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June 4, 1999

DCP 99-384

Ms. Genevieve Salmonson, Director
Office of Environmental Quality Control
State Office Tower
235 South Beretania Street, Room 702
Honolulu, Hawaii 96813

Dear Ms. Salmonson:

Subject: Finding of No Significant Impact (FONSI) for Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment
TMK: 7-3-07: 02 (Wahiawa WWTP), 7-3-07: 01 (Wahiawa Reservoir)
7-1-01: por. 8, por. 20, 21 (Wahiawa Reservoir)
Wahiawa, Oahu, Hawaii

The Department of Design and Construction has reviewed the comments received during the 30-day public comment period which began on December 8, 1998. The agency has determined that this project will not have significant environmental effects and has issued a FONSI. Please publish this notice in the June 10, 1999 Environmental Notice.

We have enclosed a completed OEQC Publication Form and four copies of the final EA. Please call Mr. Bill Liu of the Planning and Programming Division at 527-6871 if you have any questions.

Very truly yours,

for RANDALL K. FUJIKI
Director

Enclosure

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FINAL ENVIRONMENTAL ASSESSMENT

Wahiawa Wastewater Treatment Plant Modifications
and Outfall Adjustment
Wahiawa, Oahu, Hawaii

Prepared For

Department of Design and Construction
City and County of Honolulu

Prepared By

Calvin Kim and Associates, Inc.
and
Gerald Park Urban Planner

May 1999

FINAL ENVIRONMENTAL ASSESSMENT

Wahiawa Wastewater Treatment Plant Modifications
and Outfall Adjustment
Wahiawa, Oahu, Hawaii

Prepared Pursuant to Chapter 343, Hawaii Revised Statutes
and Chapter 200, Title 11, Administrative Rules
Department of Health, State of Hawaii

Proposing Agency

Department of Design and Construction
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

Responsible Official: ____________ Date: 6·4·99
FOR Randall K. Fujiki, AIA
Director

Prepared for

Department of Design and Construction
City and County of Honolulu

Prepared By

Calvin Kim and Associates, Inc.
and
Gerald Park Urban Planner

EXECUTIVE SUMMARY

Project:	Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment
Proposing Agency:	Department of Design and Construction City and County of Honolulu 650 South King Street, 2nd Floor Honolulu, Hawaii 96813
Accepting Authority:	*Department of Design and Construction for* Mayor, City and County of Honolulu
Project Location:	Wahiawa, Oahu, Hawaii
Tax Map Key:	
Wahiawa WWTP	7-3-07: 02
Wahiawa Reservoir	7-3-07: 01, 7-1-01: por. 8, por. 20, 21
Contact Person:	Bill Liu Division of Planning and Programming Department of Design and Construction City and County of Honolulu 650 South King Street Honolulu, Hawaii 96813 Phone: 527-6871

The City and County of Honolulu proposes to modify wastewater treatment facilities at the Wahiawa Wastewater Treatment Plant located in Wahiawa, Oahu, Hawaii. The plant treats domestic wastewater collected within the town of Wahiawa and Whitmore Village. The plant provides secondary treatment with an activated sludge process designed for an average dry weather flow of 2.5 mgd. The average daily flow for the past several months has ranged between 1.9 to 2.0 mgd.

Since its construction in 1928, the Wahiawa WWTP has discharged treated wastewater into Wahiawa Reservoir. The discharge is permitted by a National Pollutant Discharge Elimination System permit issued by the State Department of Health to the Department of Public Works (currently the Department of Environmental Services), City and County of Honolulu. A non-renewable NPDES permit and authorization to discharge expired at midnight March 1, 1994. Since that time, the City and County of Honolulu has continued to discharge secondary treated and disinfected effluent into Wahiawa Reservoir.

Because of water quality problems in the reservoir, manifested primarily by fish kills, there is a strong desire on the part of the State Department of Health to improve the quality of water in the reservoir.

In March 1998, the City and County of Honolulu and the State of Hawaii signed a Consent Decree. The objectives of which are "to provide a long-term reliable solution for effluent disposal from the Wahiawa Wastewater Treatment Plant, to improve reservoir water quality, and to promote resource conservation through wastewater reclamation". To comply with the Consent Decree, both parties have agreed: 1) the City shall construct and complete modification to the Wahiawa WWTP within 3 years of signing of the Consent Decree; 2) the modifications shall produce R-1 water; 3) the City shall reclaim all the wastewater from the Wahiawa Wastewater Treatment Plant, now about 2.0 mgd; 4) effluent shall be discharged through a deep outfall into Wahiawa Reservoir; and 5) the City shall monitor water quality for a period of up to one year after implementation of the treatment plant upgrades.

The City proposes to add filtration units and to modify the existing disinfection unit process to produce R-1 water. In addition, modifications to existing treatment facilities are proposed to produce a high-quality secondary effluent for delivery to the filtration units. The modifications include:

- Modifying the existing aeration tanks to provide an anoxic zone for operation in a nitrification-denitrification mode.
- Replacing two existing secondary clarifiers with two new 55-foot diameter secondary clarifiers.
- Replacing the existing secondary effluent pumping station with a new secondary effluent pumping station.
- Combining primary and waste activated sludge thickening in dissolved air flotation thickeners.

The consulting engineers have recommended constructing an Operations Building in the northeast portion of the plant site. A two-story building of approximately 2,600 square feet is proposed with space for three offices, a conference room, men's and women's locker rooms, lunch room, and a SCADA room.

The proposed project confines modifications to existing treatment facilities to the Wahiawa Wastewater Treatment Plant site and developed areas on-site where the natural environment has been altered by man. Short-term construction impacts would temporarily affect air quality, noise, and traffic. Negligible impacts are anticipated on land use, fish assemblages in the reservoir, and public utilities.

R-1 water will be discharged into Wahiawa Reservoir through a proposed 24" outfall approximately 340 feet in length. Installing the outfall in the reservoir will not adversely affect underwater terrain except at the diffuser end of the outfall. The end of the outfall will be supported on piles and elevated above the bottom of the reservoir. Piles will be driven and acoustical impacts can be expected for about two weeks. Most of the outfall will be laid atop the sloping bank to minimize ground disturbance to the underwater landform. Underwater "fences or curtains" may be used to keep aquatic animals away from the work site.

Significant long-term adverse impacts on the treatment plant and its unit processes are not anticipated. Both filtration and disinfection units can be accommodated on the plant site with no significant change in plant related noise and odor. The R-1 water to be produced by the Wahiawa WWTP is the highest quality of reclaimed water prescribed by State of Hawaii Department of Health reclamation guidelines. Modeling of effluent diversion to a deep water discharge (rather than surface discharge) and analysis of the effect of R-1 water on water quality parameters indicate that water quality will improve over time with the better treatment and deep water discharge. Improvements in water quality will be most evident in the surface waters of the reservoir (since the existing surface discharge will be removed) and sediment quality of the bottom of the reservoir should improve.

The City has budgeted $10.0 million to construct the proposed project. The proposed modifications will be built in three phases. The first phase, modifying facilities at the treatment plant, is projected to commence in September, 1999 with a projected completion by March, 2001, a period of 18 months. The second phase is to adjust the existing outfall to discharge effluent deeper into the reservoir. This phase is scheduled to commence in February, 2000 with completion by March, 2001, a period of 12 months. The third phase is to construct wet weather flow facilities. A construction timetable has not been set for this project.

Pre-Assessment Consultation: All agencies, organizations, and individuals identified in Section 6 of this Environmental Assessment were consulted in the preparation of this Environmental Assessment.

Determination: The Department of Design and Construction, having reviewed the Preliminary Engineering Report, Schematic Plans for Modifications to the Wahiawa Wastewater Treatment Plant, Schematic Plans for the Adjustment to the Existing Outfall, this Environmental Assessment, and comments received during the public comment period has determined that an Environmental Impact Statement is not required and is filing a Finding of No Significant Impact for the proposed Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment project.

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SECTION 1
DESCRIPTION OF THE PROPOSED PROJECT

The City and County of Honolulu proposes to modify wastewater treatment facilities at the Wahiawa Wastewater Treatment Plant located in Wahiawa, Oahu, Hawaii (See Exhibit 1-1). The purposes of the project, as stated in a Consent Decree signed by the City and County of Honolulu and the State of Hawaii, are 1) to provide a long-term reliable solution for effluent disposal from the Wahiawa Wastewater Treatment Plant, 2) to improve reservoir water quality, and 3) to promote resource conservation through wastewater reclamation.

A. Background

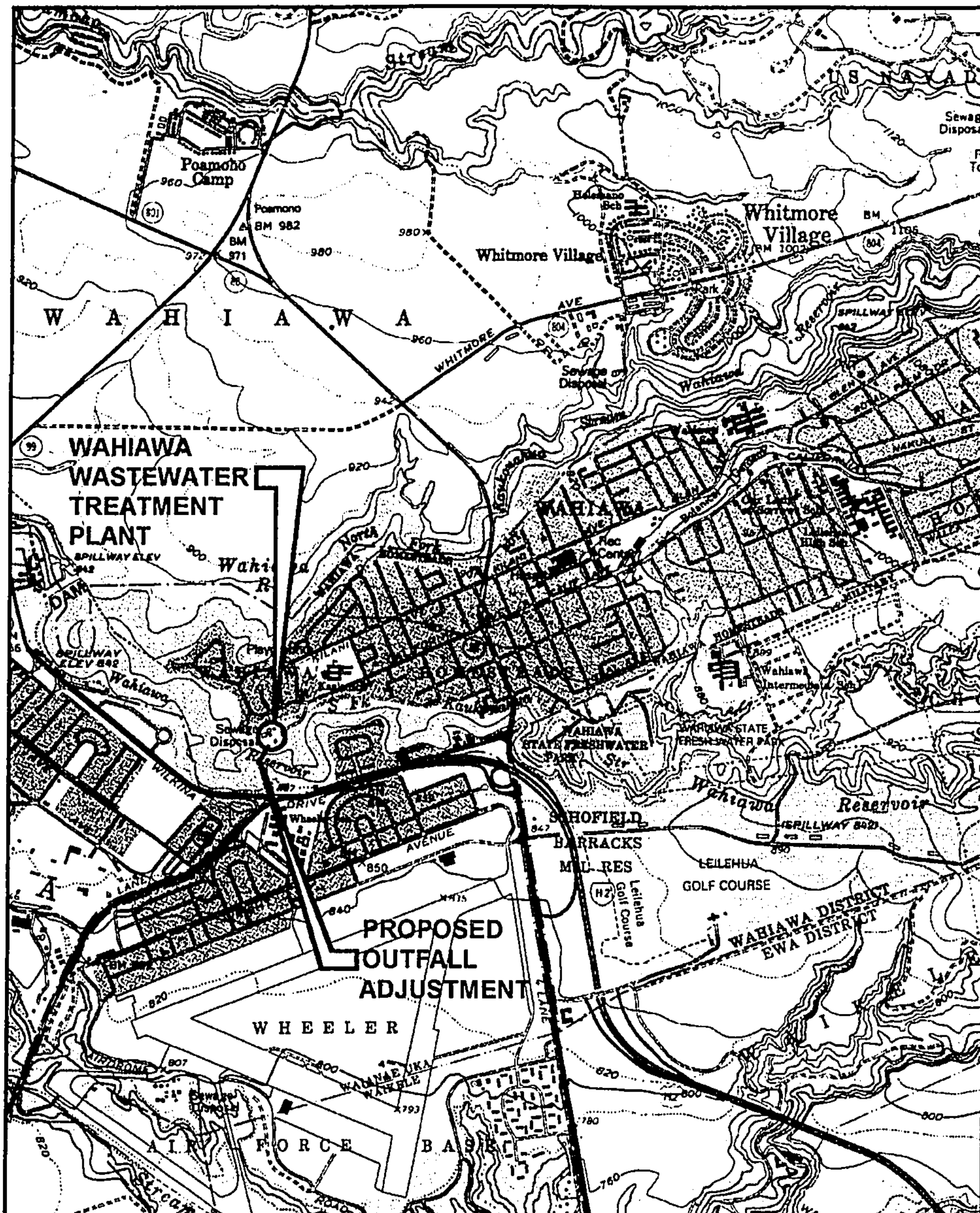
The Wahiawa Wastewater Treatment Plant ("Wahiawa WWTP") is a 2.5 million gallon per day (mgd) secondary treatment facility. Treated effluent from the plant has been discharged into the adjacent Wahiawa Reservoir, also called Lake Wilson, since the plant was constructed and placed in service in 1928.

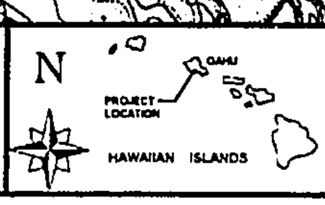
A non-renewable National Pollutant Discharge Elimination System ("NPDES") permit for the Wahiawa WWTP (Permit No. HI 0020125) was issued by the Department of Health, State of Hawaii ("DOH") to the City and County of Honolulu, Department of Public Works on April 7, 1989. The permit authorized the discharge of secondary treated domestic wastewater into Wahiawa Reservoir in accordance with effluent limitations, monitoring, and conditions made a part of the permit. The permit and authorization to discharge expired at midnight March 1, 1994. The permit also required the City and County of Honolulu ("City") to divert its effluent out of the reservoir by the permit expiration. The City currently does not have an NPDES permit to discharge treated effluent into the reservoir.

On May 20, 1994, the State of Hawaii filed a Complaint for injunctive relief and assessment of civil penalties against the City and County of Honolulu (State of Hawaii vs. City and County of Honolulu, First Circuit Court Civil No. 94-1896-05) for alleged violation of Chapter 342D, Hawaii Revised Statutes (Water Pollution).

Prior to the issuance of the non-renewable NPDES permit and following its expiration, the City had and continued to investigate feasible disposal alternatives for the Wahiawa WWTP effluent (Belt Collins, 1987; Kim, 1992; and Kim and Brown and Caldwell, 1995). In 1996, the City chose to evaluate treatment and effluent disposal alternatives through the environmental impact statement process. An Environmental Impact Statement Preparation Notice ("EISPN") entitled "Wahiawa Effluent Reuse for Central Oahu" was prepared and circulated for public review and comment pursuant to Chapter 343, HRS and Title 11, Chapter 200, Administrative Rules, Department of Health. Nine treatment and disposal alternatives were identified based on upgrading treatment levels, revising treatment processes, and /or redirecting treated effluent from the Wahiawa WWTP (the alternatives are summarized in Section 4 of this Environmental Assessment). The City planned to select a preferred alternative through the EIS process based on a comprehensive analysis of the issues and concerns relating to the project, as well as a thorough consideration of all comments received from government agencies and the general public.

At the same time the City was coordinating its efforts with the Department of the Army's effluent disposal investigation for the Schofield WWTP. In an effort to develop a joint City and U.S. Army





USGS MAP HALEIWA, HAUULA, SCHOFIELD BARRACKS & WAIPAHU QUADRANGLES Scale: 1" =2000'	WAHIAWA WWTP MODIFICATIONS AND OUTFALL ADJUSTMENT **LOCATION MAP**	**EXHIBIT** 1-1

wastewater disposal solution for Central Oahu, representatives from the City, State of Hawaii, and the U.S. Army formed the Joint Agency Wastewater Task Force ("JAWTF") in early 1994.

In 1997, the JAWTF proposed three lead alternatives for effluent disposal of Central Oahu wastewater. The alternatives were labeled: Common Reuse Reservoir, Constructed Wetlands, and Honouliuli Pipeline (also known as the Wahiawa Diversion Line).

The Wahiawa Diversion Line alternative was selected by the JAWTF Executive Committee as the preferred effluent disposal alternative. This alternative proposed converting the Wahiawa WWTP from a secondary treatment plant to a pump station and preliminary treatment facility. A 14-mile pipe line would be constructed from the Wahiawa WWTP to the Honouliuli Wastewater Treatment Plant ("Honouliuli WWTP") in Ewa. Secondary treated effluent would initially be diverted to the Honouliuli WWTP and upon completion of the preliminary treatment facility at Wahiawa, untreated wastewater would be diverted to the Honouliuli WWTP.

The U.S. Army would upgrade the Schofield WWTP to produce R-1 water and convey the effluent to the Honouliuli WWTP in a common trench containing two pipelines. The Army's flow would tie into the City's proposed R-1 distribution system or Campbell Industrial Park's reclaimed water users. The Army could also use the City's deep ocean outfall for emergency discharge.

Following the selection, the City withdrew its EISPN (1996) and began preparation of environmental documents for the diversion of effluent from the Wahiawa WWTP to the Honouliuli WWTP. Construction of the pipeline was to be jointly undertaken by the City and the U.S. Army. The City and the Army were not able to jointly negotiate an agreement to the satisfaction of both parties (Department of the Army, 1998). The City was, therefore, forced to abandon the joint solution and pursue a solution on its own.

Resolution of the lawsuit was reached between the City and the Department of Health ("DOH"), State of Hawaii in the form of a Consent Decree which was signed by representatives of the City and County of Honolulu and the State of Hawaii and filed by the Circuit Court of the First Circuit on March 2, 1998. The Consent Decree is intended to resolve all the claims alleged by the State in its Complaint (1994) against the City and provides a legal vehicle for both parties to avoid the costs and uncertainties of litigation. The objectives of the Consent Decree are "to provide a long-term reliable solution for effluent disposal from the Wahiawa Wastewater Treatment Plant, to improve reservoir water quality, and to promote resource conservation through wastewater reclamation."

The Consent Decree stipulates:

- Not later than three years after the effective date of the Consent Decree (March 2, 1998) the City shall complete construction and operation of a system to reclaim all the wastewater from the Wahiawa WWTP now about 2.0 mgd.

- Wastewater reclamation (or water reuse) may be accomplished by several methods which shall be acceptable to the Department of Health. The methods shall include but are not limited to: 1) complete diversion of effluent from the reservoir followed by treatment at facilities at locations other than at the present plant, and then applied at any location; 2) it may be accomplished by appropriate treatment at the plant, continuous discharge through a deep outfall into the reservoir, and then irrigation with reservoir water; or 3) it may be accomplished by other alternatives also acceptable to the DOH.

