge of effluent.

New wells

Four additional injection wells are included in the proposed additions and modifications project. These new wells will be located in the north-east portion of the plant site, each 145 feet from its neighbor, 130 to 240 feet from the beach, and approximately 450 feet from the wildlife sanctuary boundary. As shown in Figure D-1, the new wells will be similar to the existing wells except that the diameter of their bore will be 14 inches.

Background geology

The WWRF site and the surrounding area, including Kanaha Pond, is underlain by a deep sequence of lava beds covered with a layer of sand and coral. The surface of the lava slopes down in a general north-west direction, as shown in Figure D-2. Below the plant site, the upper surface of the lava sequence is 60 to 85 feet below ground level (approximately 10 feet MSL). An irregular clayey layer is found just above the lava, overlain by a mixture of soft coral, coral debris and medium to fine sand.

The lava sequence underlying the area is composed of basalt flows a few feet to 50 feet deep, separated from each other by rubble, clinker, or cinder zones a few inches to a few feet thick. These porous horizontal layers and cracks in the basalt act as conduits for flow of groundwater through the lava sequence. The general direction of groundwater flow is northerly toward the ocean, generally normal to the shoreline. The principal source of this water is the slopes of Haleakala and the West Maui mountains. Rain falling in these areas infiltrates into the soil and flows through the ground toward the ocean. These groundwater flows converge in the Central Maui isthmus and enter Kahului Bay in the area adjacent to the WWRF, as shown in Figure D-3.

The groundwater beneath the treatment plant consists of a freshwater lens floating on underlying saline water. A transition zone, or zone of mixing, forms at the interface of the freshwater and saline water bodies. This transition zone is approximately 50 feet thick with its midpoint about 100 feet below the ground surface. The freshwater flows towards the ocean at a specific velocity of approximately 1.0 foot/day. In contrast, the saline water is essentially stationary with slight movement inland, as required to satisfy saline water diffusion upward through the transition zone, into the seaward-flowing base of the freshwater lens.

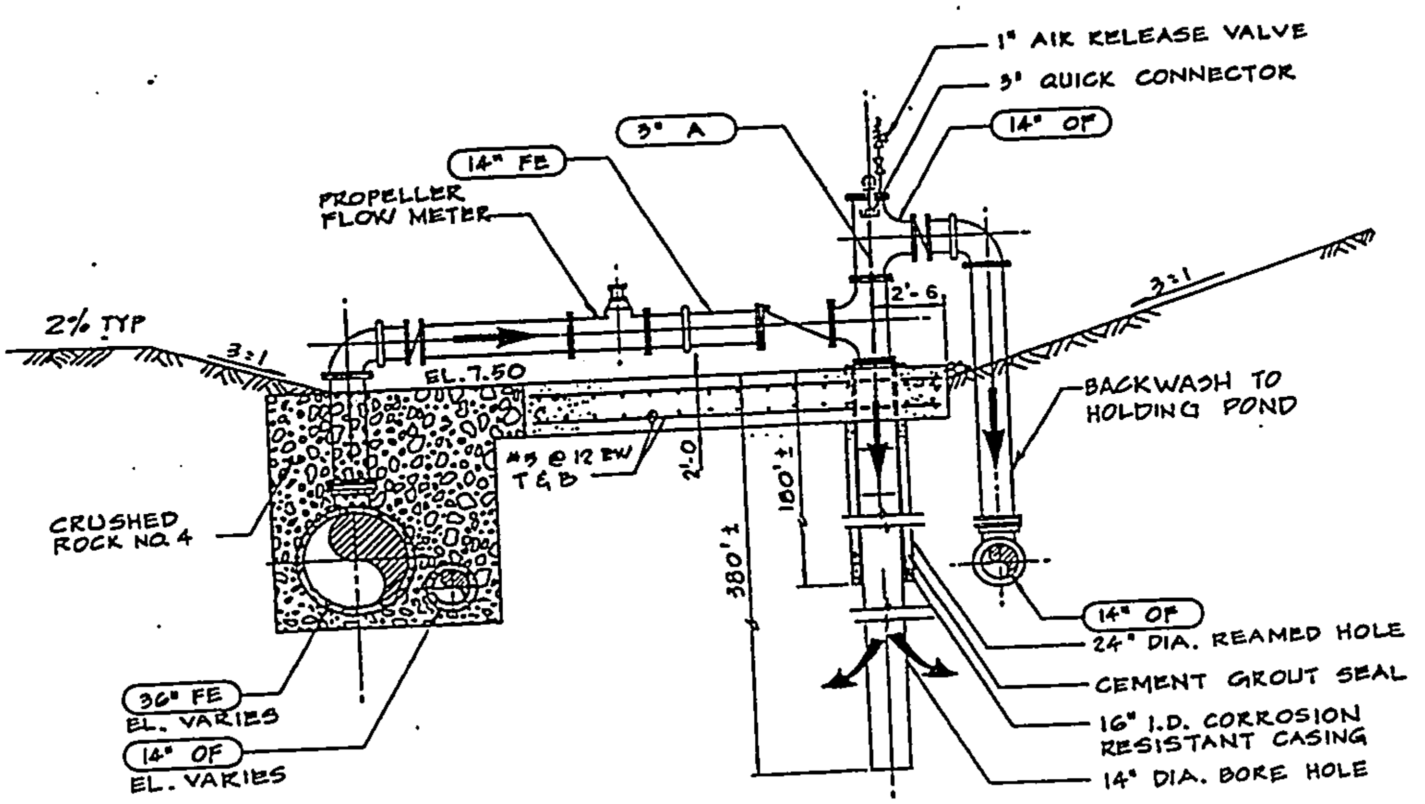

Figure D-1
New injection well construction

The freshwater lens in the upper portion of the lava sequence is slightly confined by the clay layer, with heads a few tenths of a foot to a foot higher than in the overlying zone. This head differential indicates that there is limited mixing between the groundwater in the lava sequence and the coral/sand zone above it. Even within the lava sequence, the hydraulic conductivity in the horizontal direction is at least 10 to 100 times greater than in the vertical direction. The groundwater table below the plant site varies with the tidal cycle but averages between 2.0 and 3.0 feet above mean sea level (MSL).

The preceding discussion is summarized in Figures D-4 and D-5, which show the configuration of the geological and hydrogeological features of the region surrounding the injection wells.

<u>Response to injection</u>

Because the upper section of the injection wells is sealed, all of the effluent is injected from the lower section into the saline zone. However, the density of the injected wastewater is less than the groundwater in that zone, which has essentially the same salinity as the ocean. This buoyancy causes the injected water to move upward without significant change until it eventually intercepts the seaward flow of freshwater in the upper part of the lava sequence.

As shown in Figures D-6, the injected water also spreads radially as it rises, forming an roughly conical plume. The top of the plume is displaced slightly seaward, in response to the seaward flow of freshwater at the top of the aquifer. Modeling of the injection wells[1] indicates that the plume spreads at the top of the lava sequence to about 1,000 ft landward of the wells, 1,800 feet laterally on each side, and about 2,000 feet seaward.

A portion of the injected water discharges from the lava sequence by upward seepage into the base of the unconfined aquifer over the area of the plume, but principally seaward of the injection site. The modeling suggested that the part of the plume reaching the top of the lava sequence below Kanaha Pond contains 2 percent or less of the injected wastewater. Upward leakage from this part of the plume is displaced seaward and thus does not enter the pond. Little, if any, of the injected wastewater reaches the upper part of the unconfined aquifer landward of the treatment plant site. Ultimately the injected effluent enters the ocean with the native freshwater flow, within 2,000 to 3,000 feet of the beach.

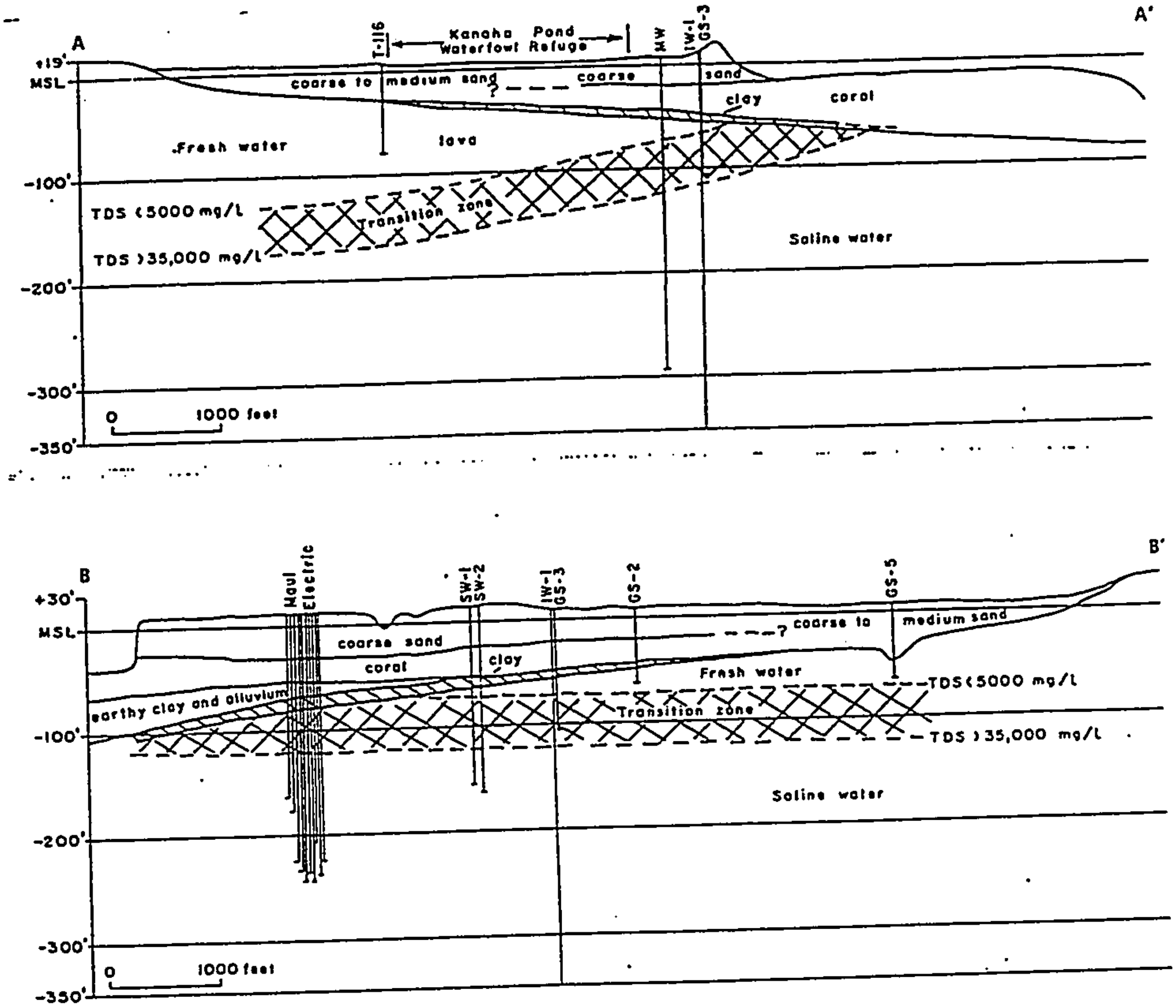

Figure D-5
Cross-sections of the area surrounding the injection wells (From Reference 1)