- The reclamation system must meet all applicable legal requirements, including, if necessary, NPDES permit requirements, water quality standards, reclaimed water guidelines, and HRS Chapter 343 (Environmental Impact Statements).

- Any treated effluent supplied for direct or indirect reuse shall meet "R-1 Water" or "R-2 Water" levels as defined in the "Guidelines for the Treatment and Use of Reclaimed Water" by the DOH Wastewater Branch and dated November 22, 1993 or shall meet the requirements of any rules that may be adopted or supersede the Guidelines. Effluent quality shall be measured at the treatment facility.

- The City shall reclaim 2.0 mgd of Wahiawa WWTP wastewater which shall be separate from the commitments of the City to reclaim water island wide under the federal consent decree in U.S.A. and State v. City and County of Honolulu, U.S.D.C. Civ. No 94-00765 DAE Order of May 15, 1995.

The Consent Decree allows the continued discharge of treated effluent into the reservoir provided effluent does not exceed the interim limits shown in Table 1-1. The City also has to achieve 85% removal of BOD and suspended solids and shall monitor Total Nitrogen, Total Phosphorus, and Fecal Coliform Bacteria at least once a week. Effluent quality shall be measured at the treatment facility.

Table 1-1. Interim Effluent Limitations

Effluent Characteristic	kg/day (lbs/day)	kg/day (lbs/day)	Units as Noted	
	Monthly Average	Weekly Average	Monthly Average	Weekly Average
Biochemical Oxygen Demand (5 day)	236 (519)	424 (935)	25 mg/l	45 mg/l
Suspended Solids	236 (519)	424 (935)	25 mg/l	45 mg/l
Fecal Coliform Bacteria	100		No. /100ml mo. geom. mean	
pH	6.0 min., 9.0 max.			
Biomonitoring Toxicity	50% survival in 100% effluent			

Source: Consent Decree, March 2, 1998. Civil No. 94-1896-05.

The City and County of Honolulu proposed and the Department of Health, State of Hawaii agreed to the following actions:

- The City shall construct and complete modifications to the Wahiawa Wastewater Treatment Plant within 3 years the of signing of the Consent Decree;

- The modifications shall produce R-1 water (as defined by Department of Health "Guidelines for the Treatment and Use of Reclaimed Water, November 22, 1993) without nutrient removal;
- The City shall reclaim all the wastewater from the Wahiawa Wastewater Treatment Plant, now about 2.0 mgd (Department of Health, 1999);
- The effluent shall be discharged through a deep outfall into Wahiawa Reservoir to be located near the treatment plant; and
- Water quality samples shall be collected at various locations in the vicinity of the outfall for a period of up to one year after implementation of the treatment plant upgrades and may terminate sooner once water quality improvements have been quantified and documented.

There are financial penalties should the City miss the deadline specified in the Consent Decree. The penalties include, in part, a $600,000 one time lump sum penalty and daily penalties beginning at $1,000 per day for the first six months of delay graduated up to $5,000 per day beginning with the 13th month of delay and thereafter.

The Consent Decree does not absolve the City from obtaining an NPDES permit. A new NPDES permit is required to operate the reclamation system. The Department of Environmental Services ("ENV") will apply for a new NPDES permit prior to completion of modifications to the treatment plant.

B. Technical Characteristics

It is becoming increasingly apparent to water resource managers that Oahu's finite potable groundwater supply may be less available in the future as demand increases. Few would dispute the contention that potable water is needed for domestic consumption primarily drinking, cooking, and bathing and that millions of gallons per day are used for conveying human waste for treatment and disposal. There is a growing public awareness that wastewater effluent is a valuable resource that with proper treatment can be reused for non-potable applications. Towards this end, the DOH has developed but not yet formally approved its "Guidelines for the Treatment and Use of Reclaimed Water". In brief, the guidelines are the blueprint for the treatment, production, transmission, and uses of reclaimed water. The guidelines define reclaimed water as "water which, as a result of treatment of domestic wastewater, is suitable for a direct beneficial use of a controlled use that would not otherwise occur (DOH, 1993)."

The objectives of the guidelines are to:

- Protect public health, avoid public nuisance;
- Prevent environmental degradation of aquifers and/or surface waters
- Delineate specific reclaimed water application with reclaimed water quality treatment;
- Facilitate reuse of wastewater in greater amounts, by more readily available knowledge of the conditions under which DOH can attest to safety of uses of reclaimed water;
- Facilitate acceleration of planning, design, permitting, and implementation of water reclamation projects.

Each of the above objectives are supported by specific recommended actions and, in some instances, advice to the DOH following expert review of current literature in the disciplines of epidemiology, microbiology, engineering, application of reclaimed water for irrigation.

Three classes of reclaimed water are defined in the guidelines and designated R-1, R-2, and R-3. By definition R-1 water is wastewater that has been oxidized, filtered, and disinfected to significantly reduce viral and bacterial pathogens (The definition and acceptable uses or R-1 water are found in Appendix A). Technically, it is the highest quality reclaimed water to be produced under State guidelines and consequently, it also has the most widespread applications for reuse. The addition of a filtration process and modifications to the existing disinfection process at the Wahiawa WWTP will allow production of reclaimed water that will comply with the DOH guidelines for producing R-1 water.

1. Filtration

Filtration is a physical process to remove small suspended solids from the effluent. Chemical coagulation typically precedes the filtration process. Chemical coagulants are added to the secondary effluent which cause colloidal and fine suspended matter to agglomerate and form sufficiently large particles that can be removed in the filtration process. The net result is that colloidal, fine suspended solids, and other material not typically removed by the secondary clarifier are removed by the filter. In addition to further reducing the amount of solids and organic material in the water, filtration also impacts the disinfection process. Microorganisms can be protected by or embedded in some of the particulate material, which is removed by the filtration process. Additional organic material and suspended solids in the water also requires a greater quantity of chemical disinfectant, since some of the chemical would be wasted combining with the organic matter and solids.

There are no existing filtration units at the Wahiawa WWTP.

Eight backwash effluent filter modules will be constructed adjacent to abandoned sludge drying beds located on the western side of the treatment plant. The modules have a total surface area of approximately 1,200 square feet. Effluent from the secondary clarifiers would be pumped to the new continuous backwash filters. The filters may be partially buried to receive pumped effluent and allow gravity flow to the disinfection channels. Hydraulically, this is an upflow filter with a deep-bed single media sand filter. The filter media is continuously cleaned by recycling the sand internally through an airlift pipe and sand wash compartment. The cleaned sand is redistributed on top of the sand bed, allowing for a continuous uninterrupted flow of filtrate and reject wash water.

2. Disinfection

Disinfection is a process where pathogenic microorganisms are inactivated, by either physical or chemical means. Two of the most common disinfection methods currently in use are chlorination, a chemical process, and ultraviolet light, a physical process. Chemical disinfection processes can leave residual or combine with other chemicals in the water to form undesirable byproducts. Residual disinfection chemicals may need to be neutralized before being discharged into the reservoir (dechlorination) so that it doesn't impact the lake biota. For this project, disinfection by ultraviolet light is proposed The disinfection process occurs instantly, there is no residual, and no toxic or harmful byproducts are formed.

Following filtration, effluent would be disinfected using ultraviolet (UV) light. One 65 foot long by 61 inch wide disinfection channel is proposed. There will be two reactors per channel with 2 banks of UV lamps per reactor. Each bank will consist of 6 modules with 6 lamps in each module. The UV lamps will operate at all times and the number of active lamps will depend on flow. The UV channel will be covered to assure operator safety.

The Wahiawa WWTP currently disinfects effluent with chlorine before discharging into the reservoir. This process will be discontinued upon completion of the new disinfection facilities, thus eliminating the risks and hazards to humans and the environment associated with chlorine.

Producing R-1 water is one of the primary objectives of the project. In addition to adding effluent filtration and upgrading the disinfection process, modifications to existing treatment facilities are proposed to produce a high-quality secondary effluent prior to filtration. These modifications are proposed to improve the treatment process and operations and will not result in any increase or expansion of system capacity. The modifications include:

- Modifying the existing aeration tanks (no enlargement or expansion) to provide an anoxic zone for operation in a nitrification-denitrification mode. This will permit production of a high-quality effluent without concerns over denitrification in the secondary clarifiers.
- Replacing two existing secondary clarifiers with two new 55-foot diameter secondary clarifiers. These would be "state of the art" clarifiers with 18-foot side water depths, inboard launders, flocculator centerwells, and appropriate sludge withdrawal mechanisms. The new clarifiers are necessary to ensure that a high-quality secondary effluent is delivered to the effluent filters.
- Replacing the existing secondary effluent pumping station with a new secondary effluent pumping station. Two fixed-speed and two variable speed pumps each with a capacity of 3.25 mgd are proposed. The fixed-speed pumps will normally be used during wet-weather conditions and a variable speed pump used during dry weather conditions. The pumping station will have a dry-weather design peak flow capacity of 6.0 mgd.
- Combining primary and waste activated sludge thickening in dissolved air flotation thickeners. Two units (one for standby) will be constructed from the two existing gravity thickeners. Sludge will continue to be hauled to the Honouliuli WWTP for further processing and disposal.

Also recommended are an Operations Building in the northeast portion of the plant site to accommodate general staff needs and operational requirements, a laboratory control building, and reconstruction of the parking area and facility roads. A two-story building of approximately 2,600 square feet is proposed with space for three offices, a conference room, men's and women's locker rooms, lunch room, and a SCADA room.

A preliminary site plan is shown in Exhibit 1-2.

3. Adjustment to Outfall

Following disinfection, effluent will be discharged into Wahiawa Reservoir. The existing outfall discharges effluent at elevation 844 feet, which is near the reservoir water surface elevation. With the outfall improvements, the discharge into the reservoir will be near the bottom of the reservoir (elevation 800 feet msl). The Consent Decree allows for "continuous discharge through a deep outfall into the reservoir." The existing surface discharge is no longer desirable.

The proposed outfall will be a 24-inch diameter pipe that extends from a new junction manhole within the treatment plant site, down the reservoir bank to the bottom of the reservoir. The pipe will be water tight except at the diffuser section. The total length of pipe from the property line is approximately 340 feet. About 220 feet of pipe will be laid on the surface of the reservoir bank below water. The pipe proposed here is a ductile iron pipe with a ball joint that prevents separation and permits a large deflection. The bottom length of outfall will be supported on piles slightly above the reservoir bottom.

Diffusers will be provided along the lower length of the outfall to disperse effluent evenly within the bottom water of the reservoir.

It is anticipated that construction of the outfall will be done in the water. Dewatering will be required during pile construction. Small cofferdams will be provided around each pile site for driving the piles. Disturbance of bottom sediments will be kept to a minimum and confined to the cofferdam. A preliminary plan and profile of the outfall is shown in Exhibit 1-3 and pipe support detail in Exhibit 1-4.

The higher quality R-1 water will have less suspended solids, less organic material, and will be disinfected to deactivate pathogenic microorganisms. The outfall will be adjusted to discharge at a greater depth in the reservoir. Based on water quality modeling of a deep outfall (R.M. Towill, 1997), the higher quality effluent, in conjunction with deeper discharge, should improve water quality in the reservoir.

4. Wet Weather Flow

When rain falls in an area served by a sewer system, wastewater flows increase, sometimes significantly. This increase in flow is called infiltration/inflow and is caused by rainfall entering the sewer, either directly such as through illegal roof drains, or indirectly, through cracks in the pipes or deteriorated pipe joints. Current peak wet-weather flows identified by the Sewer Rehabilitation and Infiltration /Inflow Minimization Plan for Oahu Report (March, 1998) are 10.27 mgd for a 2-year recurrence 6-hour duration storm and 11.38 mgd for a 5-year 6-hour storm. The existing plant does not have the capability of storing existing and projected wet-weather flow. During periods of heavy rainfall, spills can occur in the form of water backing up and overflowing the sewer system or overflows at treatment plant facilities.

To remedy this shortcoming, the city proposes a flow-equalization project to accommodate wet-weather flow rates in excess of 6.5 mgd at the Wahiawa plant. The project would include installation of new influent pumps with a capacity of 12 mgd, construction of a second primary clarifier similar in size to the existing clarifier, and flow equalization facilities.

Flow equalization facilities including a primary effluent splitter box, dry-weather and wet-weather equalization tanks, will be constructed along the northern edge of the plant grounds. The total storage volume will be approximately 1.5 mg which will permit flow rates in excess of 6.5 mgd to be stored and then treated in the 6.5 mg secondary treatment facilities when the high flow rates subside. Below ground sealed storage tanks are proposed.

C. Economic Characteristics

The City has budgeted $10.0 million to fund construction of the project.

The proposed modifications will be built in three phases. The first phase entails modifying facilities at the treatment plant as previously described and will commence after all permits are received. Construction is projected to commence in June, 1999 with a projected completion by March, 2001, a period of 21 months.

The second phase is to adjust the existing outfall to discharge effluent deeper into the reservoir. This phase is scheduled to commence in February, 2000 (after start up of modifications to the WWTP) with completion by March, 2001, a period of 12 months. Work on the outfall will commence after water use and building permits are secured.

The third phase is to construct wet weather flow facilities. A construction timetable has not been set for this project.

At this time, the proposed modifications represent the only viable alternative to meet the time limit specified in the Consent Decree. Water quality monitoring following completion of the project will quantify improvement to water quality in the reservoir.

D. Social Characteristics

The proposed project will not displace any recreational activity occurring in the reservoir or residential use adjacent to the treatment plant.

E. Land Tenure

The Wahiawa Wastewater Treatment Plant is located on land owned by the City and County of Honolulu. The proposed new outfall will be located on land owned by the Wahiawa Water Company. The City will request an easement on which to locate the deep outfall from the owner (Dole Food Company Hawaii, 1999). The area of the easement is estimated at 10,350 square feet.

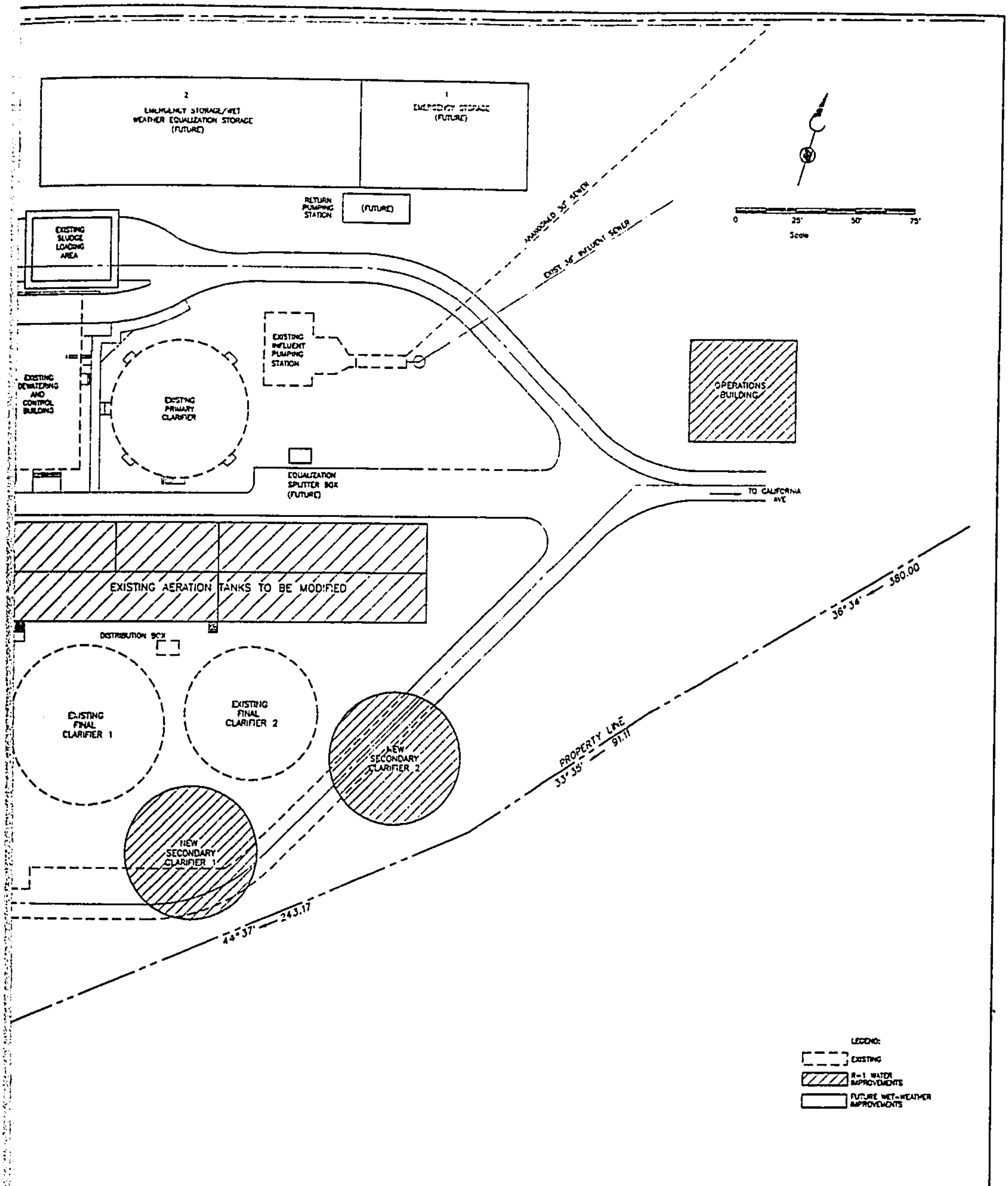
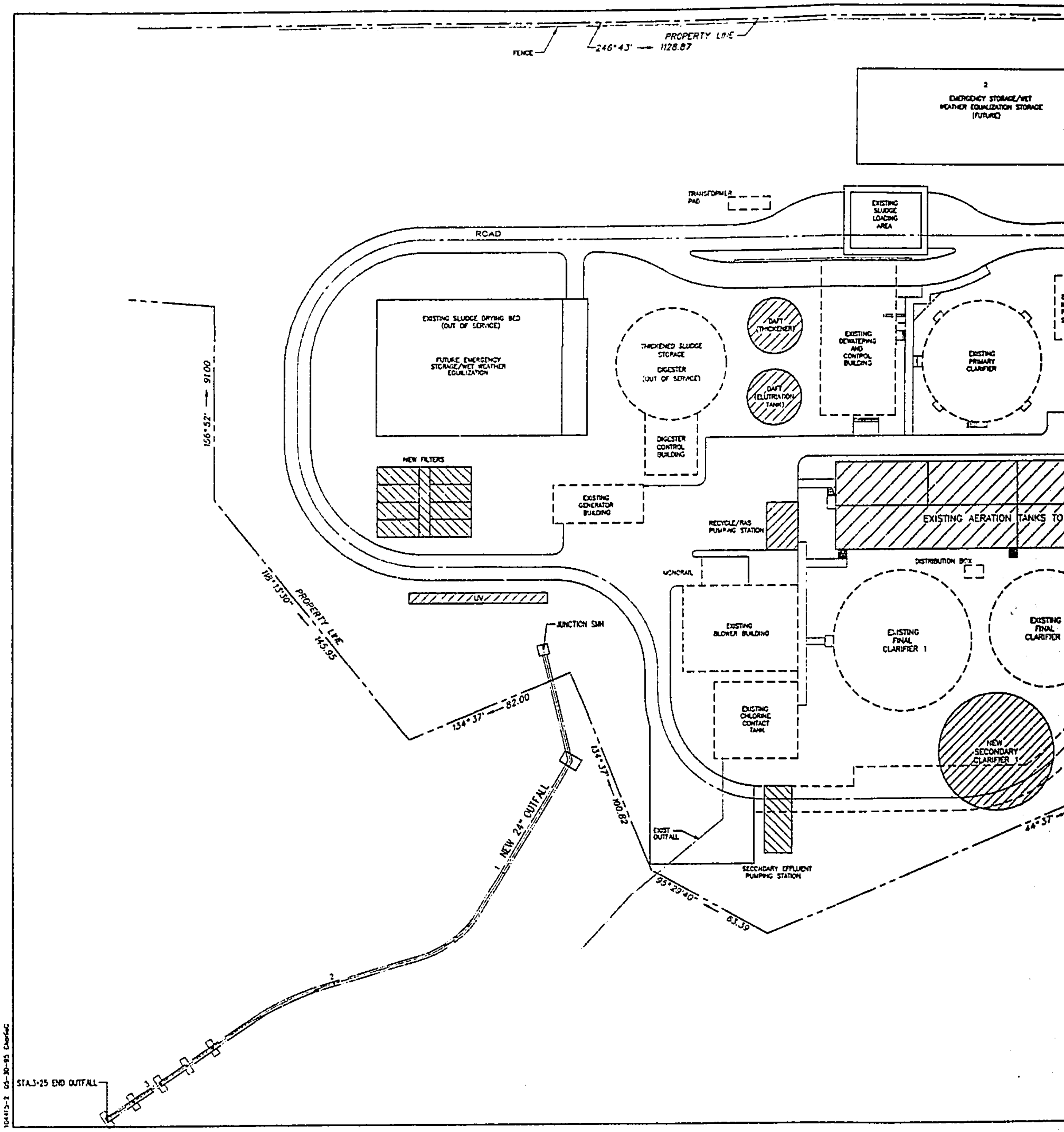
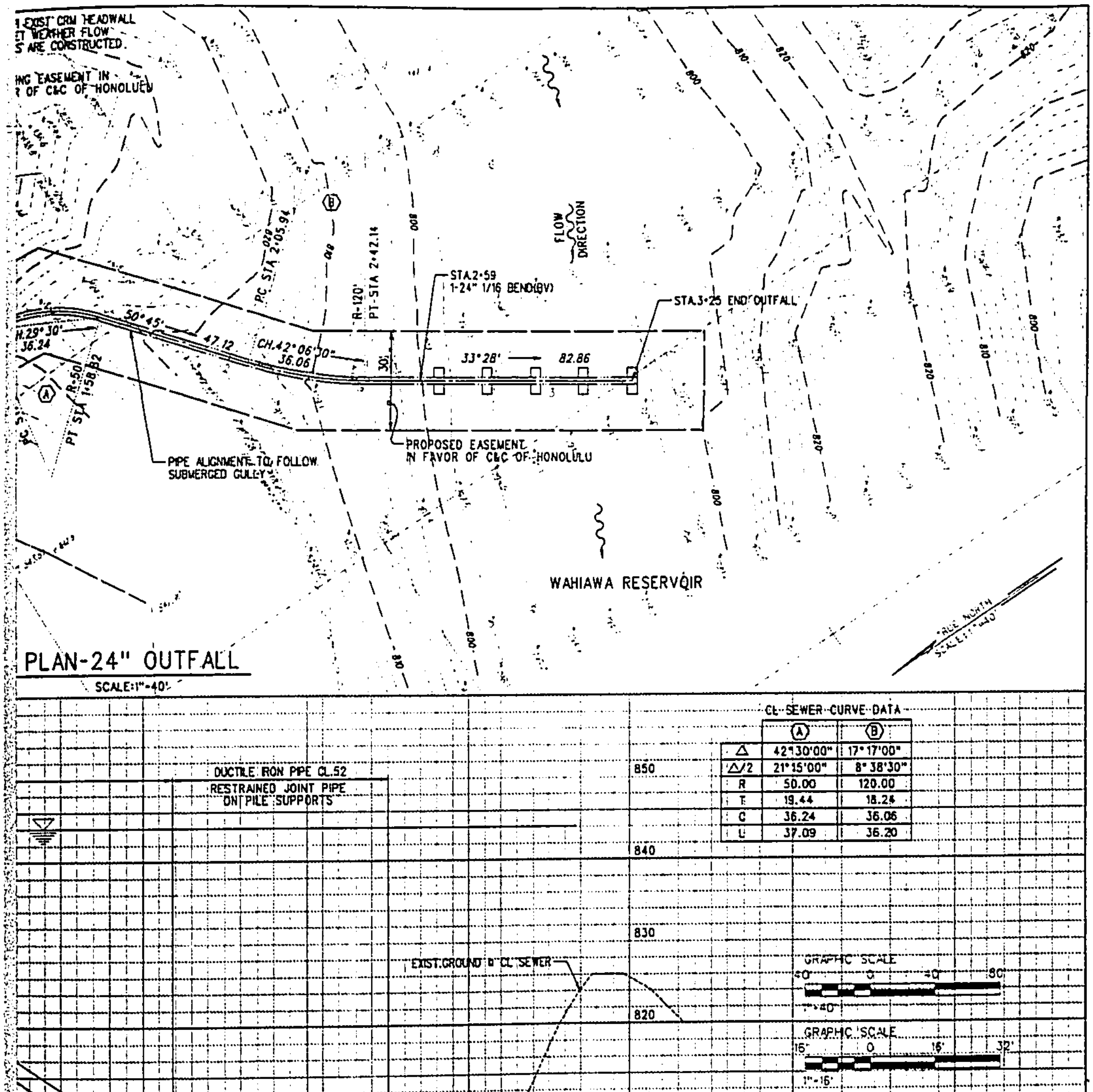
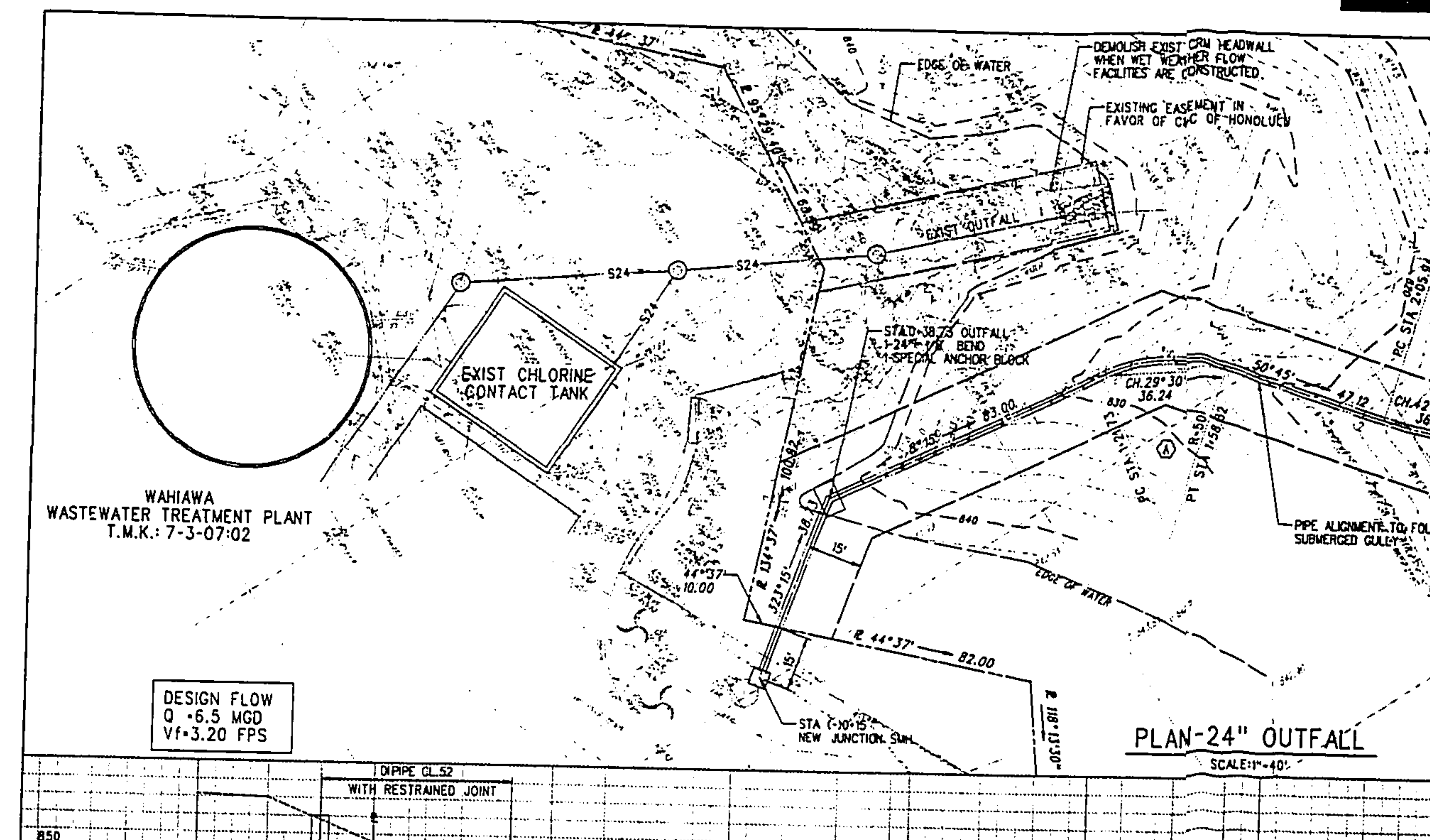


EXHIBIT 1-2
WAHIAWA WWTP SITE PLAN

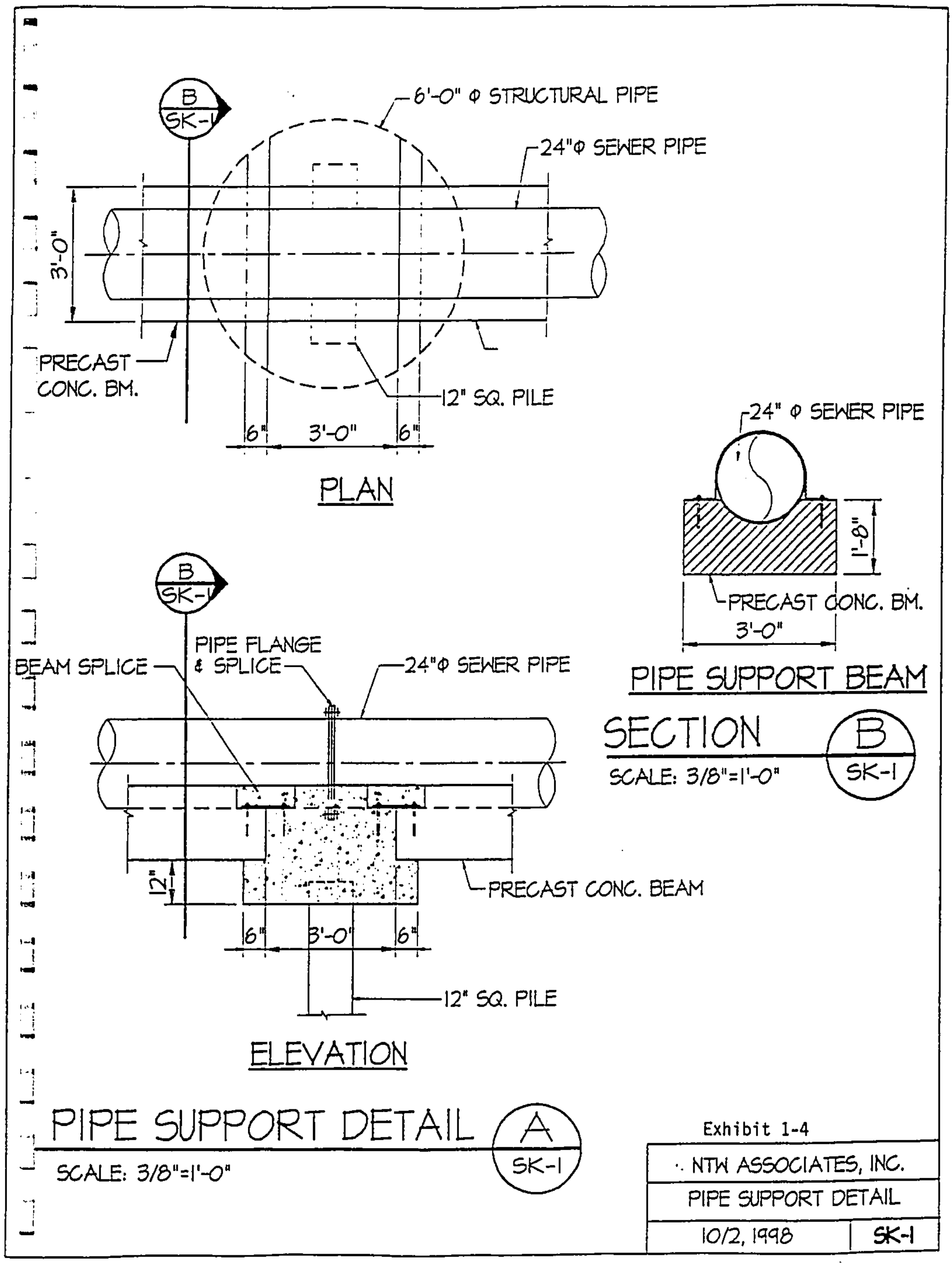

FENCE
PROPERTY LINE
246°43' — 1128.87
2
EMERGENCY STORAGE/WET WEATHER EQUALIZATION STORAGE (FUTURE)
TRANSFORMER PAD
EXISTING SLUDGE LOADING AREA
ROAD
EXISTING SLUDGE DRYING BED (OUT OF SERVICE)
FUTURE EMERGENCY STORAGE/WET WEATHER EQUALIZATION
THICKENED SLUDGE STORAGE
DIGESTER (OUT OF SERVICE)
DAFT (THICKENER)
DAFT (ELUTRIATION TANK)
EXISTING DEWATERING AND CONTROL BUILDING
EXISTING PRIMARY CLARIFIER
156°52' — 91.00
DIGESTER CONTROL BUILDING
NEW FILTERS
EXISTING GENERATOR BUILDING
RECYCLE/RAS PUMPING STATION
EXISTING AERATION TANKS TO
DISTRIBUTION BOX
MONORAIL
UV
118°13'30" — 145.95
PROPERTY LINE
JUNCTION SMH
EXISTING BLOWER BUILDING
EXISTING FINAL CLARIFIER 1
EXISTING FINAL CLARIFIER
134°37' — 82.00
EXISTING CHLORINE CONTACT TANK
NEW SECONDARY CLARIFIER
134°37' — 100.82
NEW 24" OUTFALL
EXIST OUTFALL
SECONDARY EFFLUENT PUMPING STATION
44°37'
95°23'40" — 63.39
STA.3+25 END OUTFALL
104115-2 05-30-95



EXIST. CRM HEADWALL
WEATHER FLOW
ARE CONSTRUCTED.
EASEMENT IN
OF C&C OF HONOLULU
PC STA 2+05.94
R-120'
PT STA 2+42.14
STA.2+59
1-24" 1/16 BEND(BV)
FLOW DIRECTION
STA.3+25 END OUTFALL
50°45'
47.12
CH.42°06'30"
36.06
33°28'
82.86
N.29°30'
36.24
R-50'
PT STA 1+58.82
PIPE ALIGNMENT TO FOLLOW SUBMERGED GULLY
PROPOSED EASEMENT IN FAVOR OF C&C OF HONOLULU
WAHIAWA RESERVOIR
TRUE NORTH
PLAN-24" OUTFALL
SCALE:1"=40'
CL SEWER CURVE DATA
	(A)	(B)
Δ	42°30'00"	17°17'00"
Δ/2	21°15'00"	8°38'30"
R	50.00	120.00
T	19.44	18.24
C	36.24	36.06
L	37.09	36.20
DUCTILE IRON PIPE CL.52
RESTRAINED JOINT PIPE
ON PILE SUPPORTS
850
840
830
820
810
800
790
EXIST. GROUND @ CL SEWER
GRAPHIC SCALE
40 0 40 80
1"=40'
GRAPHIC SCALE
16 0 16 32
1"=16'
PIPE SUPPORTS
DIFFUSERS
STA.2+59
STA.3+25
800.00
1-24" 1/16 BEND(BV)
800.00
2+50
3+00
3+50
4+00
DEPARTMENT OF DESIGN AND CONSTRUCTION
CITY AND COUNTY OF HONOLULU
WAHIAWA WASTEWATER TREATMENT PLANT
IMPROVEMENTS AND OUTFALL ADJUSTMENT
PLAN AND PROFILE
24" OUTFALL
CALVIN KIM & ASSOCIATES, INC.
EXHIBIT 1-3



DEMOLISH EXIST CRM HEADWALL WHEN WET WEATHER FLOW FACILITIES ARE CONSTRUCTED
EDGE OF WATER
EXISTING EASEMENT IN FAVOR OF C&C OF HONOLULU
EXIST OUTFALL
EXIST CHLORINE CONTACT TANK
STA 0+38.73 OUTFALL 1-24" 1/8 BEND 1-SPECIAL ANCHOR BLOCK
WAHIAWA
WASTEWATER TREATMENT PLANT
T.M.K.: 7-3-07:02
PIPE ALIGNMENT TO FOLL SUBMERGED GULLY
DESIGN FLOW
Q =6.5 MGD
Vf=3.20 FPS
STA (-)0+15 NEW JUNCTION SMH
PLAN-24" OUTFALL
SCALE:1"=40'
DIPIPE CL.52
WITH RESTRAINED JOINT
DUCTILE IRON RIVER CROSSING PIPE CL.60
LAID ON EXISTING GROUND
APPROX. WATER SURFACE ELEV
STA (-)0+15
NEW JUNCTION SMH
INV. 844.00
ANCHOR BLOCK
STA 0+38.73
843.00
1-24" 1/8 BEND
PIPE FOLLOWS EXIST GROUND
PIPE SUPPORTS
STA 2+59
800.00
1-24" 1/16 BEND(BV)
PROFILE-24" OUTFALL
SCALE:HORIZ. 1"=40'
VERT. 1"=16'
850
840
830
820
810
800
790
0+00
0+50
1+00
1+50
2+00
2+50
3+00


6'-0" Φ STRUCTURAL PIPE
24"Φ SEWER PIPE
B
SK-1
3'-0"
PRECAST CONC. BM.
12" SQ. PILE
6"
3'-0"
6"
PLAN
24" Φ SEWER PIPE
1'-8"
PRECAST CONC. BM.
3'-0"
PIPE SUPPORT BEAM
SECTION
B
SK-1
SCALE: 3/8"=1'-0"
BEAM SPLICE
PIPE FLANGE & SPLICE
24"Φ SEWER PIPE
12"
PRECAST CONC. BEAM
6"
3'-0"
6"
12" SQ. PILE
ELEVATION
PIPE SUPPORT DETAIL
A
SK-1
SCALE: 3/8"=1'-0"
Exhibit 1-4
NTW ASSOCIATES, INC.
PIPE SUPPORT DETAIL
10/2, 1998
SK-1

SECTION 2
DESCRIPTION OF THE AFFECTED ENVIRONMENT

The Wahiawa WWTP site and Wahiawa Reservoir are the affected environment for the proposed action. Both areas are described and discussed in subsequent sections of this Environmental Assessment.