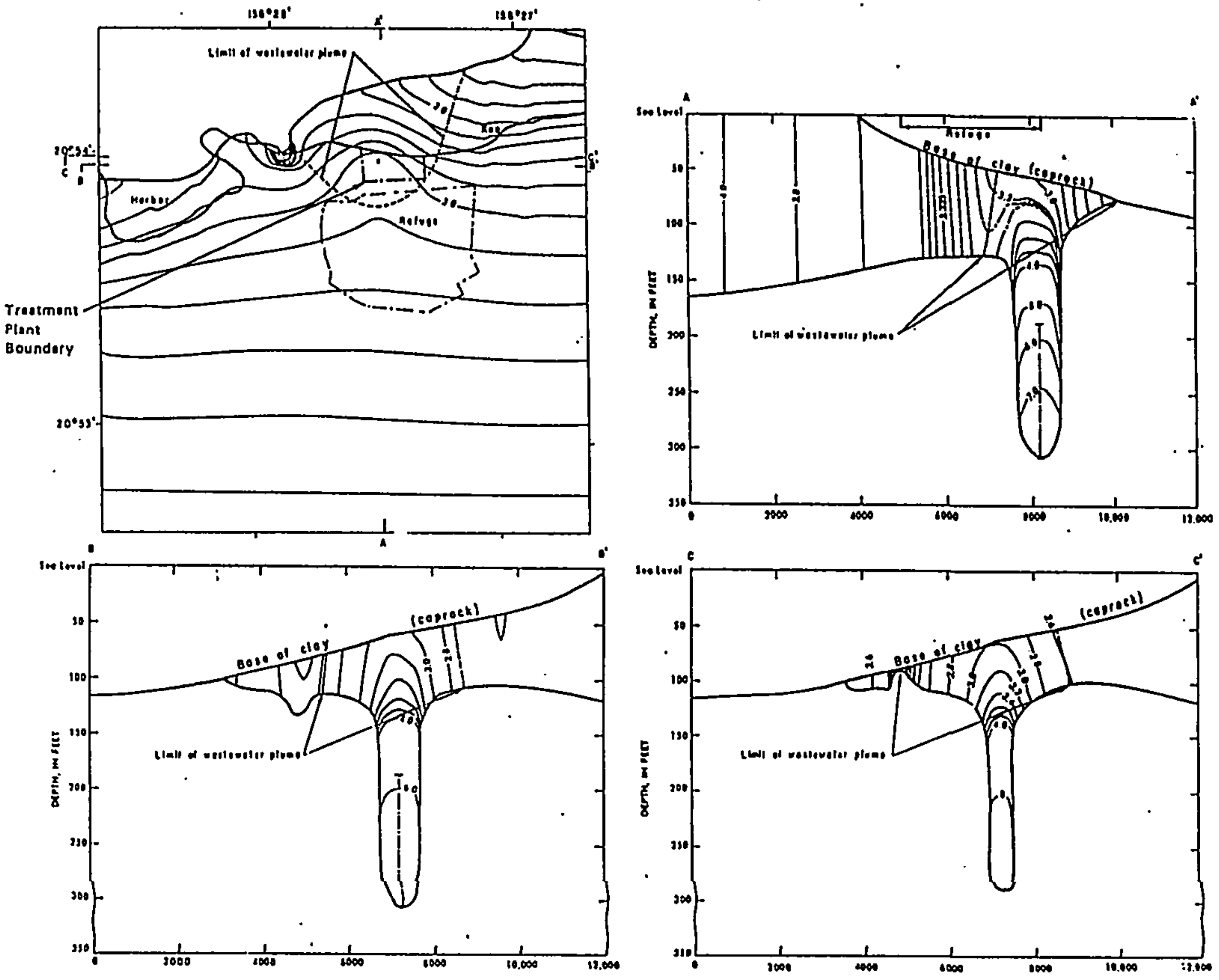

Figure D-6
Plan and sections of the wastewater plume, showing head and wastewater distribution within the lava sequence (From Reference 1)

REFERENCES

1. Burnham, W.L., Steven P. Larson, and Hilton H. Cooper, Jr. Distribution of Injected Wastewater in the Saline Lava Aquifer, Wailuku-Kahului Wastewater Treatment Facility, Kahului, Maui, Hawaii. USGS Open-File Report No. 77-469. Prepared in cooperation with the County of Maui, Public Works Department, June 1977.

2. Chung Dho Ahn and Associates, Results of a Pilot Test on an Injection Well for the Wailuku-Kahului Wastewater Reclamation Facilities, WPC-Hawaii-45, Prepared for the County of Maui, 1970.

3. U. S. Environmental Protection Agency, "Geohydrology of the Injection Well Sites", Appendix A of Final Environmental Statement, Wailuku-Kahului Wastewater Treatment and Disposal System, F-EPA-24004-HI, June 1974.

APPENDIX C
RECEIVING WATER QUALITY

AN ASSESSMENT OF NONPOINT SOURCE POLLUTION OF THE MARINE ENVIRONMENT OFF KAANAPALI, MAUI, HAWAII

FINAL REPORT

Submitted to:

State of Hawaii
Department of Health
Environmental Planning Office
500 Ala Moana Blvd.
5 Waterfront Plaza, Suite 250
Honolulu, HI 96813

by:

Steven Dollar
Assistant Researcher
University of Hawaii
Hawaii Institute of Marine Biology
School of Ocean & Earth Science and Technology

January 31, 1991

SUMMARY

In response to concerns regarding pollution of the nearshore marine environment off Kaanapali, Maui from nonpoint input of chemicals used for golf course maintenance, a research program was carried out in the latter half of 1990. Goals of the program were to determine if nutrient subsidies from golf course fertilizers were entering the ocean and resulting in detrimental changes to biota. In addition, sediment samples from areas exposed to runoff from the golf course were evaluated for the presence of two commonly used pesticides.

Results of the investigation indicate that there are nonpoint subsidies of nutrient materials (primarily nitrate nitrogen) into the nearshore region owing to drainage of the Kaanapali Golf Course. The input is most noticeable in the area where a drainage culvert has been built to empty into the ocean in an area known as "Black Rock". Such input is sufficient to elevate nutrient concentrations above established DOH water quality criteria. However, while there is detectable input of nutrients, there is no indication of any alteration in biological community structure. Nutrient-rich freshwater runoff forms a low density surface layer that is stratified from oceanic deeper water. As a result, the benthos is not exposed to the high nutrient water, and residence time of the surface layer is too short to result in stimulation of phytoplankton growth. As a result, excess nutrients are quickly diluted to background oceanic levels by physical processes with no apparent impact on biota.

In the region directly downslope from the Lahaina Sewage Treatment Plant, which utilizes injection wells for effluent disposal, no substantial nutrient or salinity gradients were encountered. As a result, it does not appear that effluent materials are leaching to groundwater and entering the ocean near the shoreline in the area surveyed.

Analyses of pesticides revealed no positive results for the herbicide metribuzin; one sample from the Black Rock area showed the presence of chlorpyrifos, an insectide that is used for termite control. Golf course managers, however, report that this material is not used on the golf course. As the drainage for the stream that was sampled includes agricultural (sugarcane) and residential uses, it is possible that the insecticide is originating from sources outside the golf course.

The contract period for this project encompassed only the months of dry weather. It is important to note that the findings of this research may change substantially if sampling was conducted during the period when heavy rainfall and runoff occur.

MOTIVATION AND PURPOSE

Detrimental impact to marine ecosystems from chemical materials associated with shoreline activities, including urbanization, resort development, and agriculture, is currently a critical concern in the Hawaiian Islands. Perception of the problem is that activities on land cause increased rates of nonpoint source transfer of materials to the marine environment that result in diminished water quality, altered biological community structure, and decreased quality of marine recreational resources.

With increasing population and shoreline development in the foreseeable future, the potential problem is expected to become more severe, necessitating the immediate need for developing effective investigative, planning, and management strategies. There has been little scientific research, however, specifically focused on the effects of man's influence on nonpoint source discharges in the nearshore marine environment around Hawaii. Key materials with the potential for nonpoint source pollution include commercial chemicals and treated sewage effluent that are used for irrigation, fertilization, pest, and weed control. These chemicals can leach to groundwaters, or become incorporated in stream flow, with subsequent discharge into the ocean. Injection well and cesspool wastes are introduced directly into the water table.

Chemicals materials that reach the ocean after application on land can be either passively dispersed in ocean waters by purely physical processes, or can be taken up via biological process with the possibility of changing biotic community structure. Nutrient subsidies from fertilization practices can result in excessive growth of algae and other plants (termed eutrophication) which can result in degradation of both water quality and biotic community structure. While most pesticides are rapidly degraded after application, bound to soil organics preventing movement after application, or are unable to bind to living organic material owing to chemical structure, other categories of toxic substances used as pesticides have been identified as causing problems in coastal regions. Toxic contaminants entering the marine environment can be absorbed onto sediments and particulate material, remain in the water column or be accumulated by biota.

The purpose of this document is present the results of a research study to investigate the effects of nonpoint source discharges from resort developments, including the potential for hazardous substances to affect nearshore marine life. This investigation was aimed at determining the magnitude and impacts of nonpoint source pollution in the Kaanapali area of the Island of Maui caused by the operation of resorts, with golf courses being the primary focus.

One motivation for the study was reports of substantial blooms of a drift algae (identified as *Cladophora vagabunda*) along the Kaanapali coast during the summer of 1989. The algae was noted to entangle living coral colonies, resulting in death or damage to living coral tissue. It was hypothesized by concerned citizens that the anomalous blooms were the result of nutrient enrichment owing to fertilization of the Kaanapali golf courses. Another motivation for the research is to address the question of pesticide contamination of nearshore marine resources from golf course pest control procedures.

In order to accomplish these goals, two groups of chemicals were assessed; fertilizer nutrients including nitrogen and phosphorus, and a commonly used herbicide (metribuzin) and insecticide (chlorpyrifos) on golf courses in Hawaii that have the potential for leaching to groundwater. The methods utilized for investigation of each of these groups of potential pollutants, as well as the results and conclusions of the program are present below.

FERTILIZER NUTRIENT SUBSIDIES

Introduction

Major changes in land-use patterns associated with urbanization and agriculture can substantially augment nonpoint source inputs of inorganic plant nutrients (nitrogen and phosphorus) to nearshore marine environments. Nutrients injected into coastal oceans can either be diluted to background concentrations with little environmental effect, or can be taken up by biota, creating a potentially deleterious impact on the ecosystem.

In Hawaii, where the ocean provides a spectrum of vital resources of both nonconsumptive (tourism, marine recreation) and consumptive (fisheries) uses, there is growing concern regarding the magnitude and consequence of alteration of the marine environment owing to human activities on land. To successfully analyze the extent of the problem, hypotheses must be clearly defined and interpreted in a thorough quantitative fashion.

Several hypotheses were tested in the present research work: 1) the subsidies of nutrient materials to the marine environment that originate from activities on land can be differentiated quantitatively from natural "background" nutrient inputs, and 2) where such nutrient subsidies are entering the ocean, an estimate of the extent of dispersive mixing, and net community uptake can be determined. These hypotheses were addressed by applying a one-dimensional hydrographic mixing model that relates the concentration of any dissolved material to salinity. A detailed description of the rationale on which the model is based is presented in Smith and Atkinson (in press) which summarizes earlier literature. In the simplest form, the model allows calculation of the net source or sink of material in a defined system, when the input of groundwater or streamflow, and the gradient of nutrient concentration with respect to salinity is known within the system (see Figure 1). Characteristics of the nutrient/salinity mixing curves also provide information on the physical and biological processes that affect nutrients in the system.

Methods

Conservative Mixing Model

The methodology that was used for determining the fate and effect of fertilizer nutrients centered on application of a basic hydrographic concept in the form of a "conservative mixing model". Derivation and rationale of the model are presented in detail in Smith and Atkinson (in press) and Dollar and Smith (1988). The model is based on a simple hydrographic principle that relates the concentration of any material in question to conservative mixing. If a material moves through a system in direct proportion to its abundance relative to some non-reactive material such as salinity, then this material is said to be "conservative" relative to salinity. In this context, "conservative" is defined as physical mixing only, with no other interactions from biological or chemical processes. If on the other hand, the material of interest moves through the system disproportionally relative to such a conservative tracer, it is said to be "nonconservative." Materials that are nonconservative are likely to be biogeochemically and ecologically important.

Thus, if waters with two compositions are mixed, relative admixtures will produce straight lines on 2-dimensional plots as long as there are not additional sources or sinks for either material. In the ocean, the concentration of salt (salinity), responds only to physical mixing; this property of seawater is not altered by biological or chemical activity. Figure 2 shows hypothetical cases of application of the mixing model. The solid, straight lines represent the "conservative mixing lines", and are constructed by connecting the endpoint concentrations of open ocean water (salinity = 35‰) and freshwater (salinity = 0‰) from uncontaminated groundwater or stream water.

In the upper graph of Figure 2, data points of material "Y" plotted versus salinity yield straight lines, indicating that only physical mixing processes are occurring. Because the open circles fall on the conservative mixing line, it is evident that there are no sources or sinks of material Y. The closed circles represent a situation where there is a subsidy of material Y. The horizontal data line out to about 10°/oo suggests a source input in this area. The straight character of the data points over the rest of the salinity range indicate that the subsidy is affected only by physical mixing processes.

The shape of the measured mixing line also provides important information about ecosystem response to nonpoint source discharge. Curvature of mixing lines indicates the nature of nonconservative behavior; upward concave curvature reveals uptake of material, while downward concave curvature reveals release of material into the system. Considering dissolved nutrients, upward concavity implies community autotrophy, a possible signal of impending eutrophic conditions. Downward concavity, on the other hand, reveals community heterotrophy, a potential response to increased particulate input.

The lower graph of Figure 2 shows theoretical data points which prescribe curved lines when concentration of Y is plotted as a function of salinity. The open circles, which are concave downward and fall above the conservative mixing line, indicate a nonconservative source of Y to the system. An example of such a source is net input of dissolved nutrients owing to the biological processes of heterotrophic communities. The curve prescribed by the closed circles, which is concave upward, indicates a net nonconservative sink of Y in the system. An example of such a sink is biological uptake of dissolved nutrients by autotrophic plant communities. The magnitude of the sink (R_y) can be calculated as the difference between the Y intercepts of the tangents to the measured mixing line (depicted by the dashed line). Data from actual situations can display various combinations of these curves; as long as there is a gradient in the conservative property (salinity) the functioning of the material under scrutiny can be evaluated.

In the situation of nonpoint source discharges, the model can be made explicit. The endmembers are offshore seawater, with salinity near 35°/oo and nutrient concentrations near zero, and groundwater with salinity of 0°/oo and high concentration of dissolved nutrients. At study sites on Maui, seawater and groundwater endmembers can be considered constant in composition relative to the large concentration differences involved. Materials to be considered (Y) include silica (Si), a nutrient leached from basaltic lava and soils, but not supplied in large quantity in fertilizers, and the active constituents of fertilizers, nitrogen and phosphorus. Following application on land, nitrogen can leach to groundwater as dissolved inorganic nitrogen, composed of nitrate (NO_3^-) and ammonium (NH_4^+). The form of phosphorus that can occur in groundwater owing to fertilizer application is dissolved inorganic phosphorus (PO_4^{3-}). Dissolved organic N and P can also be present. There is no distinction in the methodology or application of the model between nutrients originating from sewage effluent of commercial fertilizer mixes.

Field Methods

Field sampling was conducted at 3 sites in the Kaanapali area (Figure 1). As the intent of the study was to determine the effect of materials used on golf courses, two of the sites were located near drainage channels that passed through the Kaanapali Golf Course. The southernmost drainage was Wahikuli Stream, which bisects the Kaanapali golf course and empties into the ocean near Hanaka'o'o Park. The area where the stream empties is popularly known as "Canoe Beach", and the sampling site is therefore designated as "CB". The central site is located off of Keka'a Point, popularly known as "Black Rock" (BR). At the northern border of the point, a drainage culvert has been constructed which empties water from the golf course into the ocean.

A third sampling site was located near the Lahaina Sewage Treatment Plant (STP). The method of disposal of the secondary sewage treated at the plant is injection wells located on the STP grounds. The sampling site was located downslope from the STP in order to determine if effluent is reaching the ocean via groundwater discharge at the coastline. In addition, the drainage of Honokowai Stream, which passes through agricultural lands (sugarcane) is adjacent to the STP grounds. The stream empties into the ocean through a drainage culvert.

Water samples were collected from each of the sites three times, once in June, July and November of 1990. Samples were collected from the shoreline out to a distance of approximately 500 m from shore. Sampling was concentrated in the nearshore regions as this is the area most likely to show nutrient subsidies emanating from land. In addition to ocean samples, water was collected from freshwater upland wells, streams and drainage channels, irrigation waters, golf course ponds, and sewage effluent.

Samples were analyzed for dissolved inorganic nutrients nitrate + nitrite (NO_3^- + NO_2^-), ammonium (NH_4^+), orthophosphate (PO_4^{3-}) and silica (Si), as well as dissolved organic nitrogen (DON) and dissolved organic phosphorus (DOP). All nutrient analyses were performed using standard methods of seawater analysis techniques (Strickland and Parsons

1976) on a Technicon Autoanalyzer at the Analytical Services Facility operated by the Hawaii Institute of Marine Biology, University of Hawaii. Salinity was measured on all samples using a AGE salinometer, which has the capabilities to report to 0.0001°/oo.

For the July sample set, Chlorophyll a and turbidity were also evaluated. Chlorophyll a was measured by filtering 1 liter of water through glass-fiber filters; pigments on filters was extracted in 90% acetone in the dark at -5°C for 12-24 hours. Fluorescence before and after acidification of the extract was measured with a Turner Designs fluorometer. Turbidity was assessed using a Monitek Model 21 nephelometer, and reported in nephelometric turbidity units.

Results and Discussion

As described above, one motivation for this research was to identify potential causes for the anomalous outbreak of the drift algae *Cladophora vagabunda* during the summer of 1989. It was planned to conduct the program of water sampling during a similar outbreak in the summer of 1990. Close monitoring of the situation during the spring and summer of 1990, however, revealed no such atypical occurrences of the algae. As a result, it was not possible to correlate any observed nutrient inputs to previously observed changes in biotic structure. It is theorized that the 1989 outbreak was a result of some unidentified periodic cycle in the life history of the algae, possibly enhanced by anthropogenic inputs. Because the process did not recur, it is unlikely that the population bloom was solely a result of anthropogenic inputs, as there have been no apparent changes in the processes associated with golf course operations in the intervening year.

Even though there were no observed algal blooms during 1990, it was possible to assess the extent of nutrient subsidy to the nearshore ocean owing to land-use activities. During the months that encompassed the funding period, however, rainfall is typically very low on the leeward coast of Maui. As a result, during the time of sampling runoff and streamflow were minimal, and there was very little evidence of flow into the ocean. Had the funding period extended through the winter months, when rainfall and runoff are substantially higher, it is likely that results of the study describing nutrient subsidies from land to the ocean would be substantially different than those reported below.

Tables 1, 2, and 3 show the concentrations of dissolved nutrients and salinity from the samples collected at the 3 sites in June, July and November of 1990, respectively. In addition to the nearshore ocean samples, results of analyses of waters from the drainage channels, golf course ponds, and sewage effluent are also shown. Several patterns are immediately obvious when examining the data in these tables. First, the concentration of all nutrients (except DOP) is extremely high in the drainage flumes and channels, golf course ponds, and sewage effluent compared to all of the ocean samples. Conversely, salinity of the samples is low compared to oceanic values. It is therefore apparent that there are nonpoint inputs of nutrient materials from sources on land.

Ocean samples outlined in boxes in Tables 1, 2, and 3 are values greater than the Department of Health *water quality standards* for coastal waters under dry conditions (not to exceed more than 10% of the time criteria). It can be seen that at Black Rock and Canoe Beach numerous samples exceeded the criteria for NO_3 and NH_4 for all three sampling periods. No values exceeded DOH standards at the Sewage Treatment Plant site in June and July, and only NH_4 samples exceeded standards in the November sampling. During July, one sample of Chl a exceeded standards, while several values of turbidity were over the limits at Canoe Beach and the Sewage Treatment Plant.

Figures 3, 4, and 5 show plots of nutrient concentrations as functions of salinity at each of the sites during each of the sampling periods. Conservative mixing lines are also shown for both uncontaminated groundwater taken from wells in the West Maui area (dotted lines), and water from drainage channels that traverse the golf courses near each site (solid and dashed lines). As the environmental attributes of each sample area are somewhat different, each will be discussed separately.

The environmental setting at Black Rock in comprised of a sluice-like drainage channel that receives drainage water from the golf course. At the juncture of the drainage channel and the ocean, tidal and wave circulation cause an abrupt zone of mixing between fresh drainage water and oceanic water. Water depth in the area is quite deep (3-5 m), and there is essentially no intertidal region, except on the vertical wall of the basalt structure of Black Rock. Bottom composition in the area is white sand with occasional protrusions of limestone. No growths of filamentous or fleshy algae were observed in the area.

Nutrient concentrations of samples collected at the drainage juncture, as well as seaward of the drainage channel, are plotted as functions of salinity in Figure 3. Several major points are evident when examining the plots. Concentrations of Si, PO_4, and especially NO_3, are significantly lower in the freshwater endmember from well water (dotted line), compared to golf course drainage water (solid and dashed lines). Such a result is not unexpected, as golf course fertilization could result in runoff or leaching of fertilizer nutrients. Thus, owing to the golf course there is a distinguishable nutrient subsidy to the nearshore ocean.

The other conspicuous observation is that most of the data points for Si, PO_4, and NO_3 during all three samplings fall in relatively straight line distributions along the mixing lines constructed from endpoints of golf course drainage water. The distribution of NH_4 is substantially different. The highest concentrations occur in the highest salinity samples, and there is no indication of any relationship with respect to mixing from the drainage flow. Such a result concurs with the observation of low NH_4 levels in any of the freshwater sources.

The linear relationships of Si, PO_4, and NO_3 suggest that the drainage water is mixed and diluted with ocean water following discharge at the shoreline without apparent uptake by biological processes. Examination of the data indicates that the nutrient subsidies from the drainage discharge were entrained in a surface layer of low salinity water that remained stratified from deeper oceanic water. Owing to the stratification, there was no mechanism for the nutrient enriched layers to impinge on the benthos, resulting in "abnormal" algal growth. The linearity of the mixing distributions shown in Figure 3 indicates that there does not appear to be uptake of the nutrient subsidy by planktonic communities in the upper stratified layer. It appears that the residence time of the nutrient enriched layer prior to mixing to background levels (at the most several hours) is not sufficient to result in eutrophic conditions in the plankton. Thus, while there is a distinct nutrient subsidy to the ocean as a result of golf course drainage at Black Rock, during the three intervals of water sampling there does not appear to be any discernible alteration to biotic community structure.

The physical setting at Canoe Beach consisted of a wide sand beach. The beach forms a berm separating the drainage channel of Wahikuki Stream from entering the ocean, except during storm drainage. Owing to low rainfall throughout the contract period of this project, the drainage channel at Canoe Beach was never observed to be flowing into the ocean. As a result, the range of salinity for the oceanic samples was only 1‰ (34-35‰); substantially less than the range at Black Rock.

Examination of the mixing diagrams for data collected at Canoe Beach reveals some of the same characteristics as described above for Black Rock. Again, distributions of Si, PO_4, and NO_3 fall in relatively straight line distributions along the conservative mixing lines prescribed by the golf course irrigant water. Also, as at Black Rock, NH_4 distribution is a function of oceanic processes rather than input from land. One apparent difference with the Canoe Beach data is the greater variation between sampling increments. During the June sampling, several of the Si and NO_3 concentrations fall close to the conservative mixing line derived from uncontaminated well water rather than the golf course irrigant. Such a result suggests that there is a source of groundwater entering the ocean in this region that does not contain leachate from golf course irrigation. It can be seen that such input was not apparent in the July and November samples. As with the Black Rock samples, there is no indication from the mixing diagrams of any substantial biological uptake of nutrient subsidies (curvature of mixing lines), and the excess nitrogen is rapidly diluted to background levels by physical mixing processes in the nearshore zone.

Results from the Sewage Treatment Plant site were perhaps the most surprising of the program. As the Lahaina STP disposes of treated effluent by injection wells, it was expected that there would be a substantial nutrient/salinity signal directly downgradient from the plant site where groundwater would presumably enter the ocean. Examination of Figure 5, however, shows that there is neither a clear salinity nor nutrient gradient in samples from any of the three surveys. In addition, concentrations of nutrients, particularly NO_3, that are present in very high concentrations in sewage (see Table 1) were considerably lower at the STP sampling site than at either of the other two sample areas. While the patterns are very weak, there is a suggestion that Si and NO_3 distributions generally fall near the conservative mixing lines formed from the sewage effluent endpoints, rather than the uncontaminated groundwater endpoint.