The terms "Wahiawa Reservoir" and "Lake Wilson" are both used to describe the same body of water. Wahiawa Reservoir or Reservoir generally will be used in this Assessment.

A. Wahiawa Wastewater Treatment Plant Site

The town of Wahiawa is situated on the "saddle" created by overlapping lava flows from the Waianae and Koolau volcanoes. The Schofield Plateau, or saddle, is bordered by the Waianae Mountains to the west, the Koolau Mountains to the east, the Waialua Plain to the north, and the Ewa and Pearl Harbor Plains to the south (See Figure 1-1).

The elevation of the town varies from 850 feet in lower Wahiawa to about 1,250 feet at the upper sections of the town (Wahiawa Heights). Wahiawa features an appealing climate—the mean temperature averages 72 degrees Fahrenheit, annual rainfall averages 44.7 inches, and cool light tradewinds (generally less than 10 knots) prevail most of the year (Lau, 1977).

Encircled by Wahiawa Reservoir, the town extends linearly in an east-west direction. Schofield Barracks Military Reservation and Wheeler Army Air Base to the south and the plantation villages of Poamoho and Whitmore to the north are located just outside Wahiawa. Mililani Town, a large suburban residential community, and Waipio Acres, a small established residential subdivision, are located approximately 2.5 miles to the south of town.

The Wahiawa WWTP is located in lower Wahiawa Town off California Avenue. The plant site is bordered by Wahiawa Reservoir to the south and west, the City and County of Honolulu Wahiawa Corporation Yard, and residential dwellings to the north. Olive United Methodist Church, a small residential cul-de-sac, and Kaala Elementary School are located opposite the entrance to the plant.

The plant is located on a 6.1 acre parcel comprising a portion of Tax Map Key: 7-3-07: 02. The parcel is owned by the City and County of Honolulu.

1. Existing Treatment Facilities and Process

Constructed in 1928, the Wahiawa WWTP was the first major treatment facility to be built on the island of Oahu (Department of Public Works, 1966). The plant was expanded in 1956 to increase treatment capacity to 1.0 mgd and again in 1967 to its present configuration and capacity. The Wahiawa WWTP treats domestic wastewater generated within Wahiawa and nearby Whitmore Village. The City originally operated a separate treatment plant at Whitmore Village but began diverting all its wastewater (approximately 0.2 to 0.3 mgd) to the Wahiawa WWTP in 1994. The Whitmore Village flow includes 0.12 mgd from Naval Computer and Telecommunications System Eastern Pacific ("NCTAMS") located about one mile east of Whitmore Village.

The plant is an activated sludge secondary treatment facility with a design average dry weather flow of 2.5 mgd. The average flow for the past several months has ranged between 1.9 to 2.0 mgd.

Wastewater entering the plant is given preliminary treatment through the use of comminutors. Primary sedimentation is provided in a 50-foot diameter, 10-foot deep circular sedimentation tank. Primary effluent flows to a four-compartment aeration tank with floor mounted fine bubble diffusers.

The aeration tanks were originally designed as a step-aeration system with primary effluent added at the entrance of each of the four compartments. However, the system is currently operated in the plug-flow mode with the first tank out of service and used as a flow equalization facility. All the primary effluent plus the return activated sludge is added at the entrance of the second compartment.

Two secondary sedimentation tanks, one 50-foot diameter and one 60-foot diameter, receive the mixed liquor from the aeration tank. The two tanks are 8 feet deep which is shallower than most standard clarifiers.

From the secondary clarifiers, the effluent flows thorough a chlorine contact tank where it is disinfected then discharged into Wahiawa Reservoir through a 24-inch diameter outfall. Located to the south of and outside the boundaries of the treatment plant, the discharge end of the outfall is encased in concrete and surrounded by a protective chain link fence. The outfall invert is set at elevation 844 feet mean sea level (msl) and oftentimes it is exposed during periods of low water and effluent can be seen and heard tumbling down the rip-rap lined bank.

The outfall is located in a 1,790 square foot perpetual easement agreement between the City and County of Honolulu and The Wahiawa Water Company, Inc., part-owners of Wahiawa Reservoir. The agreement, which was signed in 1929, allows the Wahiawa WWTP to discharge undiluted effluent directly into Wahiawa Reservoir (Dole Food Company Hawaii, Consultation Letter, 1998).

Solids handling facilities include only a gravity thickener. The thickened primary waste and waste activated sludge are hauled by truck to the Honouliuli WWTP for further treatment and disposal. Currently, 4 to 5 loads of sludge are transported daily to the Honouliuli WWTP (Department of Environmental Services).

The plant is operated and maintained by the Department of Environmental Services ("ENV") Division of Treatment and Disposal. Plant staff consists of 1 supervisor, 5 operators, 2 drivers, and 1 laborer. The plant operates two shifts per day, 7 days a week. The plant is unstaffed between midnight to 7 am.

2. Topography

The plant grounds are relatively flat with no significant grade changes. The property has been graded with a north to south slope in the direction of Lake Wilson. Ground elevation is estimated at 854 to 870 feet above mean sea level over the entire site.

3. Geology

The geological structure of the Wahiawa area is dominated by lava flows of the Koolau Volcano. These flows followed and partially overlapped the lava flows of the Waianae Series. Roughly, the area west of the Wahiawa Reservoir and Kaukonahua Stream (underlying Schofield Barracks Military Reservation) is composed of alluvial sediments (Rosenau, et al, 1971 in First West Engineers, 1979).

The Koolau Volcanic Series is characterized by basaltic flows with a thickness exceeding 3,100 feet. These flows are composed of thin layered pahoehoe and a'a, which were very fluid and occurred in rapid succession. The volcanic rocks of Koolau origin are highly permeable.

4. Soils

Soil Conservation Service (1972) soil maps identify only one soil type occurring over the property. Wahiawa silty clay (WaA) is a well drained soil derived from igneous rock. Permeability is moderately rapid, runoff is slow, and the erosion hazard is no more than slight.

5. Drainage and Flood Hazard

The site is well drained and no significant on-site flooding resulting from surface runoff has been experienced. Graded in a north to south direction, on-site runoff sheet flows across the site and into the reservoir.

The Flood Insurance Rate Map (FEMA, 1990) designation for the entire site is Zone D which is defined as "areas in which flood hazards are undetermined."

6. Groundwater

Wahiawa Town and Wahiawa Reservoir sit atop the Wahiawa Aquifer System (formerly known as the Schofield High Level Water Body). The Wahiawa Aquifer System occurs at about 280 feet above sea level and covers a 69 square mile trapezoidal shaped area. It is bounded on the east and west by the Koolau and Waianae dike-impounded water bodies and on the north and south by two subsurface dams of impermeable rock.

The Wahiawa Aquifer receives water from infiltration of rainfall and surface runoff on the Schofield Plateau and from leakage of high level groundwater from the Koolau dike-impounded water (Dale, Takasaki, 1976 in First West Engineers, 1979). It is estimated that 80 percent of all groundwater discharged naturally from the Wahiawa Aquifer flows into the Pearl Harbor Basal Aquifer to the south and the remainder flows north into the Waialua Basal Aquifer.

The State Commission on Water Resource Management (CWRM) , Department of Land and Natural Resources, has declared the Wahiawa Aquifer a groundwater management area (GMA). As a GMA, water use from this aquifer is regulated by the CWRM. The CWRM has determined a sustainable yield of 23 mgd for the Wahiawa Aquifer. For 1997, water usage averaged 10.625 mgd (CWRM) well below the sustainable yield.

7. Seismicity

According to the 1994 Uniform Building Code (UBC), the island of Oahu is classified as a Seismic Zone "2A". Zone "0" designates areas with the least seismic activity while Zone "4" designates areas with the greatest seismic activity (GMP Associates, Inc., 1997).

8. Archaeological Resources

No recorded archaeological or cultural features are found on the premises (Historic Site Maps, DLNR; Ogden in GMP Associates, Inc., 1997). The nearest historic feature, the Wahiawa Healing Stone (Site 493), is located opposite the entrance to the treatment plant.

9. Flora and Fauna

The treatment plant grounds are planted primarily with landscaped ornamentals and fruit trees. Gardenia, bird-of-paradise, croton, ti, and plumeria trees are used for landscaping alongside internal roads and some of the treatment works. A banana patch stands behind the blower building and papaya are raised for their fruit.

10. Air Quality

Owing to its residential character and the absence of stationary pollution sources, ambient air quality in Wahiawa is considered good. Although there are no State Department of Health air quality monitoring stations in Wahiawa, it is not likely that the combined agricultural, residential, and commercial activities in the town collectively violate Hawaii's air quality standards.

On the other hand, neighboring residents have filed complaints of odor emanating from the plant. Investigation into the complaints revealed that the odors are principally hydrogen sulfide and various organic compounds common to wastewater treatment plants. Several odor generation areas were discovered but the chief cause of odors was found to be the truck loading area. This area was identified by neighboring residents who smelled foul odors only during truck loading operations (GMP Associates, 1995). The problem has been mitigated by the installation of an odor control system at the loading area. Foul air is drawn from the tankers during loading and run through an activated carbon filter unit and filters have been placed over the tanker vents to minimize escaping odors (DES).

Climate also plays a role in conveying odor into surrounding neighborhoods. Warm weather is reported to exacerbate the odor problem and on days with Kona winds, the winds blow odors out toward the residential area to the north of the plant. Days with no wind results in a stagnant plume of odors hanging over the plant (Op.cit., 1995).

11. Acoustical Quality

Ambient noise levels were not measured. Background sound levels are controlled by sounds of plant operations to include electrical motors, mechanical equipment, and sloshing liquids. Sounds from passing traffic on California Avenue, school bells from Kaala School, overhead aircraft, and discharge from the treatment plant outfall are audible at different locations.

12. Land Use Controls

All of the town of Wahiawa is designated Urban by the State Land Use Commission. The City and County of Honolulu Central Oahu Development Plan Land Use Map classifies the site Industrial and it is zoned I-2 Intensive Industrial. The existing plant is a permitted use under the cited land use controls.

The Planning Department, City and County of Honolulu (Planning Department, Consultation Letter, 1998) commented that "proposed upgrade at the Wahiawa WWTP is consistent with the Central Oahu

Development Plan Public Facilities Map ("DPPFM"). Ordinance 96-35, approved by City Council in April, 1996 placed a wastewater treatment modification symbol on the Central Oahu DPPFM to recognize proposed improvements to the Wahiawa Wastewater Treatment Plant. The adjustment of the existing outfall to a lower elevation in the Wahiawa Reservoir would be considered a minor improvement and would not require a DPPFM amendment."

B. Wahiawa Reservoir

Wahiawa Reservoir is formed by an earth dam located just downstream of the convergence of the North and South Forks of Kaukonahua Stream (Koebig & Koebig, 1977). "The reservoir was built in 1905 by The Wahiawa Water Company, Inc. for irrigation purposes" (Dole Food Company Hawaii, Consultation Letter, 1998). The reservoir is owned by The Wahiawa Water Company, Inc. and The George Galbraith Trust and maintained by The Wahiawa Water Company, Inc.

A flow balance for the reservoir covering the period 1953 to 1968 is presented in Table 2-1. The balance shows a flow of approximately 40 mgd in and out of the reservoir; the difference between inflow and outflow estimates is less than 5 percent. Based on a reservoir volume of 3 billion gallons, the average hydraulic retention time of the reservoir is approximately 75 days (Brown and Caldwell, 1992).

Table 2-1. Lake Wilson Flow Balance

Item	Average flow, mgd[1]	Percent of Total
Inflow:		
Streamflow	37.4	90
Treatment Plant Effluent	1.0[2]	2
Rainfall	1.0	2
Local runoff	2.2	6
Total Inflow	41.6	100
Outflow:		
Irrigation Use	23.9	60
Leakage	0.2	<1
Overflow	14.7	37
Evaporation	1.0	3
Total Outflow	39.8	100
Computed difference, mgd	1.8	—
Computed difference, percent	4.3	—

[1] For period 1953 through 1968.
[2] Current flow from Wahiawa and Whitmore Village WWTPs total approximately 2.0 mgd.

Source: Brown and Caldwell, 1992

1. Wahiawa Dam

The Wahiawa Dam was constructed in 1905-06 below the confluence of the North and South forks of Kaukonahua Stream. The earth and rock fill dam is approximately 460 feet long with a height of 98.5 feet above the bed of Kaukonahua Stream. The dam has a crest width of 25 feet, a crest elevation of

852.5 feet (msl), and a spillway elevation of 842.5 feet. The original spillway, located on the right side of the dam, was approximately 50 feet wide at the completion of construction in 1906. Subsequent modifications were made increasing the width to the present crest width of 183 feet (Hirata, 1996).

The dam backs water up each branch (or fork) of Kaukonahua Stream for a distance of 6.0 miles. With water at the spillway crest, the reservoir has a surface area of 302 acres, an average depth of between 80-85 feet, and a capacity of 7,671 acre-feet (Ibid, 1978) or 2,500,000,000 gallons. The reservoir is filled almost entirely by runoff from a 16.9 square mile drainage basin stretching up to the base of the Koolau Mountain Range.

Irrigation water is released into 6.5 foot diameter tunnel,1,262 feet long, leading downstream from a gatehouse structure located just upstream of the left side of the dam. A 20-inch diameter valve located at the gatehouse provides the control for discharge to the tunnel (Ibid, 1978).

The condition of the dam is a major concern if the reservoir is to continue to be used as a receiving water for treated effluent. In the 1970s, two studies of the dam were prepared as part of the National Dam Safety Program. The Phase I study prepared by the Corps of Engineers (1978) concluded that dam is in good general appearance and condition. The study also determined that the spillway is inadequate to handle the Probable Maximum Flood ("PMF") and that the existing dam and spillway will be overtopped during the PMF. Additionally, it was found that leakage through the spillway and abandoned outlet tunnel has remained constant while seepage through the dam had increased.

Hirata (1996) recently completed a study for the owners of the dam. He concluded that the dam would be overtopped during the PMF which was calculated to occur for a 10,000 year flood thus confirming the earlier findings of the Corps of Engineers. A 50% PMF would result in about a 0.8 foot height above the crest and would be for an occurrence rarer than 500 years. If the water level rose to the crest height elevation of 852.5 feet, this event would be rarer than a 250 year event. Hirata also concluded that the dam is stable and no modifications are necessary.

The Wahiawa Dam and spillway are owned by The Wahiawa Water Company, Inc. and the George Galbraith Trust (Dole Food Company Hawaii, Consultation Letter, 1998).

2. Topography

Results of topographic survey data for that portion of the reservoir fronting the treatment plant are shown in Exhibit 1-3. From the treatment plant to the proposed discharge area, the ground slopes about 21% from elevation 850 to 796 feet. The relatively wide (80 to 100 feet) and flat bottom resembles a U-shaped channel. Opposite the discharge area, the ground is fairly steep and a finger of land projects into the reservoir. The end of the finger generally is not visible except during low water.