Owing to low rainfall, there was no surface drainage of Honokawai Stream during any of the sampling visits. The lack of a salinity gradient in the STP area indicates that either there is very low groundwater efflux at the shoreline, or that physical mixing processes are so strong that groundwater input is mixed so rapidly with oceanic water that the signal in not detectable, even with samples collected very near the shoreline. The benthos in the area is composed of substantial growth of fleshy algae and coral. However, with no salinity gradient, it is not self-evident that this algal growth is a response to nutrient subsidies from land. If such subsidies were responsible for the abundant algal growth, salinity versus nutrient plots would express such uptake as upwardly concave mixing lines.

In summary, results of the sampling program indicate that there are nonpoint source nutrient subsidies to the nearshore ocean as a result of drainage and runoff from the Kaanapali Golf Course and associated land uses. However, there are no indications from the data that the nutrient subsidies are resulting in any alteration of biological community structure or function. Rather, data suggest that the materials reaching the ocean are rapidly mixed to background oceanic levels by physical mixing processes such as waves and currents.

Several caveats, however, must be cited. First, one rationale for the program was the abnormal abundance of an algae that did not reappear during the sampling. Second, the sampling was all conducted during the months of low rainfall and runoff. A similar analytical program conducted during periods of high rainfall and runoff may result in substantially different results.

PESTICIDES

Introduction

There are a number of weed, insect, and disease pests of turfgrasses in Hawaii which sometimes require application of chemical pesticides. Pesticides are normally applied to golf courses only in response to outbreaks of pests. Most pesticides used in golf course management are of low toxicity, and most are either rapidly degraded in soil and/or are sorbed tightly to organic matter or soil colloids and move little from the site of application (Murdoch and Green 1989). Of the herbicides used on golf courses in Hawaii, the one with the most potential to move below the root zone, and hence leach to groundwater is metribuzin. One insecticide that is widely used on golf courses in Hawaii is chlorpyrifos (Murdoch and Green 1989). This compound is also used extensively as a termiticide in residential areas.

Pesticide and fertilizer contamination of surface and groundwater associated with golf courses has drawn increased public concern. A groundwater monitoring study for pesticides and nitrates associated with golf courses on Cape Cod found 10 of the 17 pesticides analyzed although only one, chlordane, was above the health guidance level (HGL)(Cohen et al., 1990). Since chlordane is not registered for use on golf courses, none of the 12 currently registered turf pesticides targeted in this study were detected at 20% of the HGL. These findings are significant since the sandy soils are highly permeable and the depth to groundwater is relatively shallow. Studies of pesticides and fertilizer runoff from turfgrass show that, even under extreme conditions, that only small amounts of water move from sodded slopes (Watschke, 1990). Degradation and sorption in the turf and dilution in receiving waters resulted in pesticide concentrations below drinking water standards in almost all cases (Watschke et al., 1989).

Metribuzin (SENCOR ® and LEXONE®) is a selective systemic herbicide registered for use on golf courses. High water solubility (1220 mg/L), moderate half-life (30 d) and moderate sorption to soils (K_{oc} = 41) contribute to a large leaching potential and medium surface loss potential (USDA, 1989). Deamination followed by further degradation to water soluble conjugates is the major dissipation mechanism in soils (Royal Society of Chem, 1987). Chlorpyrifos (DURSBAN®) is a non-systemic insecticide also registered for golf course use. Low water solubility (2 mg/L), moderate half-life (30 d) and high sorption to soils (K_{oc} = 6070) yield a small leaching potential and a high surface loss potential (USDA, 1989). In soil, the major degradation pathway is hydrolysis to 3,5,6-trichloro-2-pyridinol (Royal Society of Chem, 1987).

Hawaii is economically dependent upon a tourist industry and the associated golf courses are highly desirable. The Hawaii State Department of Health (HDOH) has imposed conditions that for development of new golf courses that include protection of surface and groundwater resources (HDOH, 1990). The state is also concerned about the impact of pesticides on marine resources. This investigation examined marine sediments near golf course drainage ditches on the island of Maui, Hawaii for metribuzin herbicide and metabolites and chlorpyrifos insecticide.

Materials and Methods

Soils associated with the sampling sites are the Pulehu and Jaucas series (USDA/SCS, 1972). Pulehu soils developed from alluvium washed from basic igneous rock. These silt loam texture soils have moderate permeability and slow runoff is slow. Jaucas series are excessively drained, calcareous soils usually found in narrow strips on coastal plains near the ocean. They have a fine sand texture, rapid permeability, and slow runoff. The water erosion hazard of both soils is slight.

Sediment samples were collected by grab sampling from each of the three sites described above (see Figure 1). Sampling sites consisted of drainage ditches which passed through the golf courses, and beach sands over which drainage water flowed. Most samples were largely composed of sand although some had large amounts of organic matter. Surface sediments (ca. 200 g ea) were collected by stainless steel auger and stored in polyethylene bags. Samples were refrigerated in the field and frozen in the laboratory until analyzed (less than 2 months).

Analytical standards of metribuzin (97.2%) and chlorpyrifos (99.7%) were obtained from EPA (Research Triangle Park, NC), deaminated metribuzin (DA; 99.6%), diketo metribuzin (DK; 98.7%) and deaminated diketo metribuzin (DADK; 84.8%) were obtained Mobay Chem. Corp. (Kansas City, MO), and chlorpyrifos oxon (98.2%) and 3,5,6-trichloro-2-pyridinol (99.9%) were received from Dow Chem. Co. (Midland, MI). Metribuzin and chlorpyrifos and metabolite standards were prepared in toluene while metribuzin metabolite standards were prepared in 20% methanol and toluene.

Sediments were thawed and homogenized by stirring before 25 g subsamples were placed into 300 mL round bottom flasks. Fortification was performed by adding a mixture of standards in 0.25 mL of acetone, stirring, and allowing 1 hour for the acetone to volatilize. Ten mL of methanol and 100 mL of ethyl acetate were added before refluxing for 1 hour. After cooling, the sample was filtered (Whatman #4) and quantitatively transferred to a round bottom flask with 0.25 mL of decyl alcohol. The extract was rotary evaporated (30 °C) until only water and decyl alcohol remained. After drying with 100 g sodium sulfate, the sample was rotary evaporated until only decyl alcohol remained. The sample was made to 2.5 mL with ethyl acetate and ready for gas chromatographic (GC) analysis.

GC analysis was performed on a Hewlett-Packard 5730 gas chromatograph equipped with a nitrogen-phosphorous detector (NPD). Injector and detector temperatures were 250 °C and 300 °C. A 0.53 mm ID X 15 m (0.5 μm film) Supelco Herbicide wide bore capillary column was used with helium carrier gas (5 mL/min). The column was temperature programmed from 120 °C to 240 °C at 10 °C/min and held for 8 min at 240 °C. Retention times were 3.8 min for DADK, 5.0 min for DK, 6.2 min for DA, 6.4 min for the parent metribuzin, and 6.8 min for chlorpyrifos. Confirmation was performed with a Hewlett-Packard 5890 GC equipped with NPD (250 °C) and splitless injector (250 °C). A 0.53 mm ID X 10 m (2.65 μm film) HP-5 (Hewlett-Packard) wide bore capillary column was used with helium carrier gas (5 mL/min). After 1 min at 120 °C, the column was temperature programmed at 7 °C/min to 220 °C and held for 8 min. Retention times were 12.0 min for DADK, 14.6 min for DK, 17.5 min for DA, 18.4 min for the parent metribuzin, and 19 min for chlorpyrifos. Confirmation also was achieved with GC/mass spectrometry using a Hewlett-Packard 5890 GC and a VG BioTech Trio 2 mass spectrometer (MS). The MS was operated in the electron impact mode (70 eV) and MS source, GC transfer line and GC splitless injector were maintained at 200 °C, 200 °C and 250 °C, respectively. A 0.25 mm

ID X 30 m (0.25 μm film) DB-5 capillary column (J&W Scientific) was operated with helium carrier gas (ca. 1 mL/min). After 1 min at 50 °C, the column was temperature programmed at 15 °C/min to 200 °C and held for 5 min. Metribuzin eluted at 14.3 min while chlorpyrifos eluted at 16.2 min.

Results and Discussion

Tables 4-7 show results of the pesticide analyses and the quality control fortification analyes. Method detection limits (MDL's) for metribuzin and metabolites was 0.01 μg/g in the sandy sediments while interferences in the high organic matter sediment samples raised the MDL to 0.1 μg/g. Recovery of the metribuzin analytes from samples fortified from 0.01 to 0.4 μg/g (n = 12) were acceptable although the precision range was wide. Metribuzin (98 ± 9) and the DA metabolite (106 ± 13) were within quality assurance guidelines (65 to 135% recovery with ± 15% relative standard deviation) while the DK metabolite (89 ± 29) and DADK metabolite (118 ± 27) were outside the precision guidelines. This is not unusual for recoveries at the MDL and others have experienced poor precision of recoveries for the DADK and DK metabolites in soil (Thornton, 1972). Recoveries of chlorpyrifos (105 ± 7) were acceptable for both accuracy and precision.

The original GC/NPD analysis showed the presence of parent metribuzin in two samples from Black Rock at about 0.2 μg/g. This analysis was confirmed by GC/NPD on another stationary phase. Analysis of these samples by GC/MS did not confirm the presence of metribuzin. Control sediment samples fortified with 0.2 μg/g of metribuzin yielded an MS response similar to standard solutions in the same concentration range. Thus, none of the samples showed the presence of metribuzin or metabolites above the MDL's.

The original GC/NPD analysis also showed the presence of 1.1 μg/g of chlorpyrifos in one sediment sample near Black Rock (No. 2) collected in November (see Table 6). This sample had a high organic matter content. The presence of chlorpyrifos was confirmed by GC/NPD on a different stationary phase and also by GC/MS. The amount of chlorpyrifos injected (ca. 10 ng) was sufficient to obtain positive identification by a standard NBS mass spectral library search. Chlorpyrifos metabolites, chlorpyrifos oxon and 3,5,6-trichloro-2-pyridinol were below MDL's of 0.1 μg/g in all samples analyzed.

Because of the highly variable climatic conditions in Hawaii, there are no overall typical pesticide use patterns. Pesticide use records from two golf courses on the Kona coast of the island of Hawaii show an average herbicide use of 250 lbs a.i. (active ingredient)/acre, average insecticide use of about 550 lbs a.i./acre, and average fungicide use of 60 lbs a.i./acre (Brock and Kam, 1990). These records show high use of metribuzin along with MSMA and glyphosate herbicides as well. Chlorpyrifos was the most widely used insecticide. Pesticide use records from the associated golf course are not presently available. However, verbal inquiries of the golf course manager indicated that chlorpyrifos is not used on the Kaanapali course.

The high sorption of chlorpyrifos to soil organic matter contributes to a high surface loss potential and resulting capacity to accumulate in sediments, especially in drainage areas. Since chlordane has been banned as a termiticide, Hawaii homes and other buildings are often treated with chlorpyrifos and are treated more often than with chlordane (Oki et al., 1990). Several buildings are in the drainage area where chlorpyrifos was detected. In addition, the drainage area that terminates in the sluiceway at Black Rock includes residential areas outside of the golf course grounds. It is, therefore possible that the chlorpyrifos detected in the sediments in the golf course drainage originated from usage in controlling termites in residential areas.

Although chlorpyrifos and metribuzin have relatively high surface loss potentials, they usually are applied to golf courses in areas with a thick turf thatch. Absorption by the turfgrass, sorption to fixed soils, and degradation in this environment greatly reduce the surface loss potentials. Heavy rain storms that occasionally occur coupled with a recent pesticide application can cause significant surface and leaching losses.