3. Flora and Fauna

The following description of flora and fauna was prepared by Funk for GMP Associates (1997). Vegetation between the periphery fence (at the treatment plant) and Lake Wilson consists of "Reforested Lakeside Vegetation". Here, the planted emergent trees are Lemon scented gum (*Eucalyptus citriodora* Hook.), ironwood (*Casuarina equistifolia* L.), African tulip (*Spathodea campanulata* P. Beauv.), Formosan koa (*Acacia confusa* Merr.), and octopus tree (*Schfflera actinophylla* (Endl.) Harms.). The understory of the Reforested Lakeside Vegetation is a combination of garden escapees, weeds, and obligate wetland vegetation. Among the escapees are banana trees (*Musa x paradisiaca* L.), ti (*Cordyline fruticosa* (L.) A. Chev.), 'ape (*Xanthosoma roseum* Schott), Syngonium (*Syngonium auritum* Schott), and [philodendron] (*Philodendron selloum* C. Koch). Common weeds found in the understory of the Reforested Lakeside Vegetation are the sedge McCoy grass (*Cyperus gracilis* R. Br.), *Dicliptera chinensis* (L.) Juss., white shrimp plant (*Justica betonica* L.), Guinea grass and wire grass (*Eleusine indica* (L.) Gaertn. The most common obligate wetland plant is the floating aquatic water hyacinth (*Eichornia crassipes* (Mart.) Solms) and in some places, California grass (*Brachiara mutica* (Frossk.) Stapf) forms dense stands.

The water hyacinth, *Eichhornia crassipes*, was introduced into the Hawaiian Islands in the late 1800's (Wagner, Herbst, and Sohmer, 1990). How and when it was introduced into Wahiawa Reservoir is unknown. While there is a current overgrowth of the plant in the reservoir, it is a recent occurrence. The DLNR is striving to keep the spread of the plant under control and the waterway between the treatment plant and the Wahiawa Dam open to fishermen and boaters.

The hyacinth forms thick mats that reduce light, reduce dissolved oxygen, and alter the aquatic fauna and flora of the body of water. Unless removed by water outflow or harvesting, water hyacinth plants killed by whatever means (natural, biological, or chemical treatment) will contribute decaying biomass to the reservoir bottom, reducing DO in deep water. Significant quantities of hyacinth have gone over the Wahiawa Dam in recent months, completely choking pools in Kaukonahua Stream immediately downstream with large masses of decaying plant matter.

Below the southern boundary of the Wahiawa WWTP site, Northern cardinals (*Cardinalis cardinalis*) and House sparrows (*Passer domesticus*) were observed in trees near the reservoir. Night Herons (*Nycticorax nycticorax*), which are native to Hawaii but not endangered, were present near the water while three small pigs (*Sus scrofa*), probably domesticated, were located near the reservoir in a pen. Both the House Mouse (*Mus musculus*) and Black Rat (*Rattus rattus*) are also presumed to be present around the reservoir area.

4. Fishing and Recreation

In the 1950s the Department of Land and Natural Resources ("DLNR"), State of Hawaii, began stocking Wahiawa Reservoir with freshwater sport fish. This imposed a third use on the impoundment in addition to irrigation and effluent disposal. In 1957, the DLNR acquired fish management functions and public fishing rights to the Wahiawa Reservoir through a cooperative agreement with Waialua Sugar Company (the lessee) and Castle & Cooke, Inc. (the owner). Designated the Wahiawa Public Fishing Area, Wahiawa Reservoir is one of the largest bodies of freshwater and the most heavily fished freshwater body in the State (Koebig & Koebig, 1975). The reservoir is stocked with introduced game fish including large and smallmouth bass, bluegill, threadfin shad, channel catfish, tilapia (*Tilapia mossambiaca* and *T. macrochir*), snakehead, carp, Chinese catfish, tucunare, and oscar (DLNR, 1963).

Other freshwater fish have been taken in its waters. These species, which have been accidentally introduced, include:

Common Name	Species	Year Discovered
Goldfish	Carassius auratus	1904
Swordtail	Xiphophorus helleri	1968

Tilapia	Tilapia melanotheron	1976
Angelfish	Pterophyllum sp.	1982
Armored Catfish	Pterygoplichtys multiradiatus	1987
Pacu	Colossoma macroponum	1987
Stickfish	Xenotodon cancila	1988
Red Piranha	-----	1992

Recently, another species of cichilid, *Hemichromis fasciatus* or jewel chichlid, was accidentally introduced into the reservoir. This species is similar to the stickfish in being an aggressive predator on other species, including the juveniles of more desirable game fishes.

The area next to the outfall is a popular fishing spot as fish are attracted to the surface discharge. As many as 8 to 12 fishermen at a time have been observed shore fishing in waters off the outfall. Public access to the outfall and lakeside areas along the perimeter of the plant is permitted through a gate in the fence surrounding the treatment plant.

The Wahiawa Public Fishing Area is administered by the Division of Aquatic Resources, Department of Land and Natural Resources.

In addition to fishing, the reservoir is also popular for recreational boating and aesthetic enjoyment. Permanent boat launching facilities are available for public use at Wahiawa Freshwater Park about 1.0 mile east of the treatment plant. Administered by the Division of State Parks, Department of Land and Natural Resources, park facilities include picnic tables and benches, open areas for play, parking for vehicles and boat trailers, an informal system of trails along the reservoir banks, and a comfort station. Water recreation is limited to non-contact activities by the DOH.

5. Land Use Controls

Wahiawa Reservoir is designated Conservation by the State Land Use Commission. Use of conservation lands is under the jurisdiction of the Board of Land and Natural Resources. All Conservation lands in the State are divided into one of four subzones—Protective, Limited, Resource, or General. Certain uses are permitted in each subzone with the Protective subzone the most use restrictive and the General subzone the least use restrictive. The reservoir is designated a Resource subzone.

The objective of the Resource subzone is "to develop, with proper management, areas to ensure sustained use of the natural resources of those areas" (Hawaii Administrative Rules, 1991). The areas (or lands to develop) encompass: lands necessary for providing future parkland and lands presently used for national, state, county, or private parks; and lands suitable for outdoor recreational uses such as hunting, fishing, camping, and picnicking.

The DLNR recently identified Wahiawa Reservoir as one of 25 sustainability hotspots throughout the State where, "in spite of an active community there is resource degradation, there are conflicts among users, public welfare is compromised, and there may be illegal activity (DLNR, No Date)". The report stated "excessive nutrient input in the effluent discharge from the Wahiawa WWTP is said to cause over-productivity in the reservoir, fish kills, and a fertilizing effect on alien species, primarily the water hyacinth".

According to the DLNR, however, the most difficult and serious issue in the reservoir is the unplanned introduction of alien species by private individuals. Although the problem has been checked in recent years, the area is still suffering from depletion in the large mouth bass population due to predators, uncontrolled growth of water hyacinth which in some areas are clogging the waterway, and a new species of tilapia which has replaced the previously dominant species.

The City and County of Honolulu Central Oahu Development Plan Land Use Map Designates the reservoir Preservation and it is zoned P-1 or Restricted Preservation. Uses, structures, and development standards in the P-1 zoning district are governed by the appropriate State agency.

Wahiawa Reservoir is defined as waters of the United States and under the regulatory jurisdiction of the US Army Corps of Engineers. The placement of fill in waters of the United States is subject to review and approval of the US Army Corps of Engineers through its permitting procedures. The project is subject also to permits and approvals from the State Department of Health (401 Water Quality Certification), Office of Planning (Hawaii Coastal Zone Management Program Federal Consistency), and Commission on Water Resources Management (Instream Uses of Water: Petition to Amend Interim Instream Flow Standard, Permits for Stream Alteration and Diversion Works).

6. Water Quality

Over the past twenty-five years a considerable body of data has been collected for Wahiawa Reservoir in an effort to characterize cause and effect relationships for water quality in this impoundment. Studies have dealt with the effects of sewage disposal on water quality, eutrophication potential of the sediments, fish toxicity, algal growth potential, and changes in sport fishery conditions. Over the course of time that these studies encompass, methodologies and techniques have changed thus making a strict comparison of data difficult and, in some cases, impossible. Also, studies have been carried out at different periods of the year and at different locations within the reservoir. This section of the EA summarizes several water quality parameters in Wahiawa Reservoir.

A water quality report titled "Review and Assessment of Wahiawa Reservoir Water Quality in Relation to Proposed Modifications to the Wahiawa WWTP" is found in Appendix A. Persons interested in a technical discussion of the subject should refer to that document.

a. Nutrients

The nutrients of primary concern in water quality assessment of natural waters are nitrogen and phosphorus. These nutrients are typically present in pristine, unpolluted aquatic (oligotrophic) environments in amounts that regulate, or limit, plant growth; i.e., aquatic plant biomass will remain relatively low so long as nitrogen and phosphorus are supplied to the system in small, growth-limiting quantities.

1) Nitrogen

There are three environmentally important components of nitrogen in aquatic systems: total nitrogen, ammonia, and nitrate/nitrite. In the past twenty-five years TN levels in all three sections of Wahiawa Reservoir have displayed considerable variability. However, the surface TN levels recorded in 1973 (Schmitt, 1973) are quite comparable with those for 1995-96 (Towill, 1996), suggesting that there has been little change in mean TN levels in these waters. Also, considering averages, there seems to be little difference in TN levels between the surface and deeper waters of the reservoir.

Mean TN concentrations in the North Fork of the reservoir have been consistently lower in both the surface and bottom waters over the years when compared with the Basin and South Fork levels. Interestingly, there was not a noticeable decrease in TN in the North Fork after sewage discharge from the Whitmore Village WWTP was diverted to the Wahiawa WWTP in March, 1994. Ammonia levels tend to be higher in the bottom waters of all three sections of the reservoir. In an average sense, the highest levels of ammonia tend to occur in the Basin waters and the lowest in the North Fork. There also appears to be a trend towards increasing ammonia levels over the years in the surface waters of the South Fork.

The highest ammonia levels are generally expected to occur in the South Fork because that is where contribution of high ammonia WWTP effluent is occurring. However, a consideration of the ammonia levels measured near the point of effluent discharge in the South Fork shows that ammonia concentrations fall off rapidly in the water. Interestingly, nitrate + nitrite levels tend to increase with distance from the discharge. Thus, while much of this ammonia may be consumed by phytoplankton, it appears that some portion may be oxidized to nitrate + nitrite by nitrifying bacteria in the water column. Dissolved oxygen levels in the hypolimnic waters of Wahiawa Reservoir are already low and the maintenance of aerobic conditions in these waters is essential.

There are, therefore, two negative impacts associated with the WWTP discharge of ammonia into Wahiawa Reservoir: (1) decrease in dissolved oxygen levels due to nitrification of ammonia to nitrate + nitrite; and (2) the potentially toxic effect of un-ionized ammonia on fishes.

Nitrate + nitrite, like ammonia, is a major nitrogen source for phytoplankton growth and productivity. Both the spatial and temporal distribution of this nutrient in the surface waters of the reservoir are quite variable. Nitrate + nitrite levels in the bottom waters have remained relatively constant and low over the years, possibly due to the low DO conditions which prevent nitrification of ammonia to nitrate + nitrite.

2) Phosphorus

Phosphorus frequently regulates, or limits, the productivity of aquatic plants and algae in aquatic environments, especially in freshwater environments. Two forms of phosphorus in the reservoir are of interest: total phosphorus (TP) which, like TN, is a quasi-conservative property in aquatic systems; and orthophosphate which, in its dissolved form, is assimilated by plants and algae and transformed into living tissue (i.e., is taken up and converted to organic phosphorus).

There appears to have been a definite trend towards lower TP concentrations in both the surface and bottom waters over the past twenty-five years throughout the reservoir. The highest surface levels have typically occurred in the South Fork and the lowest in the North Fork. TP concentrations in the bottom water follow a similar pattern to those in the surface layer.

Orthophosphate is the form of phosphorus that is directly utilized by aquatic plants and algae to produce cell matter by primary production (i.e., photosynthesis). If it is not available in sufficient amounts, the rate of plant growth will be restricted. Like TP, mean orthophosphate levels have decreased over the years to low levels with the highest concentrations presently occurring in the South Fork and the lowest levels in the North Fork in both surface and bottom waters.

b. External Nutrient Inputs

Nutrients are added to Wahiawa Reservoir by the Wahiawa WWTP effluent discharge and by urban and agricultural storm runoff. Storm runoff into Wahiawa Reservoir is potentially a significant source of nutrients. However, because runoff from buildings, streets, and property represents "non-point source" inputs, it is difficult to quantify the nutrient inputs.

Exhibit 2-1 depicts the watershed boundary of the reservoir. The watershed area above feeds into the reservoir via the two forks of Kaukonahua Stream, and inputs from this large area are treated under considerations of stream flow and stream water quality. Within the reservoir watershed, land use is classified as either urban, agriculture, or rural. Measurements taken off Exhibit 2-1 provide an estimate for the total reservoir watershed of 1271 ha (3,140 ac) or 12.71 km^2. Within this area, urban land comprises 43%, agriculture land 10%, and rural land 46% of the total area. From our calculations, the reservoir is estimated to be 115 ha (284 ac), or 19% of the rural land area.

At the time of the Young et al. (1975) study there was very little information available on nutrient levels in runoff. Table 2-2 represents values of average nutrient concentrations in urban runoff for Mililani Town (Yamani and Lum, 1985), in agricultural runoff from a Kunia pineapple field (Yim and Dugan, 1975), and for undeveloped land from a forested watershed in upper Manoa valley (Yim and Dugan, 1975). The values for the other areas are presented for illustrative purposes only and may not represent actual nutrient loadings in runoff from Wahiawa Town and surrounding areas.

Table 2-2 Revised Nutrient Loading Estimates from Runoff into Wahiawa Reservoir

Inputs	runoff area (km^2)	TN loading (kg/day)	TP loading (kg/day)	TN:TP	Source
WWTP	n/a	148	14	10.6	RMTC, 1996
Runoff					
Urban	5.4	3.8	0.8		Yamane & Lum (1985)
Agriculture	1.3	4.8	0.2		Yim & Dugan (1975)
Rural	4.8	2.9	1.1		Yim & Dugan (1975)
Runoff Total	12.7	11.5	2.1	5.5	

c. Chlorophyll α

Mean levels of chlorophyll α have changed little between 1973-74 and 1995-96 suggesting that the decrease in mean phosphorus concentrations over this same time period have had little or no effect on the phytoplankton standing crop in Wahiawa Reservoir.

Although there are sufficient nutrients to sustain high phytoplankton production rates in a eutrophic environment such as Wahiawa Reservoir, as in other eutrophic, sub-tropical impoundments, light penetration through the water column functionally limits primary production. As phytoplankton density increases from an abundant supply of nutrients, sunlight is attenuated more quickly as it passes through the water, eventually restricting effective photosynthesis to the upper few meters of the water column.

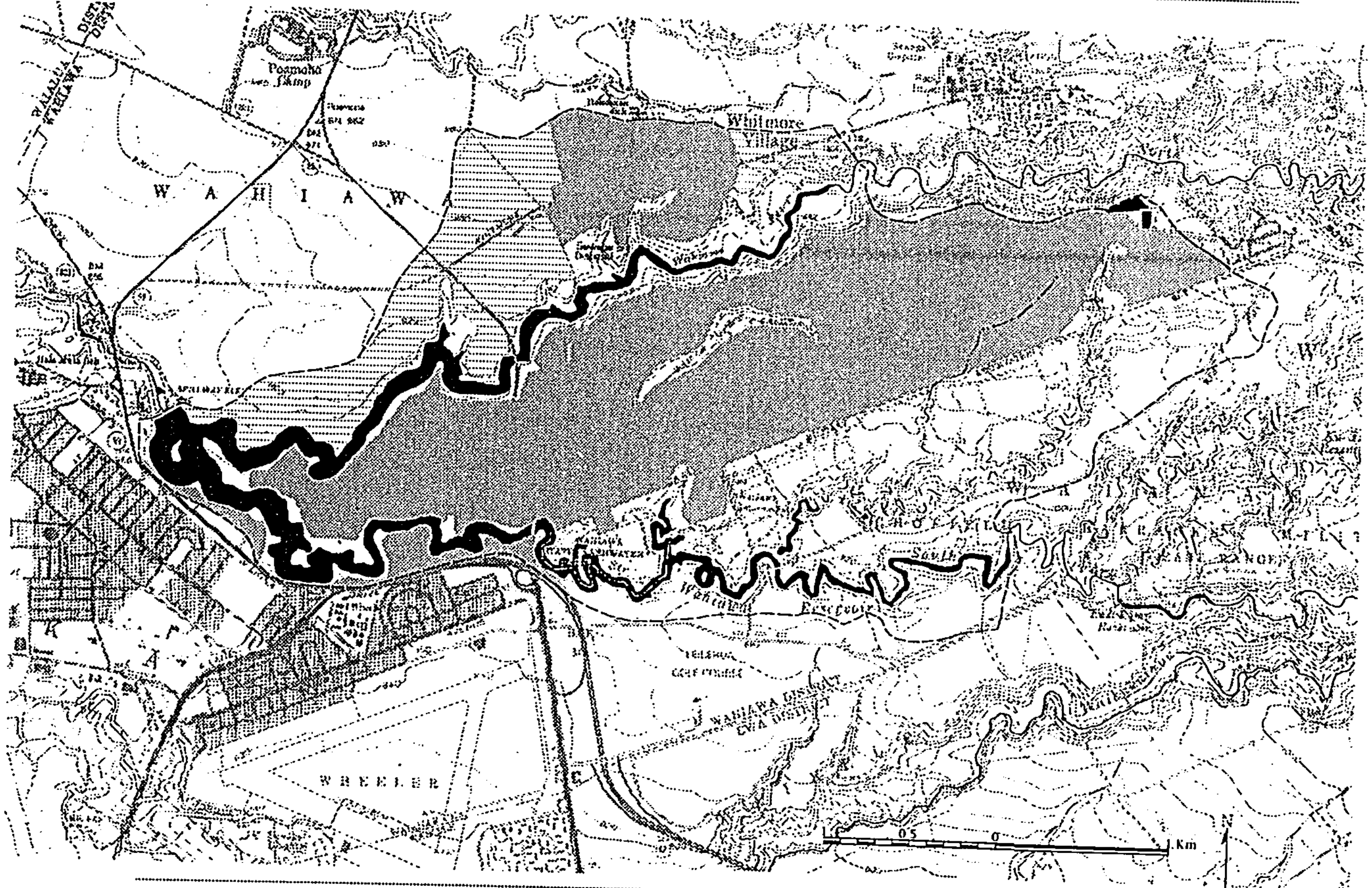


Figure 2-1. Land use map (urban, agriculture, and rural lands) of Wahiawa Reservoir (Lake Wilson) watershed.

d. Secchi Disk Depth

Secchi disk depth represents a rough estimate of the depth of zero net primary productivity; i.e., the depth at which phytoplankton respiration equals oxygen production via photosynthesis. Generally, there is little variation in Secchi disk depth in any section of reservoir. Also, there has been little change in mean values with time. The mean Secchi disk depths in Wahiawa Reservoir are quite low (i.e., shallow) and indicate that net primary productivity in this impoundment is restricted to the upper meter or so (the euphotic zone) of the water column.