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TABLE 1. Water chemistry constituents in samples collected off the Kaanapali golf course on June 13, 1990. Values in boxes exceed DOH water quality standards for 10% criteria for dry conditions. For station locations, see Figure 1.

SAMPLE LOCATION	PO4 (µM)	DOP (µM)	TP (µM)	NO3 (µM)	NH4 (µM)	DON (µM)	TN (µM)	Si (µM)	SALINITY (o/oo)
"BLACK ROCK"									
OCEAN 1	0.17	0.16	0.33	2.07	0.17	4.76	7.00	9.40	34.63
OCEAN 2	0.21	0.17	0.38	5.16	0.24	4.10	9.50	19.58	34.28
OCEAN 3	0.16	0.18	0.34	0.51	0.34	5.36	6.21	3.33	34.83
OCEAN 4	0.21			0.29	0.62			23.50	34.85
OCEAN 5	0.17	0.20	0.37	2.31	0.24	4.93	7.48	10.77	34.61
OCEAN 6	0.20	0.20	0.40	3.48	0.30	4.54	8.32	14.69	34.45
OCEAN 7	0.17	0.21	0.38	3.06	0.26	4.34	7.66	12.73	34.54
OCEAN 8	0.14	0.23	0.37	0.32	0.34	4.97	5.63	2.94	34.87
OCEAN 9	0.16	0.19	0.35	2.23	0.22	4.55	7.00	9.79	34.62
OCEAN 10	0.16	0.15	0.31	0.32	0.28	3.77	4.37	2.94	34.86
OCEAN 11	0.14	0.17	0.31	0.19	0.13	3.65	3.97	2.55	34.87
OCEAN 12	0.14	0.23	0.37	0.43	0.17	3.64	4.24	3.13	34.85
OCEAN 13	0.16	0.15	0.31	0.29	0.15	4.06	4.50	2.74	34.40
DRAINAGE FLUME	2.65	BDL	2.65	179.18	1.12	2.20	182.50	619.32	11.07
DRAINAGE FLUME	3.33	BDL	3.33	218.39	0.00	4.64	223.03	785.75	1.98
DRAINAGE FLUME	3.73	BDL	3.73	219.72	1.42	1.89	223.03	788.29	1.87
DRAINAGE FLUME	4.27	BDL	4.27	218.39	0.69	3.29	222.37	775.96	1.73
GOLF COURSE POND	2.72	0.29	3.01	205.76	1.20	8.10	215.06	802.98	1.90
"CANOE BEACH"									
DRAINAGE CHANNEL	0.21	0.40	0.61	0.05	0.37	17.64	18.06	9.59	34.25
DRAINAGE CHANNEL	0.23			0.05	1.36			8.42	34.30
DRAINAGE CHANNEL	0.27	0.44	0.71	0.05	0.75	16.81	17.61	9.20	34.29
DRAINAGE CHANNEL	0.37	0.55	0.92	0.05	1.03	21.93	23.01	13.51	34.14
TAP WATER	1.96	BDL		13.40	0.13	1.12	14.65	538.65	0.44
OCEAN 1	0.30	0.20	0.50	7.28	0.15	5.10	12.53	30.15	34.00
OCEAN 2	0.24	0.16	0.40	0.45	0.17	4.01	4.63	5.48	34.83
OCEAN 3	0.18	0.15	0.33	0.32	0.11	3.28	3.71	3.72	34.85
OCEAN 4	0.16	0.15	0.31	0.16	0.00	3.29	3.45	2.74	34.87
OCEAN 5	0.16	0.19	0.35	0.21	0.04	6.09	6.34	3.33	34.85
OCEAN 6	0.14	0.16	0.30	0.29	0.41	6.25	6.95	3.52	34.85
OCEAN 7	0.18	0.19	0.37	0.35	0.02	6.24	6.61	3.92	34.84
OCEAN 8	0.17	0.23	0.40	0.21	0.22	7.36	7.79	2.35	34.88
OCEAN 9	0.26			2.45	0.17			15.86	34.61
OCEAN 10	0.17	0.17	0.34	0.27	0.15	5.21	5.63	3.13	34.86
OCEAN 11	0.26	0.24	0.50	2.50	0.45	5.89	8.84	16.25	34.61
OCEAN 12	0.17	0.17	0.34	0.35	0.32	5.49	6.16	3.13	34.85
OCEAN 13	0.16	0.19	0.35	0.16	0.22	5.04	5.42	1.57	34.88
OCEAN 14	0.16	0.18	0.34	0.16	0.09	5.04	5.29	1.17	34.88
OCEAN 15	0.16	0.19	0.35	0.16	0.11	5.42	5.69	1.57	34.88

TABLE 1. CONTINUED

SAMPLE LOCATION	PO4 (μM)	DOP (μM)	TP (μM)	NO3 (μM)	NH4 (μM)	DON (μM)	TN (μM)	SI (μM)	SALINITY (o/oo)
"SEWAGE PLANT"									
SEWAGE EFFLUENT	45.52	0.99	46.51	280.85	2.50	24.21	307.56	597.39	1.06
OCEAN 1	0.14			0.13	0.04			2.94	34.42
OCEAN 2	0.17	0.21	0.38	0.08	0.15	4.98	5.21	3.92	34.33
OCEAN 3	0.14	0.19	0.33	0.40	0.11	4.83	5.34	4.11	34.36
OCEAN 4	0.17	0.17	0.34	0.19	0.09	4.53	4.81	3.33	34.35
OCEAN 5	0.16			0.16	0.13			3.33	34.35
OCEAN 6	0.16	0.19	0.35	0.16	0.11	5.07	5.34	3.33	34.36
OCEAN 7	0.13	0.17	0.30	0.16	0.28	5.43	5.87	2.74	34.38
OCEAN 8	0.14	0.17	0.31	0.13	0.15	4.13	4.41	2.74	34.40
OCEAN 9	0.16	0.15	0.31	0.13	0.11	4.70	4.94	2.74	34.38
OCEAN 10	0.16	0.11	0.27	0.13	0.24	4.18	4.55	2.74	34.39
OCEAN 11	0.16	0.14	0.30	0.13	0.15	5.20	5.48	1.57	34.46
OCEAN 12	0.14	0.16	0.30	0.08	0.13	4.34	4.55	2.74	34.38
OCEAN 13	0.17	0.16	0.33	0.13	0.19	4.23	4.55	2.74	34.40
OCEAN 14	0.17	0.16	0.33	0.08	0.17	5.97	6.22	2.94	34.38
OCEAN 15	0.21	0.16	0.37	0.24	0.17	5.94	6.35	3.33	34.36
OCEAN 16	0.17	0.17	0.34	0.48	0.11	5.55	6.14	5.29	34.28
OCEAN 17	0.16	0.14	0.30	0.11	0.15	5.48	5.74	2.55	34.38
GC SPRINKLER	5.08	0.95	6.03	187.16	4.11	10.50	201.77	805.33	1.59

TABLE 2. Water chemistry constituents in samples collected off the Kaanapali golf course on July 20, 21, 1990. Values in boxes exceed DOH water quality standards for 10% criteria for dry conditions. For station locations, see Figure 1.

SAMPLE LOCATION	PO4 (μM)	DOP (μM)	TP (μM)	NO3 (μM)	NH4 (μM)	DON (μM)	TN (μM)	Si (μM)	SALINITY (o/oo)	CHL a (μg/L)	TURBIDITY (n.t.u)
"BLACK ROCK"											
OCEAN 1	0.07	0.23	0.30	0.03	BDL	6.25	6.28	1.36	34.93	0.05	0.08
OCEAN 2	0.09			0.03	0.05			1.36	34.92	0.10	0.08
OCEAN 3	0.10	0.17	0.27	0.05	BDL	5.83	5.88	1.38	34.92	0.10	0.06
OCEAN 4	0.16	0.17	0.33	3.30	0.21	5.77	9.28	13.82	34.46	0.12	0.10
OCEAN 5	0.09			0.24	BDL			2.34	34.88	0.03	0.08
OCEAN 6	0.13	0.21	0.34	1.90	0.55	6.49	8.94	8.95	34.63	0.10	0.08
OCEAN 7	0.24	0.16	0.40	10.93	0.31	5.54	16.78	41.07	33.49	0.17	0.13
OCEAN 8	0.11			1.82	0.13			7.40	34.67	0.12	0.09
OCEAN 9	0.40	0.19	0.59	25.36	0.49	5.43	31.28	93.81	31.65	0.24	0.20
OCEAN 10	0.19			6.89	0.08			25.69	34.05	0.15	0.11
OCEAN 11	0.11	0.19	0.30	1.11	0.03	5.94	7.08	5.45	34.74	0.12	0.07
OCEAN 12	0.10			0.26	BDL			2.53	34.85	0.10	0.06
OCEAN 13	0.10	0.17	0.27	0.40	0.16	5.58	6.14	2.53	34.87	0.11	0.06
OCEAN 14	0.11			0.42	0.08			2.72	34.87	0.12	0.08
OCEAN 15	0.13	0.17	0.30	1.37	0.23	5.29	6.89	6.03	34.75	0.14	0.17
OCEAN 16	0.10			0.50	0.16			2.53	34.87	0.14	0.08
OCEAN 17	0.14			2.27	0.23			9.93	34.60	0.13	0.09
DRAINAGE FLUME	3.07	0.11	3.18	219.45	5.35	4.52	229.32	785.93	2.87	2.05	1.45
"CANOE BEACH"											
OCEAN 1	0.14	0.12	0.26	0.32	BDL	3.48	3.80	5.84	34.83	0.14	0.69
OCEAN 2	0.16			0.32	0.44			5.64	34.83	0.15	0.76
OCEAN 3	0.13	0.16	0.29	0.24	0.16	5.03	5.43	4.09	34.83	0.10	0.31
OCEAN 4	0.13			0.18	0.08			2.72	34.87	0.07	0.20
OCEAN 5	0.11	0.19	0.30	0.21	BDL	5.88	6.09	2.92	34.85	0.08	0.21
OCEAN 6	0.11			0.18	0.03			2.34	34.88	0.08	0.14
OCEAN 7	0.10	0.17	0.27	0.13	0.03	5.98	6.14	1.56	34.90	0.04	0.08
OCEAN 8	0.10			0.13	BDL			1.17	34.91	0.05	0.09
OCEAN 9	0.10	0.24	0.34	0.08	0.03	6.83	6.94	1.36	34.89	0.06	0.10
OCEAN 10	0.10			0.08	0.03			1.17	34.90	0.09	0.07
OCEAN 11	0.11	0.18	0.29	0.21	0.13	6.15	6.49	3.11	34.85	0.08	0.16
OCEAN 12	0.10			0.13	0.05			1.36	34.90	0.09	0.12
OCEAN 13	0.22	0.17	0.39	4.20	0.26	5.81	10.27	18.49	34.39	0.12	0.51
OCEAN 14	0.14			1.06	0.36			5.06	34.78	0.10	0.18
OCEAN 15	0.67	1.02	1.69	2.14	13.10	37.72	52.96	4.09	34.64	15.04	1.92
OCEAN 16	0.20			3.62	0.31			17.13	34.43	0.17	0.30

TABLE 2. CONTINUED

SAMPLE LOCATION	PO4 (µM)	DOP (µM)	TP (µM)	NO3 (µM)	NH4 (µM)	DON (µM)	TN (µM)	SI (µM)	SALINITY (o/oo)	CHL a (µg/L)	TURBIDITY (n.t.u)
*SEWAGE PLANT											
DRAINAGE CHANNEL	3.06	0.55	3.61	41.01	57.73	1.83	100.57	435.59	7.16	0.36	0.98
DRAINAGE CHANNEL	1.84	0.37	2.21	27.87	49.03	2.66	79.56	341.19	13.29	0.48	0.91
OCEAN 1	0.10	0.16	0.26	0.13	0.08	6.01	6.22	11.48	33.92	0.02	0.22
OCEAN 2	0.09	0.15	0.24	0.08	BDL	5.24	5.32	9.93	34.01	0.20	0.21
OCEAN 3	0.10			0.05	0.05			5.64	34.30	0.38	0.20
OCEAN 4	0.11	0.15	0.26	0.13	0.10	5.06	5.29	6.81	34.23	0.13	0.20
OCEAN 5	0.11			0.18	BDL			5.06	34.35	0.14	0.23
OCEAN 6	0.11	0.13	0.24	0.24	0.10	4.55	4.89	4.87	34.36	0.13	0.21
OCEAN 7	0.11			0.29	0.05			4.67	34.39	0.14	0.18
OCEAN 8	0.13	0.11	0.24	0.29	0.08	4.58	4.95	4.48	34.37	0.10	0.18
OCEAN 9	0.13			0.26	BDL			5.06	34.34	0.19	0.17
OCEAN 10	0.13	0.11	0.24	0.42	0.13	4.00	4.55	4.28	34.41	0.09	0.14
OCEAN 11	0.11			0.29	0.08			4.48	34.41	0.11	0.17
OCEAN 12	0.13	0.11	0.24	0.48	BDL	3.40	3.88	3.11	34.46	0.08	0.11
OCEAN 13	0.11			0.32	0.29			4.28	34.38	0.08	0.14
OCEAN 14	0.13	0.11	0.24	0.48	0.03	3.24	3.75	3.11	34.47	0.09	0.11
OCEAN 15	0.11			0.11	0.18			5.26	34.28	0.24	0.26
OCEAN 16	0.10	0.14	0.24	0.05	0.10	3.68	3.83	4.87	34.28	0.22	0.33
OCEAN 17	0.09	0.15	0.24	0.21	0.03	4.26	4.50	2.92	34.46	0.26	0.09
OCEAN 18	0.10			0.21	0.03			2.53	34.48	0.12	0.15
OCEAN 19	0.10	0.16	0.26	0.11	0.03	4.41	4.55	3.11	34.44	0.11	0.21
OCEAN 20	0.10			0.11	0.03			3.31	34.42	0.13	0.18
OCEAN 21	0.10	0.17	0.27	0.11	0.03	4.54	4.68	3.50	34.43	0.14	0.26
OCEAN 22	0.11			0.13	BDL			3.11	34.43	0.16	0.29
OCEAN 23	0.11	0.15	0.26	0.11	0.05	5.05	5.21	3.70	34.39	0.17	0.48
OCEAN 24	0.11			0.05	0.03			3.50	34.41	0.14	0.24
OCEAN 25	0.11	0.15	0.26	0.05	0.05	5.19	5.29	3.50	34.41	0.13	0.51
OCEAN 26	0.13			BDL	0.05			3.70	34.40	0.22	0.47
OCEAN 27	0.13	0.13	0.26	0.03	0.26	5.46	5.75	3.70	34.40	0.17	0.24
OCEAN 28	0.13	0.14	0.27	0.05	0.05	4.87	4.97	3.50	34.41	0.15	0.37
OCEAN 29	0.13	0.14	0.27	0.05	0.42	5.51	5.98	3.50	34.40	0.24	0.59
OCEAN 30	0.13	0.16	0.29	0.05	0.23	4.88	5.16	3.70	34.37	0.16	0.46

TABLE 3. Water chemistry constituents in samples collected off the Kaanapali golf course on November 10, 11, 1990. Values in boxes exceed DOH water quality standards for 10% criteria for dry conditions. For station locations, see Figure 1.

SAMPLE NO.	PO4 (μM)	DOP (μM)	TP (μM)	NO3 (μM)	NH4 (μM)	DON (μM)	TN (μM)	Si (μM)	SALINITY (o/oo)
"BLACK ROCK"									
DRAINAGE FLUME	3.88	0.02	3.90	189.62	3.08	190.21	382.91	803.95	1.57
DRAINAGE FLUME	3.03			211.82	1.83			759.70	4.36
OCEAN 1	0.16	0.29	0.45	6.92	0.05	11.00	17.97	27.14	34.09
OCEAN 2	0.10			2.24	1.44			10.42	34.73
OCEAN 3	0.15	0.16	0.31	4.11	BDL	8.55	12.66	16.91	34.47
OCEAN 4	0.12			0.91	BDL			5.70	34.66
OCEAN 5	0.25	0.17	0.42	11.80	0.05	15.79	27.64	44.84	33.49
OCEAN 6	0.09			0.96	1.57			7.08	34.87
OCEAN 7	0.12	0.16	0.28	1.61	0.13	5.82	7.56	8.06	34.77
OCEAN 8	0.10			0.00	0.05			1.97	35.03
OCEAN 9	0.12	0.18	0.30	0.26	0.05	4.00	4.31	3.15	34.96
OCEAN 10	0.12			0.00	0.05			1.38	35.03
OCEAN 11	0.10	0.24	0.34	0.21	0.31	6.52	7.04	2.56	35.00
OCEAN 12	0.13			0.19	0.21			2.36	35.00
OCEAN 13	0.12	0.24	0.36	0.63	0.31	7.27	8.21	4.72	35.96
OCEAN 14	0.15			0.68	0.10			4.33	35.01
GOLF COURSE POND	2.36	0.24	2.60	210.07	1.07	212.40	423.54	799.03	1.90
"CANOE BEACH"									
DRAINAGE CHANNEL	0.71			0.02	0.63			50.74	31.60
OCEAN 1	0.10	0.30	0.40	1.33	1.38	8.04	10.75	7.67	34.84
OCEAN 2	0.15			0.40	BDL			3.54	34.85
OCEAN 3	0.09	0.27	0.36	1.80	0.13	8.43	10.36	8.65	34.79
OCEAN 4	0.09			0.28	0.05	9.09	9.42	3.15	34.95
OCEAN 5	0.07	0.29	0.36	1.38	2.04	7.97	11.39	7.87	34.81
OCEAN 6	0.12			0.16	0.05			2.56	34.96
OCEAN 7	0.13	0.20	0.33	1.43	1.15	7.03	9.61	8.06	34.82
OCEAN 8	0.09			0.02	1.02			1.77	34.98
OCEAN 9	0.13	0.26	0.39	1.14	0.31	11.31	12.76	7.67	34.81
OCEAN 10	0.07			0.02	3.58			2.36	34.98
OCEAN 11	0.09	0.22	0.31	1.96	4.20	6.68	12.84	9.24	34.78
OCEAN 12	0.06			0.05	0.34			1.57	34.98
OCEAN 13	0.12	0.19	0.31	1.26	0.05	7.15	8.46	6.29	34.85
OCEAN 14	0.13			0.12	0.08			3.54	34.98
OCEAN 15	0.10	0.26	0.36	1.94	0.50	6.45	8.89	8.85	34.78
OCEAN 16	0.12			1.66	0.23			7.67	34.82
OCEAN 17	0.15	0.03	0.18	1.73	0.13	9.79	11.65	7.87	34.80
OCEAN 18	0.13			4.70	0.31			18.88	34.44
OCEAN 19	0.15			4.14	0.47			17.90	34.50

TABLE 3. Water chemistry constituents in samples collected off the Kaanapali golf course on November 10, 11, 1990. Values in boxes exceed DOH water quality standards for 10% criteria for dry conditions. For station locations, see Figure 1.

SAMPLE NO.	PO4 (μM)	DOP (μM)	TP (μM)	NO3 (μM)	NH4 (μM)	DON (μM)	TN (μM)	Si (μM)	SALINITY (o/oo)
"BLACK ROCK"									
DRAINAGE FLUME	3.88	0.02	3.90	189.62	3.08	190.21	382.91	803.95	1.57
DRAINAGE FLUME	3.03			211.82	1.83			759.70	4.36
OCEAN 1	0.16	0.29	0.45	6.92	0.05	11.00	17.97	27.14	34.09
OCEAN 2	0.10			2.24	1.44			10.42	34.73
OCEAN 3	0.15	0.16	0.31	4.11	BDL	8.55	12.66	16.91	34.47
OCEAN 4	0.12			0.91	BDL			5.70	34.66
OCEAN 5	0.25	0.17	0.42	11.80	0.05	15.79	27.64	44.84	33.49
OCEAN 6	0.09			0.96	1.57			7.08	34.87
OCEAN 7	0.12	0.16	0.28	1.61	0.13	5.82	7.56	8.06	34.77
OCEAN 8	0.10			0.00	0.05			1.97	35.03
OCEAN 9	0.12	0.18	0.30	0.26	0.05	4.00	4.31	3.15	34.96
OCEAN 10	0.12			0.00	0.05			1.38	35.03
OCEAN 11	0.10	0.24	0.34	0.21	0.31	6.52	7.04	2.58	35.00
OCEAN 12	0.13			0.19	0.21			2.38	35.00
OCEAN 13	0.12	0.24	0.36	0.63	0.31	7.27	8.21	4.72	35.96
OCEAN 14	0.15			0.68	0.10			4.33	35.01
GOLF COURSE POND	2.36	0.24	2.60	210.07	1.07	212.40	423.54	799.03	1.90
"CANOE BEACH"									
DRAINAGE CHANNEL	0.71			0.02	0.63			50.74	31.60
OCEAN 1	0.10	0.30	0.40	1.33	1.38	8.04	10.75	7.67	34.84
OCEAN 2	0.15			0.40	BDL			3.54	34.85
OCEAN 3	0.09	0.27	0.36	1.80	0.13	8.43	10.36	8.65	34.79
OCEAN 4	0.09			0.28	0.05	9.09	9.42	3.15	34.95
OCEAN 5	0.07	0.29	0.36	1.38	2.04	7.97	11.39	7.87	34.81
OCEAN 6	0.12			0.16	0.05			2.56	34.96
OCEAN 7	0.13	0.20	0.33	1.43	1.15	7.03	9.61	8.06	34.82
OCEAN 8	0.09			0.02	1.02			1.77	34.98
OCEAN 9	0.13	0.26	0.39	1.14	0.31	11.31	12.76	7.67	34.81
OCEAN 10	0.07			0.02	3.58			2.36	34.98
OCEAN 11	0.09	0.22	0.31	1.96	4.20	6.68	12.84	9.24	34.78
OCEAN 12	0.06			0.05	0.34			1.57	34.98
OCEAN 13	0.12	0.19	0.31	1.26	0.05	7.15	8.46	6.29	34.85
OCEAN 14	0.13			0.12	0.08			3.54	34.98
OCEAN 15	0.10	0.26	0.36	1.94	0.50	6.45	8.89	8.85	34.78
OCEAN 16	0.12			1.66	0.23			7.67	34.82
OCEAN 17	0.15	0.03	0.18	1.73	0.13	9.79	11.65	7.87	34.80
OCEAN 18	0.13			4.70	0.31			18.88	34.44
OCEAN 19	0.15			4.14	0.47			17.90	34.50

TABLE 3. CONTINUED.

SAMPLE NO.	PO4 (μM)	DOP (μM)	TP (μM)	NO3 (μM)	NH4 (μM)	DON (μM)	TN (μM)	Si (μM)	SALINITY (o/oo)
"SEWAGE PLANT"									
DRAINAGE CHANNEL	0.12	0.46	0.58	0.93	1.10	21.12	23.15	153.98	25.20
OCEAN 1	0.12			BDL	0.44			3.74	35.00
OCEAN 2	0.13	0.15	0.28	0.07	0.23	6.80	7.10	2.95	35.00
OCEAN 3	0.13			0.05	0.18			2.75	35.00
OCEAN 4	0.10	0.17	0.27	0.00	0.13	5.63	5.76	3.15	34.99
OCEAN 5	0.10			0.02	0.44			3.15	34.99
OCEAN 6	0.09	0.19	0.28	0.12	0.18	6.99	7.29	3.15	34.97
OCEAN 7	0.13			0.21	0.31			2.75	34.99
OCEAN 8	0.12	0.16	0.28	0.19	0.10	5.98	6.27	3.74	34.94
OCEAN 9	0.10			0.19	0.39			2.56	34.99
OCEAN 10	0.10	0.20	0.30	0.05	0.21	6.57	6.83	3.54	34.94
OCEAN 11	0.10			0.26	0.21			2.56	34.99
OCEAN 12	0.10	0.21	0.31	0.02	0.21	6.45	6.68	3.15	34.95
OCEAN 13	0.07			0.16	0.63			2.56	34.98
OCEAN 14	0.10	0.20	0.30	0.16	0.57	6.10	6.83	5.11	34.88
OCEAN 15	0.15			0.12	0.31			4.72	34.80
OCEAN 16	0.09	0.18	0.27	BDL	0.26	5.86	6.12	3.15	34.94
OCEAN 17	0.12			BDL	0.44			3.34	34.93
OCEAN 18	0.12	0.15	0.27	BDL	0.23	6.80	7.03	3.54	34.87

TABLE 4. Metribuzin and metabolite, and chlorpyrifos analyses for sediment samples collected off Kaanapali sites in June 1990. All units are mg/kg. For sampling locations, see Figure 1.