The significance of light limitation in Wahiawa Reservoir is that while phytoplankton may occur in dense numbers throughout much of the water column, the net production of dissolved oxygen is restricted to the upper meter or so. Put another way, phytoplankton below the upper meter of the water column will consume more oxygen than they produce. This can lead to oxygen depletion in the hypolimnion — a situation that can have serious consequences on the reservoir environment.

e. Dissolved Oxygen

Dissolved oxygen (DO) is one of the most important environmental parameters in lakes and reservoirs. DO is produced in the upper lighted layers of the impoundment by phytoplankton primary production (photosynthesis) during the day and is consumed by respiration processes of all living matter (with the exception of certain bacteria) in the impoundment twenty-four hours a day.

The spatial distribution of DO in Wahiawa Reservoir (Table 2-3) typically demonstrates relatively high levels in the epilimnic waters and low levels in the lower, or hypolimnion, portion of the water column; the two layers being separated by the thermocline which precludes mixing between these two water body layers. This differential is to be expected since the surface waters can be supplied with DO as the result of wind-mixing with the air and also as end-product of phytoplankton photosynthesis.

Table 2-3. Mean Dissolved Oxygen levels (mg/l) in the Surface Waters (Epilimnion) and Bottom Waters (Hypolimnion) of Wahiawa Reservoir

Year	Month	Depth	Basin	South Fork	North Fork	mean	Source
1973	Jan - Jun	surface	8.7	9.3	10.5	9.5	Schmitt, 1973
		bottom	*1.3*	*1.9*	*2.4*	*1.9*	
1975 - 76	Jun - Jan	surface	7.2	—	—	7.2	Lum, et al. 1976
		bottom	*0.7*	—	—	*0.7*	
1992	Oct	surface	13.2	12.0	9.6	11.6	Horne, 1992
		bottom	*<0.1*	*<0.1*	*2.1*	*0.7*	
1994	Sep - Dec	surface	8.8	7.0	7.8	7.6	AECOS, 1995
		bottom	*5.7*	—	—	*5.7*	
1995 - 96	May - Feb	surface	7.8	7.9	7.9	7.9	RMTC, 1996
		bottom	*0.4*	*1.9*	*3.2*	*3.1*	
grand mean		surface	9.1	9.1	9.0		
		bottom	*1.6*	2.6	2.6		

Over time, considerable variability in DO levels in the reservoir can be expected especially in the epilimnion, since DO concentrations will increase as the sun rises towards its zenith due to photosynthesis and then decrease as the sun moves lower in the sky. The lowest DO levels will be reached in the morning hours just before sunrise as the result of night-time respiration. This daily cycle is known as the diel or diurnal cycle of DO.

Factors affecting DO levels in the hypolimnic waters of Wahiawa Reservoir are less well understood. It is generally agreed that DO is supplied to the hypolimnic waters principally by stream waters flowing into the North and South Forks of Kaukonahua Stream (Schmitt, 1973; *AECOS*, 1995; Towill, 1997). As these relatively DO-rich waters (S. Kaukonahua = 7.8 mg/l, N. Kaukonahua = 8.9 mg/l; *AECOS*, 1995) enter the impoundment, they descend below the warmer (less dense) water surface waters of the reservoir and move towards the dam. Movement of this lower water mass towards the dam is enhanced by drawoff of water for irrigation purposes from the lower valves of standpipe system located in the reservoir basin near the dam. This practice of drawing water from the lower standpipe valves thus promotes the transport of DO into the bottom waters and helps to reduce the residence time of water in the hypolimnion. Stagnation and anaerobic conditions in the bottom waters of the reservoir are thus alleviated to some degree.

While the results of the Towill study (1996) indicate that DO levels in the South Fork are intermediate between the North Fork and the Basin waters (Table 2-4), a closer look at individual stations in this section of the reservoir (Table 2-4) reveals that Stations S1 and S2, on either side of the Wahiawa WWTP discharge, exhibit very low DO levels (< 0.10 mg/l) on most sampling occasions. Note that at the head-end of the reservoir on the South Fork (Station S4) DO levels are relatively high and then decrease progressively with distance from this point.

Table 2-4. Distribution of DO (mg/l) in the Bottom Waters of the South Fork of Wahiawa Reservoir (after RMTC, 1996).

	Station				
Month	S1		S2	S3	S4
May-25-95	0.06	E	0.11	0.49	8.2
Jun-19-95	0.06	F	0.10	1.23	4.23
Jul-11-95	0.05	F	0.09	2.23	6.71
Aug-03-95	0.05	L	0.08	3.87	6.01
Sep-05-95	0.05	U	0.29	2.58	4.35
Sep-26-95	0.04	E	0.09	0.11	4.66
Oct-17-95	0.11	N	0.78	1.41	4.49
Nov-15-95	0.05	T	0.07	0.22	4.91
Dec-05-95	0.06	S	0.04	2.32	3.50
Dec-27-95	0.04		0.06	1.76	3.19
Jan-16-96	0.05		0.06	1.41	3.39
Feb-14-96	0.07		0.05	0.10	2.75
Feb-29=96	6.71		5.59	4.05	5.68
mean	0.72		0.71	1.78	4.29

Factors influencing the depletion of DO in the hypolimnion include: (1) respiration by plants and animals; (2) decay of organic matter (principally phytoplankton and detritus) settling out of the euphotic zone; and (3) complex, little understood interactions with bottom sediments.

Maintaining aerobic conditions in the hypolimnion is crucial to the ecological well-being of the reservoir. The most apparent consequence of oxygen depletion in the bottom layer (i.e., anaerobic conditions) would be restriction of most plant and animal life to the upper few meters of the reservoir (the epilimnion).

7. Fish Kills

The discharge of effluent into Wahiawa Reservoir has been suspected of contributing to periodic fish kills. Fish kills that occurred in the 1960s and 1970s were associated with excessive algae growth in the reservoir. High nutrient loading of phosphorus and nitrogen in the treatment plant effluent can result in eutrophication or the excessive and undesirable growth of algae. Excessive algal growth can produce low oxygen in the water (primarily during early morning hours) killing fish in the water column.

As shown in Table 2-5 there have been no documented fish kills associated with treatment plant effluent between September, 1972 and August, 1986, a 14 year period. Since 1986, 10 events have been documented by the DLNR in which toxic substances were believed to be the cause. No fish kills have been reported since December, 1991 the last recorded occurrence.

Table 2-5. Documented Fish Kills in Lake Wilson

Date	Comments
November, 1962[1]	100,000 lb of fish killed; 90% of total reservoir population.
November, 1968[1]	18,000 lb of fish killed.
September, 1971[1]	3,000 lb of fish killed.
August, 1986[2,3]	200 tilapia killed; chlorine discharge suspected.
May, 1987[2,3]	8,000 tilapia killed; detergent like suds and heavy stench in vicinity of outfall.
December, 10, 11, 1987[2,3]	3,000 tilapia killed; cause suspected to be industrial waste.
April 1, 1988[2,3]	2,000 tilapia, 10 channel catfish, 9 armored catfish killed; cause suspected to be industrial waste.
May 6, 7, 1988[2,3]	9,000 tilapia killed; cause suspected to be industrial waste.
May 12, 13, 1988[2,3]	100 tilapia killed; cause suspected to be industrial waste.
June 3, 1988[2,3]	5,000 tilapia, 12 channel catfish, 26 armored catfish killed; cause suspected to be industrial waste.
August 9, 1991[3]	3,300 tilapia, 1 armored catfish killed; cause suspected to be toxic substance passing through treatment plant.
September 26, 1991[3]	100 tialapia, 1,000 threadfish shad killed; cause suspected to be toxic substance passing through treatment plant.
December 12, 1991[3]	1,500 tilapia killed; cause not determined.

[1]Reference 1.
[2]Letter from William Paty, Board of Land and Natural Resources, to Environmental Protection and Health Services Division, Hawaii State Department of Health.
[3]Undated list of fish kills provided by DLNR.

DLNR staff have indicated that most of these recent kills are associated with toxic materials that passed through the treatment plant. The source for many of these toxic materials may have been wastes trucked into the town of Wahiawa and discharged into the sewer system at a point upstream of the plant. Many of the fish kills were preceded by treatment plant upsets, indicating that a toxic discharge might well have been responsible. Private liquid waste haulers are prohibited from discharging waste at the facility. City trucks are allowed to discharge at the plant under a strict monitoring program although none have done so for several years. Fish kills have occurred even after a complete ban was instituted leading to the possibility that illegal dumping, either from trucks or from individual commercial discharges in the service area, have been occurring.

Staff at DLNR also are aware that fish kills have periodically occurred as a result of large sediment laden storm inflows from the streams entering the reservoir and are not associated with effluent *discharge or toxic materials.*

8. Agricultural Reuse

Water in Wahiawa Reservoir is drawn primarily by Dole Food Company Hawaii Inc. ("Dole") for irrigating their agricultural lands in North Central Oahu and the North Shore. Dole (and its former parent company Waialua Sugar Company) has been impounding and drawing water from the reservoir for irrigation since its construction in 1906. Since 1929, treated effluent from the Wahiawa WWTP has been discharged into the reservoir, mixed with impounded water, and "reclaimed" for irrigation. Water from the reservoir is also combined with secondary wastewater from the Schofield Barracks WWTP in an irrigation flume below the Wahiawa Dam. This is the start of the Wahiawa Reservoir Ditch, the irrigation "backbone" of the former Waialua Sugar Company ("WSC"). The Ditch conveys water from the Wahiawa Reservoir to the vicinity of the Poamoho Agricultural Experiment Station alongside Kaukonahua Road. Here, the Wahiawa Reservoir Ditch crosses former WSC lands and conveys water as far away as Waimea Bay. The Kemoo Ditch System, a branch of the Wahiawa Reservoir Ditch, conveys water to Waialua from this juncture.

Above Haleiwa, the Wahiawa Reservoir Ditch is fed by three other systems owned by Dole: the Helemano Reservoir Ditch, Opaeula Ditch, and Kamananui Ditch. From the main ditch, a network of reservoirs, flumes, ditches, pumps, siphons, and aqueducts delivers water throughout most of the former plantation lands. The system irrigated approximately 12,000 acres of sugarcane cultivated by WSC and an estimated 4-5,000 acres of pineapple grown by Dole. The acreage in sugarcane includes about 6,000 acres leased from the Bishop Estate north of Opaeula Stream.

The quality of the water varies throughout the system and is dependent on the quality of surface runoff. Groundwater from some wells along the coastal plain are brackish but still usable. Effluent from the Wahiawa WWTP which has received secondary treatment and disinfection is added to the Wahiawa Reservoir. The ratio of impounded water to effluent is approximately 20:1. Flows from the Schofield Barracks WWTP are not discharged into Wahiawa Reservoir at the present time, but directly to an irrigation ditch below the reservoir.

Approximately 30 million gallons of water was withdrawn daily from Wahiawa Reservoir to irrigate WSC and Dole lands. With the cessation of Waialua Sugar Company in 1996, sugarcane is no longer the major recipient of irrigation water. While pineapple cultivation constitutes the major agricultural venture (in terms of cultivated acreage) Dole is spearheading new agricultural ventures on its former sugarcane lands and is the only user of water from Wahiawa Reservoir. The company is raising papaya, mango, coffee, alfalfa, assorted grasses, and flowers and has leased its lands for truck farming, growing wetland taro, and banana farming. Dole's actions both as a local landowner/grower and world wide food producer strongly emphasizes that Central Oahu and the North Shore have the environmental resources needed to sustain agriculture as an economic activity on Oahu. There is a plentiful supply of quality land, productive soils, level fields, varying elevations, high levels of sunshine, a temperate climate, and adequate rainfall. While sugarcane has ceased as a major economic activity, plans for agricultural development in the district will help to promote and maintain the rural character of the district and support general plan polices to encourage the expansion of diversified agriculture and the continuation of pineapple as a viable industry.

The Board of Water Supply (July, 1998) requested that "areas where reclaimed effluent will be applied should be indicated on a map in relation to existing and proposed groundwater wells in Waialua and Kawailoa." Exhibit 2-2 depicts lands owned by Dole, existing and proposed groundwater wells, and anticipated agricultural land uses. It is assumed that irrigation water from Wahiawa Reservoir will be applied to the areas of anticipated agricultural land uses.

Most if not all of Dole lands are above the Department of Health delineated Underground Injection Control (UIC) Line and overlay sections of the Waialua aquifer, one of three aquifer systems within the North aquifer sector of Oahu. "In the Waialua aquifer, a thick wedge of sedimentary caprock causes a thick basal lens to exist, creating an extensive freshwater body located in dike-free Kooalu lava flows. Recharge from rainfall in the Koolau Range maintains this lens (Wilson Okamoto, 1997). Many public and private water wells are located below the 200 foot contour indicating that groundwater movement in the Waialua and Haleiwa area occurs in a seaward direction.