SAMPLING LOCATION	NO.	PARENT	DA	DK	DADK	CP
BLACK ROCK	1	<0.01	<0.01	<0.01	<0.01	<0.1
	2	<0.01	<0.01	<0.01	<0.01	<0.1
	3*	<0.1	<0.1	<0.1	<0.1	<0.1
	4	<0.01	<0.01	<0.01	<0.01	<0.1
CANOE BEACH	1	<0.01	<0.01	<0.01	<0.01	<0.1
	2	<0.01	<0.01	<0.01	<0.01	<0.1
	3	<0.01	<0.01	<0.01	<0.01	<0.1
	4*	<0.1	<0.1	<0.1	<0.1	<0.1
	5	<0.01	<0.01	<0.01	<0.01	<0.1
SEWAGE PLANT	1	<0.01	<0.01	<0.01	<0.01	<0.1
	2	<0.01	<0.01	<0.01	<0.01	<0.1
	3	<0.01	<0.01	<0.01	<0.01	<0.1

* samples high in organic matter

TABLE 5. Quality control analyses for fortified sediment samples from June 1990 sampling. Units are percent recovery.

SAMPLING LOCATION	NO.	mg/kg ADDED	PARENT	DA	DK	DADK
BLACK ROCK	1	0.01	88	100	72	100
	3	0.1	100	100	100	100
CANOE BEACH	3	0.01	96	120	88	130
	4	0.1	ND	96	68	140
	5	0.1	110	120	130	130
SEWAGE PLANT	1	0.1	100	120	130	130
AVG.			99	108	92	117

TABLE 6. Metribuzin and metabolite, and chlorpyrifos analyses for sediment samples collected off Kaanapali sites in November of 1990. All units are mg/kg. For sampling locations, see Figure 1.

SAMPLING LOCATION	NO.	PARENT	DA	DK	DADK	CP
BLACK ROCK	1	<0.01	<0.01	<0.01	<0.01	<0.1
	2*	<0.1	<0.1	<0.1	<0.1	1.1
	3*	<0.1	<0.1	<0.1	<0.1	<0.1
CANOE BEACH	1	<0.1	<0.01	<0.01	<0.01	<0.1
	2*	<0.1	<0.1	<0.1	<0.1	<0.1
	3	<0.01	<0.01	<0.01	<0.01	<0.1
SEWAGE PLANT	1	<0.01	<0.01	<0.01	<0.01	<0.1
	2	<0.01	<0.01	<0.01	<0.01	<0.1
	3	<0.01	<0.01	<0.01	<0.01	<0.1

* samples high in organic matter

TABLE 7. Quality control analyses for fortified sediment samples from November 1990 sampling. Units are percent recovery.

SAMPLING LOCATION	NO.	mg/kg ADDED	PARENT	DA	DK	DADK
BLACK ROCK	2	0.1	110	110	56	110
	2	0.1	110	110	140	50
	3	0.01	80	100	56	130
	3	0.01	90	130	110	140
SEWAGE PLANT	1	0.01	ND	88	64	150
	1	0.01	ND	88	I	130
	1	0.04	100	ND	ND	ND
	1	0.04	95	ND	ND	ND
AVG.			98+12	104+16	85+38	118+36

ND = NOT ANALYZED
I = INTERFERENCE

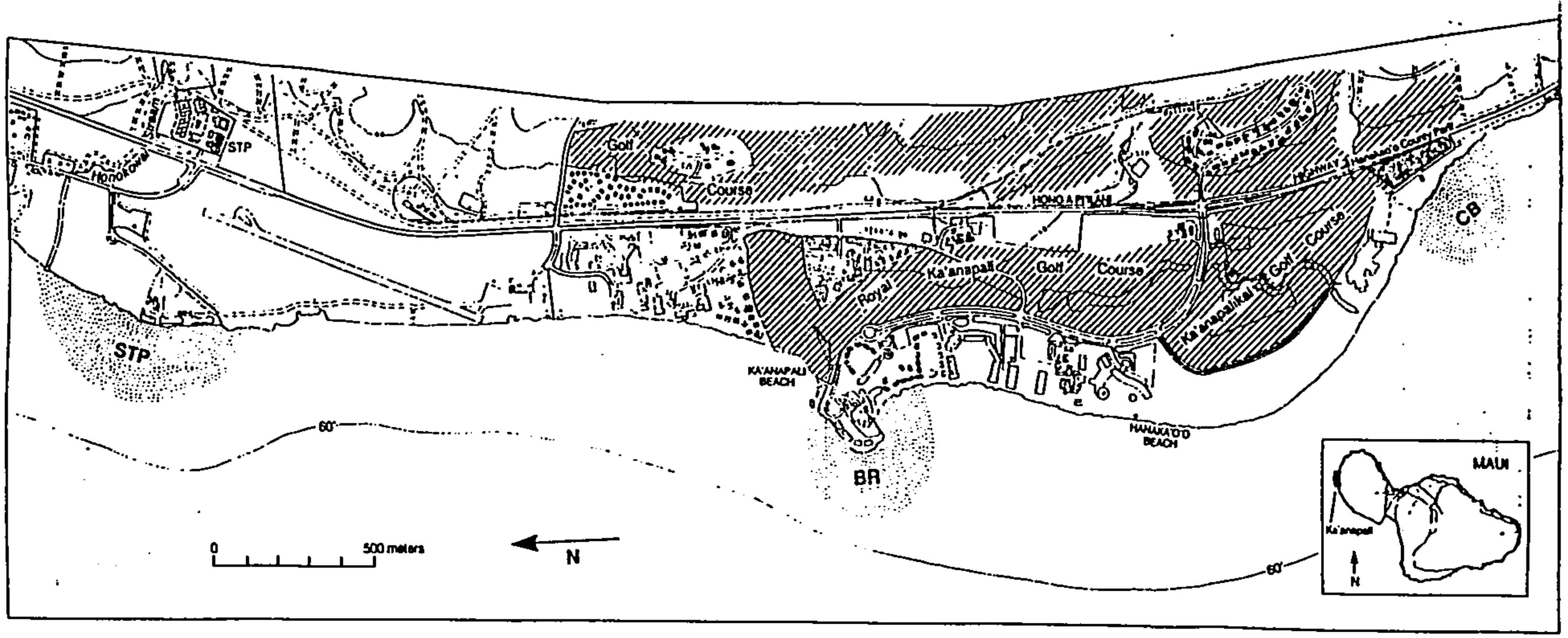

FIGURE 1. Map showing location of Kaanapali area on Island of Maui, and three sampling locations off the Kaanapali Golf Course (BR, and CB), and the Lahaina Sewage Treatment Plant (STP).

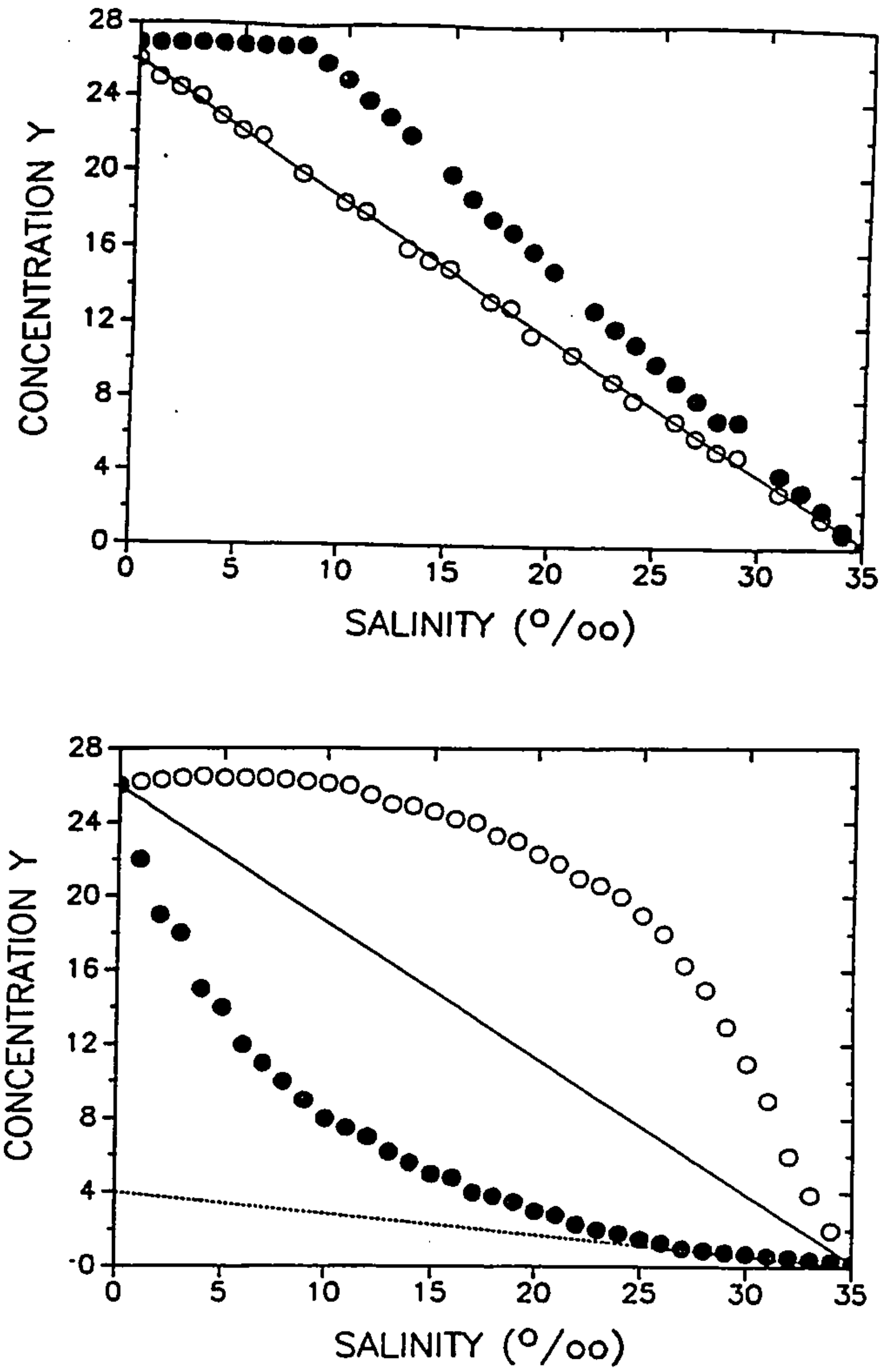

FIGURE 2. Concentration versus salinity diagrams showing several hypothetical mixing situations. Solid lines represent conservative mixing lines constructed by connecting the "endpoint" concentrations of open ocean water and uncontaminated freshwater. In top plot, open circles represent data that falls on the conservative mixing line, indicating there are no sources or sinks of material Y in the system. Solid circles occurring above the mixing line indicate a source term; the straight line distribution of the source material suggests that the material is mixed by purely physical processes. The bottom figure shows net nonconservative uptake in the system as upward concave curvature of the solid circles. Downward concavity, shown with the open circles indicates nonconservative production within the system. Quantification of the nonconservative terms is equivalent to the value between the intercept of the tangent line (dotted line) and the conservative mixing line.