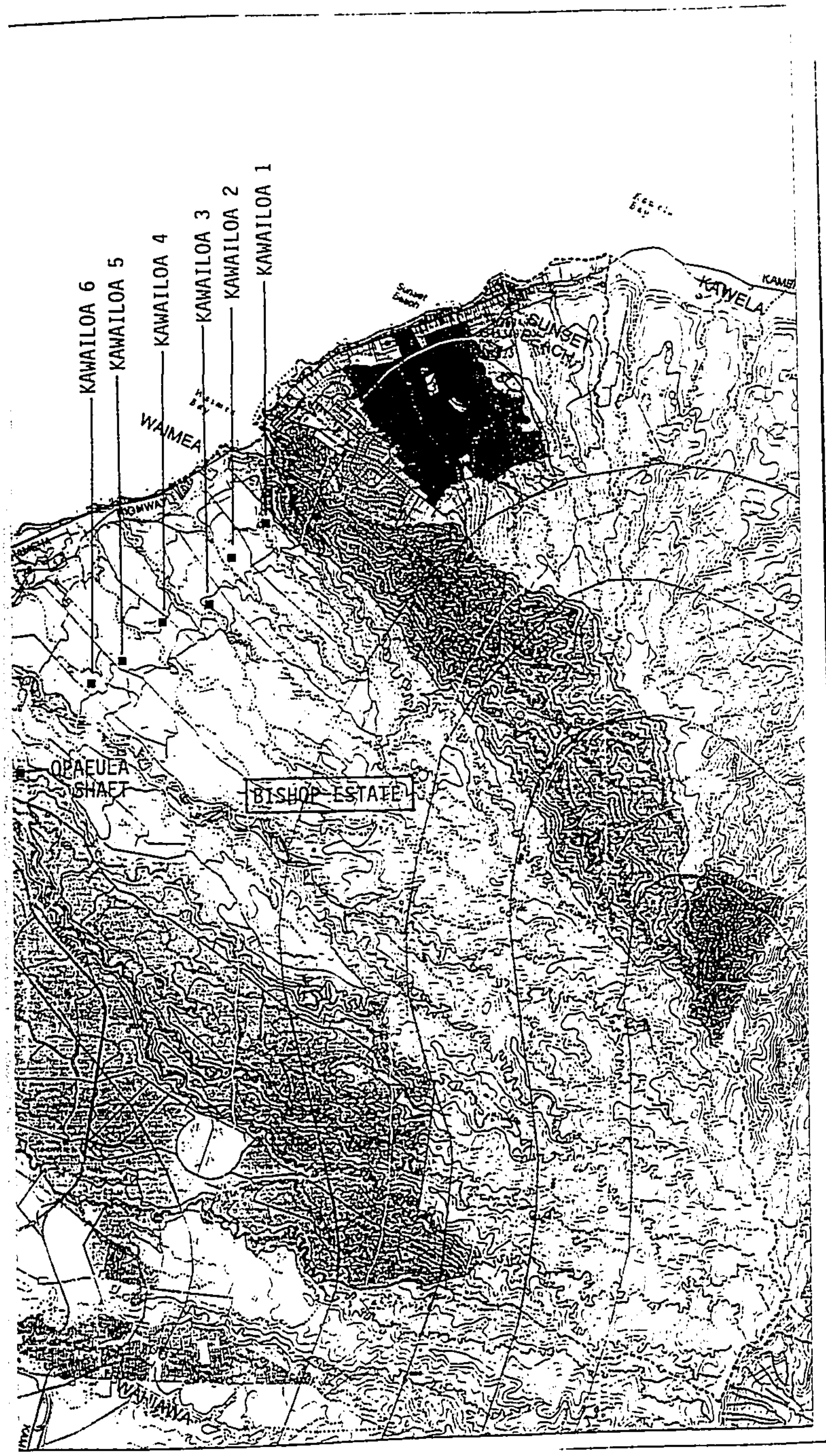


EXHIBIT 2-2

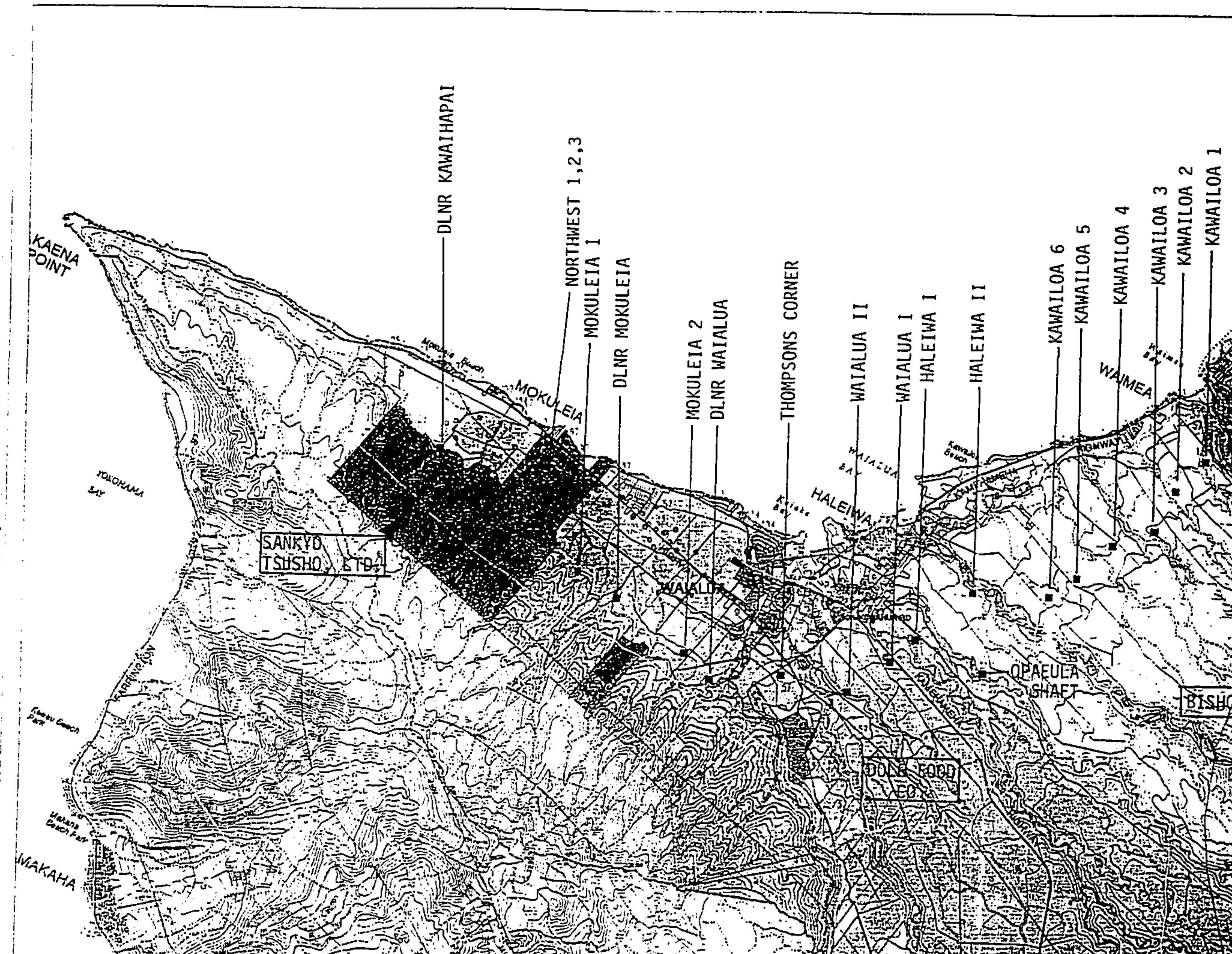
AGRICULTURAL LANDS

AND

WATER WELL LOCATIONS

SCALE IN FEET

N



DLNR KAWAIHAPAI
NORTHWEST 1,2,3
MOKULEIA 1
DLNR MOKULEIA
MOKULEIA 2
DLNR WAIALUA
THOMPSONS CORNER
WAIALUA II
WAIALUA I
HALEIWA I
HALEIWA II
KAWAILOA 6
KAWAILOA 5
KAWAILOA 4
KAWAILOA 3
KAWAILOA 2
KAWAILOA 1
KAENA POINT
MOKULEIA
WAIMEA
HALEIWA
WAIALUA BAY
YOKOHAMA BAY
SANKYO TSUSHO, LTD.
WAIALUA
OPAEULA SHAFT
DOLE FOOD CO.
GALBRAITH EST.
Wahiawa Reservoir
WAHIAWA
MAKAHA
WAIANAE
MAILI

SECTION 3
SUMMARY OF POTENTIAL ENVIRONMENTAL IMPACTS AND MEASURES TO MITIGATE ADVERSE EFFECTS

A. Assessment Process

The scope of the project was discussed with the consulting engineers, staff of the Department of Design and Construction, and others comprising the consultant team. Staff of State and County agencies were consulted for information relative to their areas of expertise. Time was spent in the field noting conditions at the Wahiawa WWTP, Wahiawa Reservoir, and in the vicinity of the Wahiawa Dam. Agency, organizations, and individuals were apprised of the project through pre-assessment consultation. From the discussions and field investigations, environmental features and existing conditions that could be affected or would affect the project were identified. These conditions and features are:

Wahiawa Wastewater Treatment Plant

- Proposed improvements to existing processing units are confined to the existing Wahiawa WWTP site;
- Land on which the improvements are proposed has been extensively modified by structures, roads, and landscaping;
- No change in the use of the site is proposed;
- The proposed improvements are consistent with land use controls for the site;
- Utilities are available and adequate to service the modified treatment facilities;
- There are no recorded archaeological features on the ground surface;
- There are no threatened or endangered flora and fauna on the premises;
- The plant is not located in a flood hazard zone;
- Truck loading operations is the primary cause of odor complaints at the plant. Measures have been implemented to mitigate the source of odor; and
- Shore fishermen are permitted access over a section of the plant grounds to a popular fishing area in waters around the WWTP outfall.

Wahiawa Reservoir

- Designated Class 2 waters by State Department of Health water quality regulations;
- Considered an irrigation reservoir;
- There are no water quality standards for irrigation reservoirs;
- Classified Conservation by the State Land Use Commission;
- There are no underwater archaeological features;
- Harbors a diverse assemblage of introduced fishes; and
- There are no endangered aquatic species or habitats.

B. Short-term Impacts

Planned modifications to existing treatment facilities will be confined to the site of the Wahiawa WWTP. The physical environment comprising the plant grounds has undergone many changes in the

70 years since the plant was built. New and upgraded facilities added to the basic plant have resulted in the current plant layout and treatment capabilities. Ancillary improvements such as driveways, piping, fencing, and landscaping also have altered the site. The proposed filtration and disinfection units are proposed in areas formerly used as sludge drying beds or graded and landscaped vacant areas, respectively.

1. **Air and Noise**

Fugitive dust will be raised by grading, trenching, stockpiling, backfilling, and other dirt moving activities. Adequate dust control can be attained by establishing a frequent watering program to keep exposed areas around work sites from becoming significant dust generators. Alternatively, the general contractor may employ other control methods based on their experience with similar projects on similar sites. Control measures shall comply with Chapter 60, Air Pollution Control Regulations, Title 11, State Department of Health. Wahiawa's frequent rains will also aid in dust control. The general contractor will be responsible for keeping the site and adjoining streets and properties reasonably free of litter, debris, and mud.

Most construction equipment and vehicles are diesel powered and emit exhaust emissions typically high in nitrogen dioxide and low in carbon monoxide. The Federal and State nitrogen dioxide standard — 100mg/m^3 per annum—which is an annual standard is not likely to be exceeded during construction. Carbon dioxide emissions should be less than that generated by automobile traffic on adjoining streets. Aldehyde odors from diesel equipment may be detected but should be dispersed by the prevailing tradewinds.

Construction noise, like fugitive dust cannot be avoided. Noise sensitive properties, principally residences adjacent to the plant, will be affected during the construction phase. Construction noise will be audible in areas surrounding the plant but exposure to noise is expected to vary in volume, frequency, and duration. Noise will also vary by construction phase, the duration of each phase, and the type of equipment used during the different activities comprising each phase.

Community Noise Control regulations establish maximum permissible sound levels for construction equipment and activities occurring within "acoustical" zoning districts. The Wahiawa WWTP site is zoned I-2 and for noise control purposes is placed in the Class C zoning district. The maximum permissible daytime sound level in the district is 70 dBA within the premises and at or beyond the property line for the entire day and night (Chapter 46, Community Noise Control, 1996).

In general, construction activities cannot exceed the permissible noise levels for more than ten percent of the time within any twenty minute period except by permit or variance. Any noise source that emits noise levels in excess of the maximum permissible sound levels cannot be operated without first obtaining a noise permit from the State Department of Health. The permit does not attenuate noise per se but it regulates the hours during which excessive noise is allowed.

The general contractor will be responsible for obtaining the permit and complying with conditions attached to the permit. Work will be scheduled during normal working hours (7:00 AM to 3:30 PM) Mondays through Fridays. If weekend work is required, notices will be posted alerting the neighborhood of impending work.

2. Erosion

Site work will expose soil thus creating opportunities for runoff and erosion. Grading will be performed in accordance with the erosion control ordinance of the City and County of Honolulu and grading plans approved by the Department of Planning and Permitting ("DPP"), City and County of Honolulu. Best Management Practices ("BMP"s) for erosion and runoff control during construction will be prepared for review and approval by the DPP.

3. Archaeology

Should subsurface archaeological sites or cultural deposits and artifacts be uncovered, work in the immediate area will cease and historic authorities notified for proper disposition of the finds.

4. Odor

Construction workers will be exposed to hydrogen sulfide and other organic odors created by the wastewater treatment process. A 1995 study identified problem areas where odor was most pronounced (primarily the truck loading bay where sludge is loaded for transport to the Honouliuli WWTP) and also identified certain climatic conditions which exacerbated the problem. Workers will be provided with filter masks to help mitigate the inhalation of odors.

5. Traffic

Construction materials will be delivered, unloaded, and stockpiled on the premises. Material deliveries will be scheduled during non-peak traffic hours on adjacent roads to minimize interfering with local traffic. No road work is proposed in any street right-of-way thus no inconveniences to motorists are anticipated.

6. Public Facilities and Energy

Negligible impacts are anticipated on public facilities servicing the existing treatment plant. The plant will remain fully operational during construction. The new secondary effluent pumping station, larger secondary clarifiers, and UV lamps will contribute to additional power demands. Power loads will be determined during the design stage and electrical systems modified as necessary.

7. Construction in Wahiawa Reservoir

Construction in water poses unique but not insurmountable challenges. Several methods or combination of methods for building the outfall are being considered by the consulting engineers and the contractor selected to build the outfall may also suggest alternatives for its construction. The construction method has not been chosen at this time. Whichever method is selected, the contractor must take into account the following engineering parameters: (1) the diffuser section of the outfall will be secured on pile supports with the pipe raised above the bottom of the reservoir; and (2) the remaining length of the outfall will be laid on top of the reservoir side slope to minimize disturbances to the underwater land form. A 24-inch ductile iron water pipe with flexible restrained joints is proposed for the outfall.

It is anticipated that the outfall will be constructed directly in the water. For the diffuser section, 80 lineal feet will be pile supported. Piles will be precast concrete or steel 'H' piles which will be driven by a pile driver that is mounted on a barge and floated directly over the selected site. This method would require no significant alteration to the underwater terrain. No dredging or excavating would be required because most of the outfall would be laid on the reservoir bank.

For the pile driving, a steel cylindrical coffer dam will be constructed around each pile allowing the pile to be driven in a dry area. Disturbance of bottom sediments would be kept to a minimum and confined to the coffer dam. Water in the coffer dam will have to be pumped out and discharged back into the reservoir (dewatered). This method would require no significant alteration to the underwater terrain. The piles will be connected by a precast concrete beam which will be placed and secured to the piles underwater.

Information gathered from geotechnical borings has determined that a 40-foot length of pile is required. Noise sensitive properties, primarily residences fronting the reservoir and adjacent to the treatment plant and residential areas and the school along Wilikina Drive will be exposed to pile driving noise. The noise may be amplified because of the relative quiet that is characteristic of the gulch-like setting and "water side" environment. Actual pile driving is estimated to take less than two weeks. The remaining pipe will be laid on the underwater ground surface. The pipe will be connected on land, floated to its design location, and sunk.

Construction may disturb accumulated bottom sediments which will be temporarily suspended in the water column. Underwater construction work to include subsurface disturbance, placing of materials, motion, and noise are expected to keep fish away from the work area. If needed, underwater "fences" could be erected to keep fish out of the work area. Silt curtains can be used to prevent the migration of silt to others areas of the reservoir.

To facilitate construction of the outfall, the City will request approval from the owner and the DLNR to lower and maintain the water level at about elevation 830 feet for about 6 months.

The projected outfall construction should take approximately 6 months and may span both wet and dry months and concomitantly periods of high and low water in the reservoir. Extending the outfall during the dry months when the sloping banks are exposed and the water level is at its lowest is ideal. However, the dry period is only a fraction of the time required to complete the outfall and it is anticipated that construction may take place primarily during the wet months and in high water.

C. Long-term Impacts

1. Air and Noise

Negligible long-term environmental impacts at the plant site are anticipated. The modifications will not adversely alter primary screening and secondary treatment processes which will continue using existing facilities. As a result, no significant change in plant related noise is anticipated. Plant odor can be contained by operational controls and the installation of odor control systems in problem areas (GMP Associates, 1995). The proposed wet weather equalizations basins could be covered for odor control.

2. Public Facilities and Energy

The project is not expected to significantly impact public facilities servicing the plant. Existing utilities to include the driveway, sewer system inflow piping, water, and communication lines and services should remain status quo. The demand for electrical power is anticipated to increase with the addition of the influent pumps for flow-equalization, the upgraded secondary effluent pumping station, and the UV disinfection system.

3. Plant Operations

Although plant operations will not be significantly changed, it is estimated that, in addition to existing staff, a minimum of 1 supervisor, 3 operators, 3 maintenance persons, 2 truck drivers, 1 laborer, and 1 lab person would be required to operate the equipment and processes at the treatment plant. The cost of additional personnel will be included in the annual operating budget of the City.

4. Fishing and Recreation

Relationships among the various fish species are complex and unsettled because of continuing introductions of new species. *Hemichromis fasciatus*, unknown in the reservoir a decade ago, is now the most abundant juvenile fish in shallow water. Mozambique tilapia also remain very abundant. The ultimate consequences to the recreational fishery of any changes in the nature of the WWTP discharge cannot be predicted.

Changing the location of the outfall to deeper water could have no impact on absolute numbers of fish species. Improved water clarity could be advantageous to predator species, but populations of predator species are highly dependent on prey species numbers.

Shore fishermen will still be able to fish at the site of the existing outfall, however, fish may not be as plentiful in the area given the absence of surface discharge. The area around the deep outfall will be readily accessible by boat (or other water craft) but not from shore. Some type of surface marking will identify the location of the outfall and alert boaters to stay a safe boating distance (to be determined) from the markings. There are no deep draft boats in use at the reservoir thus the underwater outfall will not pose an obstruction to navigable craft.

5. Water Quality

The waters of Wahiawa Reservoir can be divided, on the basis of temperature, into a warmer surface layer and a cooler deep, or bottom, layer. These two layers, or water masses, are typically separated by a thermocline: a horizontal layer in the water column where the temperature decreases noticeably over a relatively short change in depth. Since water density increases as temperature decreases, the surface (epilimnic) and deeper (hypolimnic) waters of Wahiawa Reservoir are essentially separated because the thermocline acts as a barrier to the transfer of physical and chemical properties between the two water masses throughout most of the year.

The successful operation of a deep discharge site is predicated upon complete mixing of the relatively warm (less dense) effluent with cooler (denser) bottom water --that is, the effluent does not rise into the surface layer. Based upon the Towill (1996) data, the difference in temperature between the effluent and bottom waters near the outfall ranged from 3.0 C° to 6.1 C°, with an average difference of 4.8 C°. Additionally, the depth of the deep water layer (bottom to surface layer) near the outfall appears to vary between about 6 to 10 m (20 to 35 ft) depending upon water level and depth of thermocline. These may not represent extreme conditions for either temperature differential or minimum depth of the deep water layer in the reservoir. The diffuser will be designed to achieve a condition of complete mixing. Because of the thermal stratification in the water column, the effects of diverting effluent discharge from the surface to deeper water needs to be considered separately for the epilimnic and hypolimnic waters of the impoundment.

a. **Effects on Surface (Epilimnion) Water**

Diverting effluent discharged on water surface to deeper water will reduce nutrient loading in the surface (epilimnic) waters of the reservoir so long as the effluent is kept below the thermocline. Reducing the nutrient load should, in turn, result in a decrease in phytoplankton biomass. A reduction in phytoplankton biomass would trigger a decrease in TSS with the end result that there should be an increase in Secchi depth and a general improvement in water clarity in the epilimnion - at least in the vicinity of the outfall.

The question is how much of an improvement can be expected for various water quality parameters throughout the epilimnic waters of the reservoir? To address this question, other inputs to the surface waters of the reservoir need to be considered. It is now recognized that inflowing water of the North and South Forks of Kaukonahua Stream sink beneath the less dense surface waters of the reservoir to help form the hypolimnion. As such, these stream inputs do not contribute significantly to the water quality of the surface layer.

In addition to discharge from the treatment plant, the other major inputs to the reservoir surface water are direct rainfall and storm runoff. Quantities of total nitrogen and total phosphorus from runoff were estimated in Table 2-2 (Section 2.B.6.b). An 87 percent reduction in TP loading to the surface water of the reservoir could be realized by diverting the discharge below the thermocline. Because there are other possible sources of nutrient input to the reservoir than have not accounted for, and because the runoff values used here may not strictly apply to the Wahiawa Reservoir watershed, a more conservative 70 percent reduction in TP level is estimated.

Because phosphorus is the nutrient that regulates phytoplankton biomass levels in Wahiawa Reservoir, there should be also be a significant reduction in phytoplankton biomass in the impoundment. Figure 3-1 shows the mean distribution of phytoplankton biomass for 1995-1996 (Towill, 1996), based upon an assumed chlorophyll α content of 1.15% of phytoplankton dry weight (Reynolds, 1984) for a mixed phytoplankton population composed primarily of chlorophytes and diatoms (types of phytoplankton organisms). Upon diversion of the WWTP effluents to a deep discharge, phytoplankton chlorophyll (and hence biomass) levels should fall, especially in the vicinity of the former discharge site; i.e., Station S2 and S1 (Figure 3-1).

The average chlorophyll α level in the reservoir is expected to decrease from about 26.3 μg/l (Towill, 1996) to about 8 μg/l, resulting in a decrease of phytoplankton biomass from an average of about 4.5 mg/l to about 0.5 mg/l.

TSS levels in the reservoir should also decrease. These decreases will also be most evident in the vicinity of the present outfall, but they will not be as dramatic as for chlorophyll. Thus, while there will be a small direct decrease in TSS from the diversion of the effluent itself, most of the TSS decrease will result from a decline in the phytoplankton population. It is estimated that there could be about a 42 percent reduction in the reservoir as a whole following diversion of the WWTP effluent to a deep discharge site.