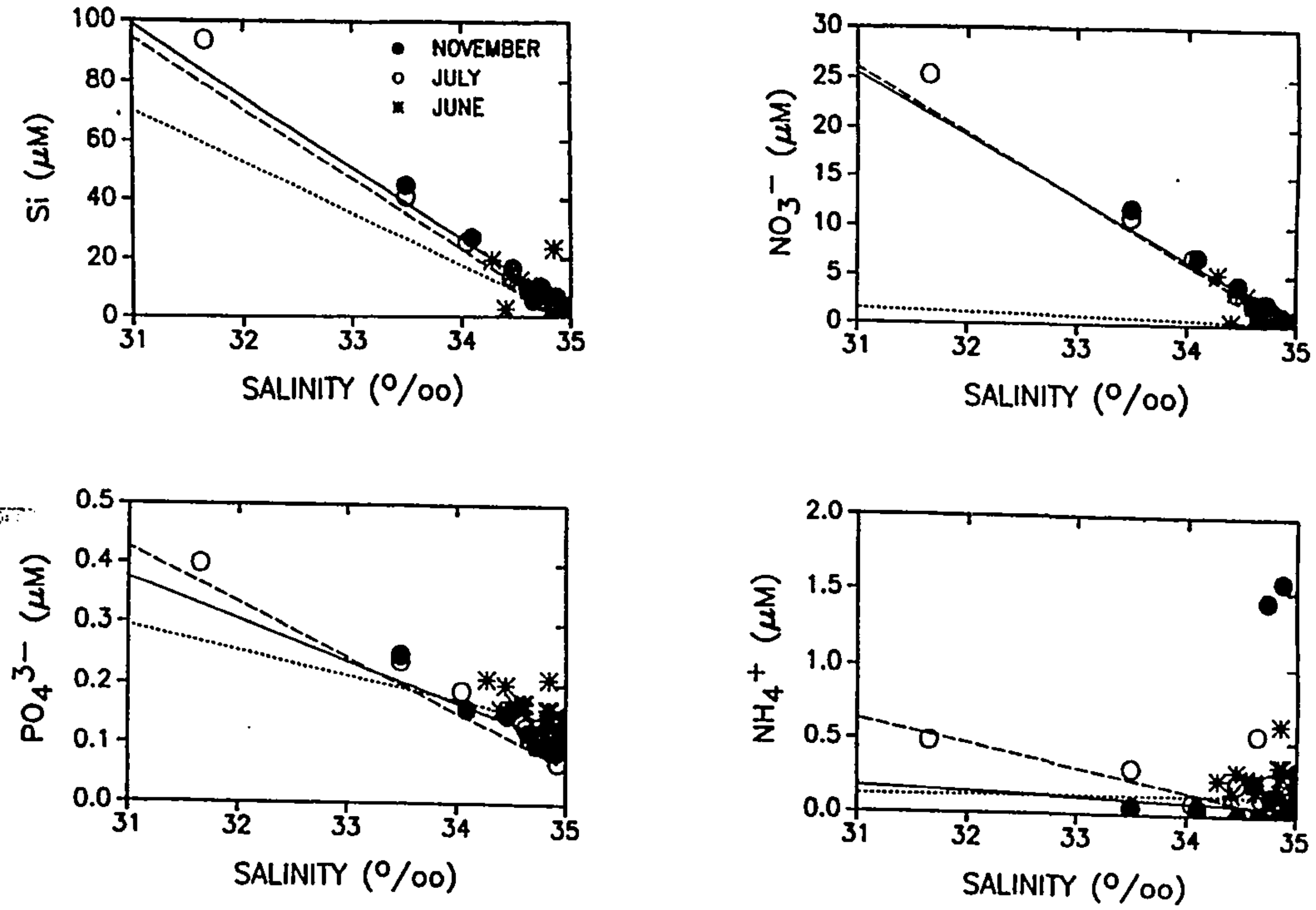

FIGURE 3. Mixing diagrams at Black Rock sampling site. Conservative mixing lines are constructed by connecting endpoint concentrations from open ocean water and golf course irrigant water collected in November (solid line), and June (dashed line), and uncontaminated groundwater (dotted line).

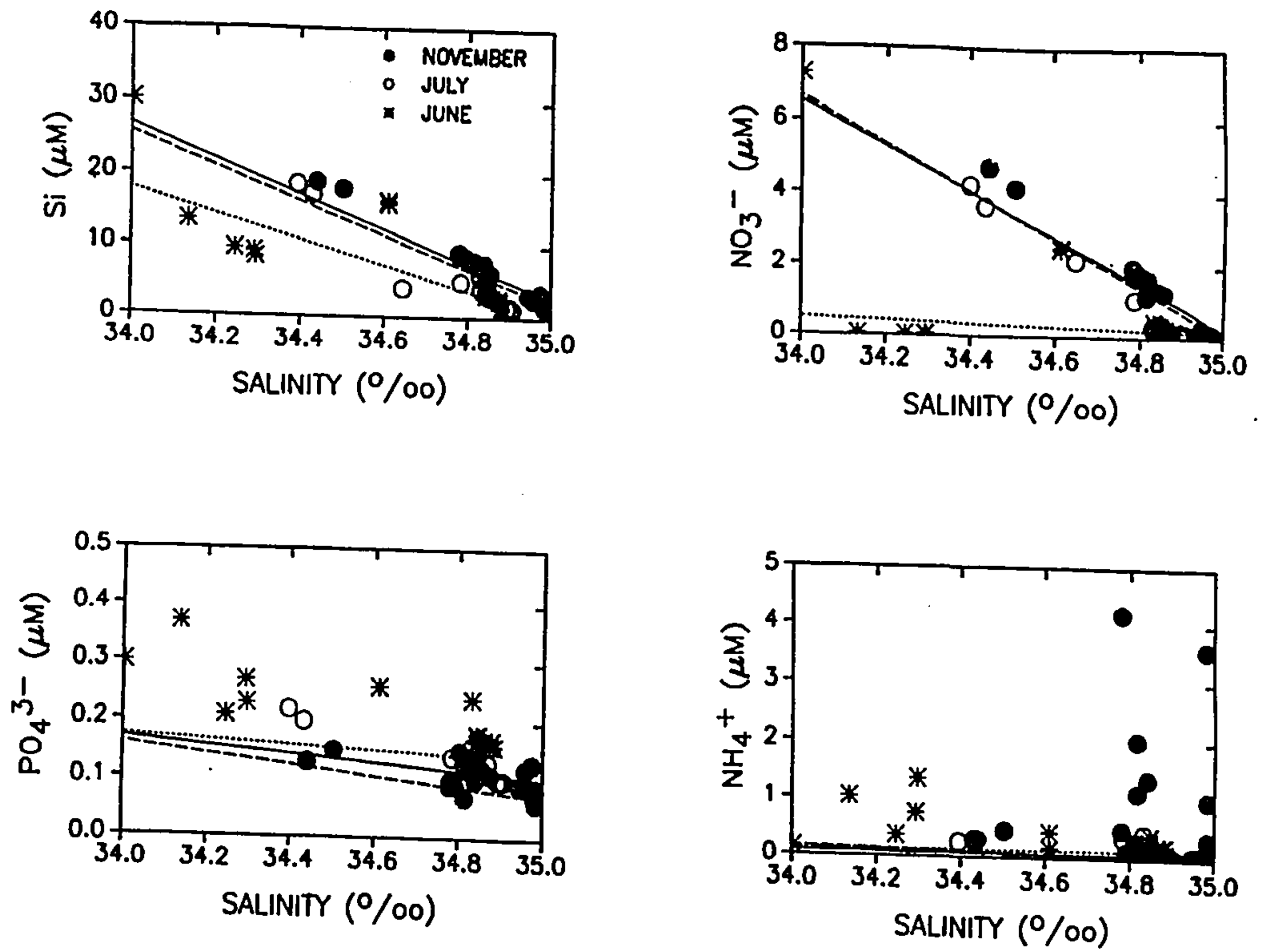

FIGURE 4. Mixing diagrams at Canoe Beach sampling site. Conservative mixing lines are constructed by connecting endpoint concentrations from open ocean water and golf course irrigant water collected in November (solid line), and June (dashed line), and uncontaminated groundwater (dotted line).

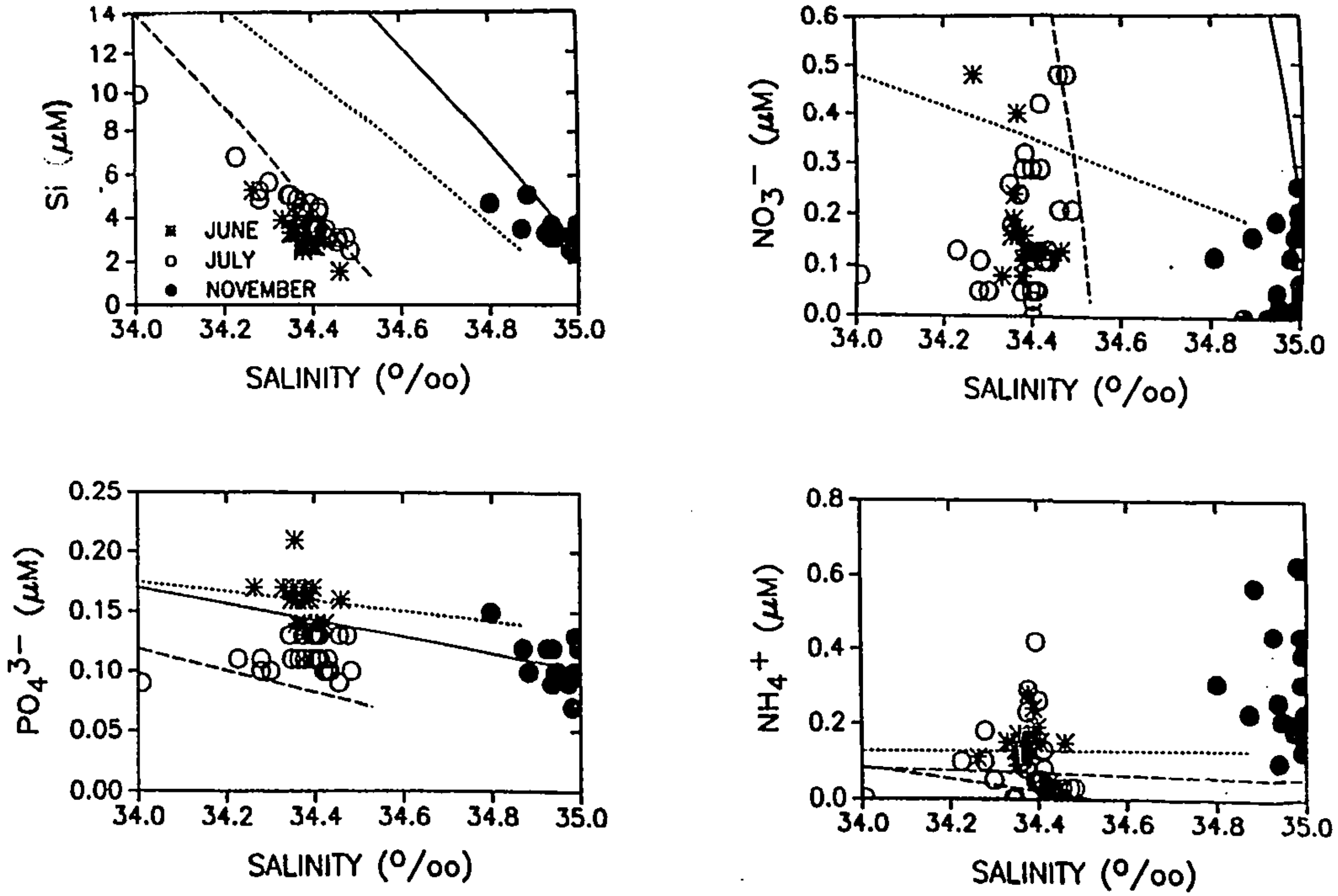

FIGURE 5. Mixing diagrams at Sewage Treatment Plant sampling site. Conservative mixing lines are constructed by connecting endpoint concentrations from open ocean water and sewage effluent water collected in November (solid line), and June (dashed line), and uncontaminated groundwater (dotted line).