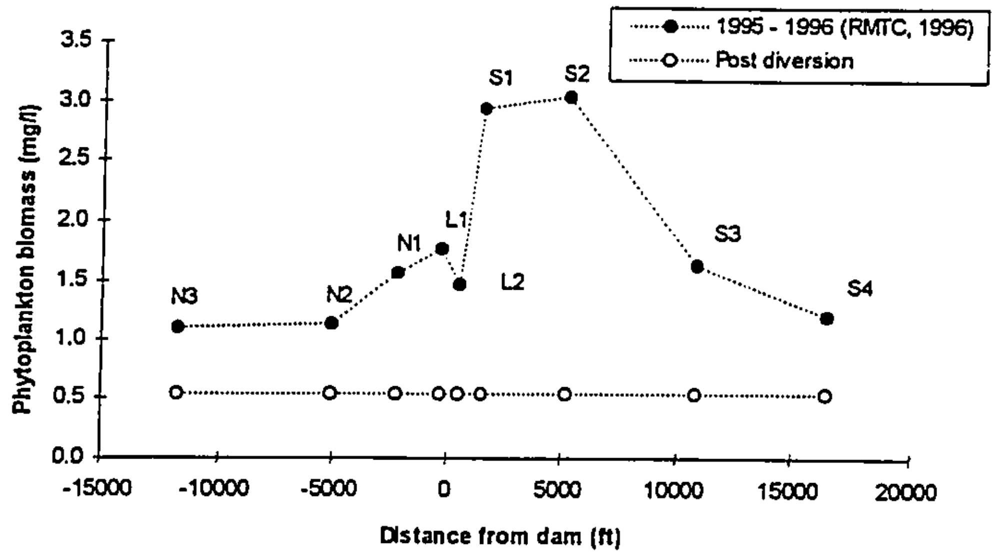


Figure 3-1. Estimated Distribution of Phytoplankton Biomass Currently and After Diversion of Surface WWTP Effluent Discharge into Deep Water in Wahiawa Reservoir.

Water clarity is expected to improve and, therefore, Secchi depth as the result of changes in the phytoplankton population. The greatest increase in Secchi depth will be in the western portion of the southern fork of the reservoir. The average increase in Secchi depth for the reservoir on the whole should be on the order of about 22 percent, increasing from the present mean depth of 1.09 m to an average of about 1.33 m during the post-diversion period.

The discussion thus far has focused on the expected effects of changes in particulate matter in the surface waters of Wahiawa Reservoir. However, changes in phytoplankton biomass levels could also affect dissolved oxygen (DO) levels since phytoplankton produce oxygen during the daylight hours and respire (i.e., consume oxygen) twenty-four hours per day. Further, changes in photosynthesis levels (i.e., primary productivity) might secondarily influence pH levels in the reservoir, as the uptake of carbon dioxide in photosynthesis tends to raise pH levels.

A comparison of DO per unit chlorophyll α with actual chlorophyll α concentrations demonstrates a marked decline in DO produced as chlorophyll levels increase in the reservoir (Figure 3-2). The implication here is that high chlorophyll (biomass) levels in the reservoir result in a self-shading effect to the extent that the production of DO from photosynthesis is restricted. In short, at high phytoplankton concentrations in the reservoir, light becomes a primary factor limiting primary productivity.

The notion that primary productivity in the reservoir is light-limited is further supported by the vertical distribution of DO. A typical DO profile is shown in Figure 3-6. Note that DO decreases rapidly from the surface to a depth of about 4 meters as the penetration of light decreases due to absorption by particulate matter (detritus and phytoplankton). At a depth of 4 meters DO is nearly undetectable, indicating that respiration demands exceed the rate of photosynthesis due to lack of light. The increase in DO below 7 meters results from advective movement of cooler, denser water from the North and South forks of Kaukonahua Stream along the bottom of the reservoir.

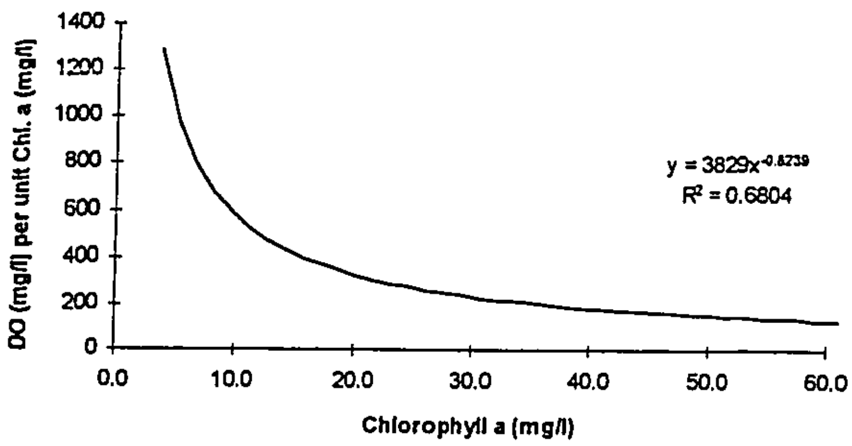


Figure 3-2. An Index of DO per unit Chlorophyll α versus Chlorophyll α Concentration in Wahiawa Reservoir.

An estimate of DO production as a function of chlorophyll α levels for Wahiawa Reservoir is shown in Figure 3-3 based upon data from the RTMC study (1996). The shape of the curve serves to point out

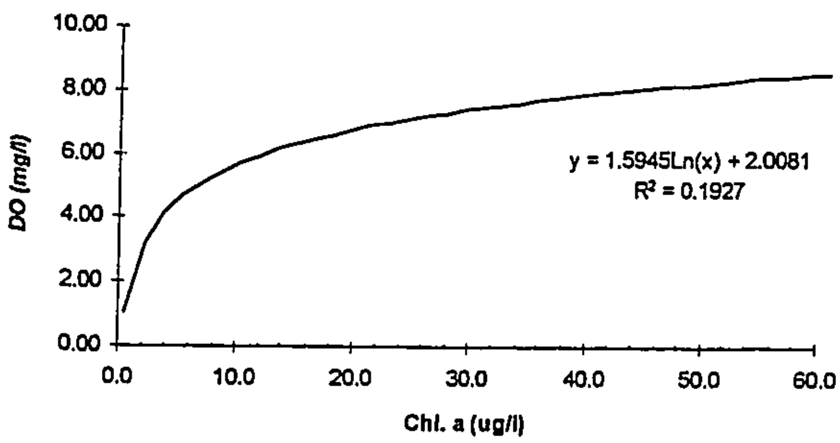


Figure 3-3. Estimated DO Production as a Function of Chlorophyll α Concentration in Wahiawa Reservoir.

an important feature of phytoplankton dynamics in the reservoir; i.e., at low phytoplankton biomass levels (low chlorophyll concentrations) there is a rapid increase in DO production (primary productivity) per unit increase in phytoplankton biomass. At a chlorophyll α concentration of about 8 μg/l, the relative increase in DO levels starts to slow perceptibly and indicates that primary productivity in the reservoir is now becoming limited by light availability due to self-shading of the phytoplankters. Therefore, a decrease in chlorophyll α levels from the present average of 26.3 μg/l to the projected level of about 8 μg/l following effluent diversion (see above) should result in a decrease in DO production from about 7.2 mg/l to about 5.3 mg/l. However, since DO respiration decreases linearly with chlorophyll α levels, there should be about a 2.5 factor decrease in respiration. The end result will likely be higher DO concentrations in the surface waters than presently exist.

The vertical profiles of DO in the reservoir (Towill, 1996) show that DO concentrations are typically high in the upper 0.5 m of the water column and then fall to low levels by 3 m depth indicating that light limits net primary productivity (DO production) to the upper 3 m of the water column. The exception to this is found at two stations (Stations S4 and N3) where DO levels may remain high throughout the shallow water column. This is due to the input of stream water which contains relatively high DO levels upstream of these two stations, rather than from the effects of photosynthesis..

pH levels in eutrophic impoundments are often influenced by phytoplankton productivity, rising in proportion to the amount of carbon dioxide removed from the water column during photosynthesis (DO production). This is the case in Wahiawa Reservoir (Figure 3-4) where the mean pH on a given date can rise to levels greater than pH = 9. *As discussed above, it is possible that DO levels in the reservoir*

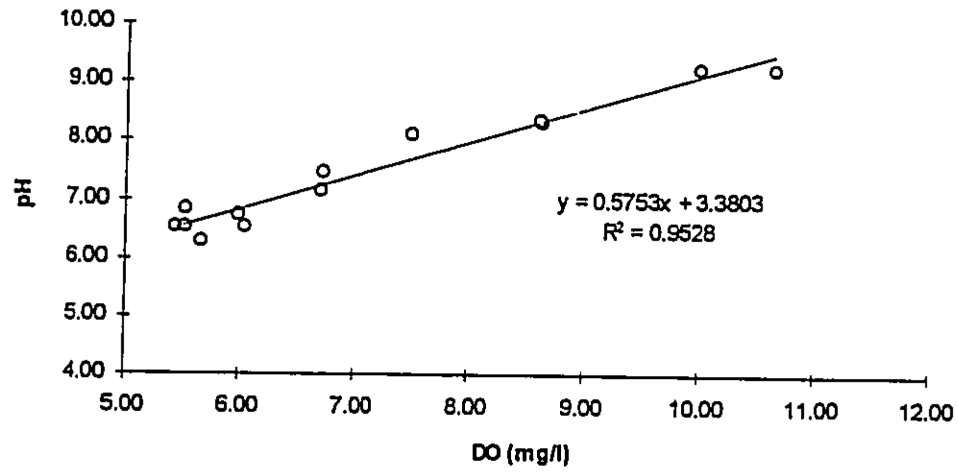


Figure 3-4. A comparison of Mean DO and pH Levels in Wahiawa Reservoir.

will rise to higher concentrations in the post-diversion period. However, since this increase in DO will be a function of reduced phytoplankton respiration, there should be no concomitant rise in pH. In fact, if the mean DO concentration via photosynthesis is reduced to about 5.3 mg/l (see above) then mean pH levels should fall to about pH = 6.4.

A careful reading of the above discussion reveals an apparent contradiction. It is stated that a reduction in phytoplankton biomass will result from a decrease in surface concentrations of phosphates upon diversion of the Wahiawa WWTP effluent. It is then concluded that light presently limits photosynthesis in the surface waters of the impoundment. However, only one factor can be limiting at any given time. Light limits the ***rate***, or speed, at which primary productivity takes place in the reservoir. However, because the detention time of the surface waters is long (weeks) compared with the potential turnover rate, or doubling-time, for phytoplankton (a few days), phytoplankton biomass continues to accumulate in the reservoir; albeit, at a reduced rate compared with its potential. This biomass increase continues until the available nutrient resource (in the present situation, phosphorus) is depleted. After diversion of the effluent, nitrogen will be the nutrient in shortest supply in the surface waters of the reservoir.

The discussion of impacts considers the most apparent factors which would influence water quality conditions in the epilimnion of Wahiawa Reservoir once the Wahiawa WWTP discharge is effectively diverted to deep water. There are many other factors which may ultimately contribute to the post-diversion water quality of the reservoir, but they are either poorly understood or there is no pertinent data upon which to base meaningful forecasts.

b. Effect on Bottom (Hypolimnion) Water

The primary environmental/water quality issue in the diversion of the Wahiawa WWTP effluent to the bottom waters of Wahiawa Reservoir is the maintenance of aerobic conditions in the hypolimnion.

Under present conditions, the distribution of DO in the bottom waters is shown in Figure 3-5. There is notable decrease in DO concentration moving from the upstream stations of both forks of the reservoir towards the dam. The higher average DO concentration at Station N3 on the north fork, as compared with Station S4 on the south fork, probably results from higher DO inputs from North Kaukonahua Stream (mean = 8.9 mg/l) as compared with the South Kaukonahua Stream (mean = 7.8 mg/l) (*AECOS*, 1995).

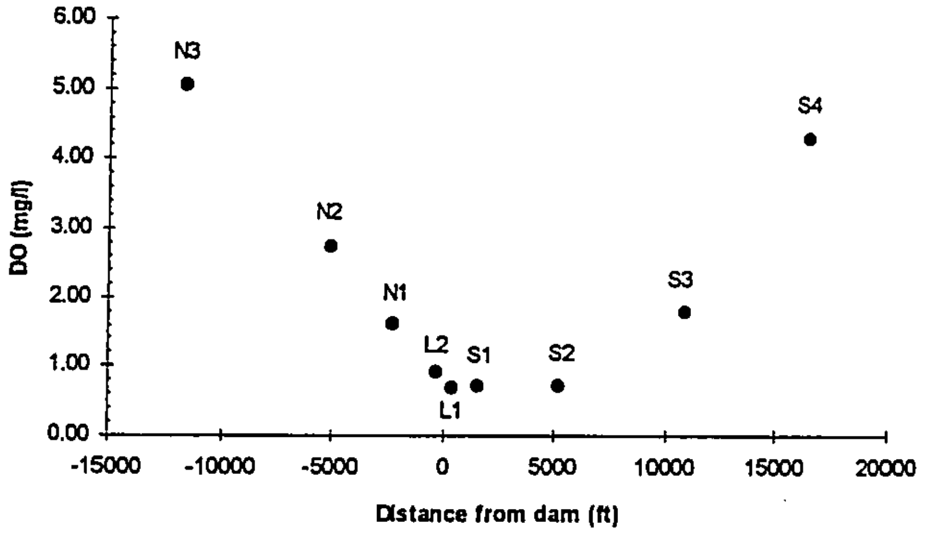


Figure 3-5. Mean distribution of DO (mg/l) in the Bottom Waters of Wahiawa Reservoir (data from RMTC, 1996)

The difference in DO patterns between the two arms of the reservoir is due to the effects of the WWTP discharge on the hypolimnic waters of the south fork. Since the epi- and hypolimnic waters of the reservoir are separated by a thermocline, nutrients must be transported into the bottom waters as particulate matter by settling through the thermocline. (Nutrients in a soluble form will not pass through the thermocline.)

In the case of nitrogen, organic nitrogen is first broken down into ammonia (Manahan, 1994). In the presence of oxygen, ammonia can be further oxidized (nitrified) by two groups of bacteria. *Nitrosomonas* bacteria bring about the conversion of ammonia to nitrite and *Nitrobacter* mediate the oxidation of nitrite to nitrate (Loke, 1966). The distribution of various nitrogen components in the hypolimnion of Wahiawa Reservoir is shown in Figure 3-6.

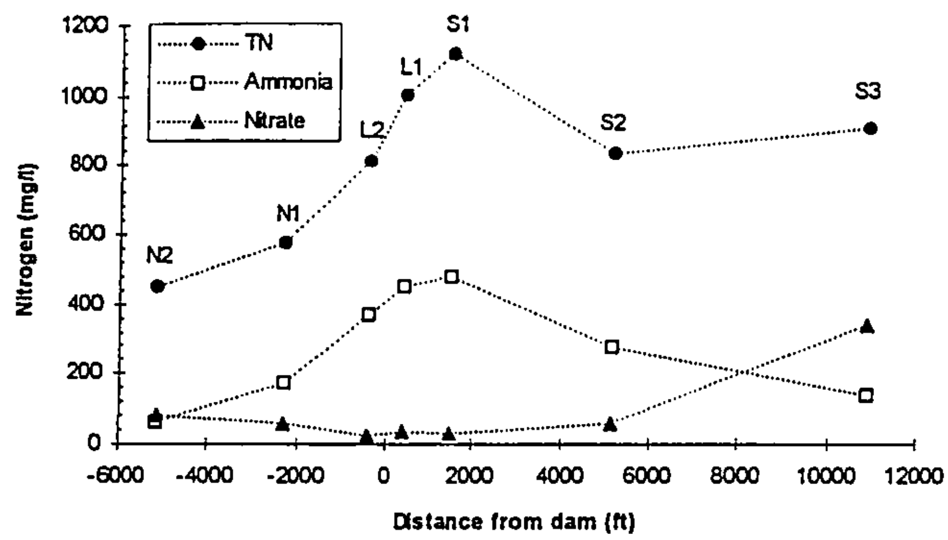


Figure 3-6. Mean Distribution of Various Nitrogen forms (mg/l) in the Bottom Waters of Wahiawa Reservoir (data from RMTC, 1996)

Thus, most of the DO consumption in the hypolimnion can be accounted for by the aerobic breakdown of organic nitrogen material to ammonia. Nitrification of ammonia to nitrate + nitrite is suppressed throughout much of the reservoir due to low DO levels.

The mean distribution of ammonia in the bottom waters pretty well mimics that of TN, except at Station S3, while nitrate levels are very low in areas of low DO concentration (Figure 3-6) and rise somewhat as DO levels increase; especially at Station S3. Since ammonia is the first breakdown product of organic nitrogen, it appears that production of ammonia is consuming most of the available DO in the hypolimnion. This is supported by a comparison of mean ammonia and DO distribution in the bottom waters (Figure 3-7) which demonstrates a significant correlation ($r = 0.969$; at $P = 0.05$ with d.f. = 6 and $\alpha = 0.707$).

Proposed modifications to the existing activated sludge aeration process will reduce the organic content of the waste and through nitrification and denitrification should produce an effluent that is relatively low in ammonia and nitrate + nitrite. This provides two major benefits to the hypolimnion: 1) the DO demand for nitrification of ammonia to nitrate + nitrite would be minimized; and 2) if high levels of nitrate + nitrite occur, this would provide a secondary oxidizing agent in the event that DO depletion occurs.

Nutrient levels in the hypolimnion can also be influenced to some degree by interaction with the sediments. There are two basic types of sediment in Wahiawa Reservoir; those that are introduced with stream inputs and runoffs and are the typical latosols found in Hawaii (Sherman, 1955), and the high organic particulate matter produced in the epilmnion that rains down through the water column to the bottom. A decrease in organic particulate matter transported from the epilimnion to the hypolimnion by diverting the WWTP discharge to the bottom waters would also result in some improvement to the reservoir sediments.

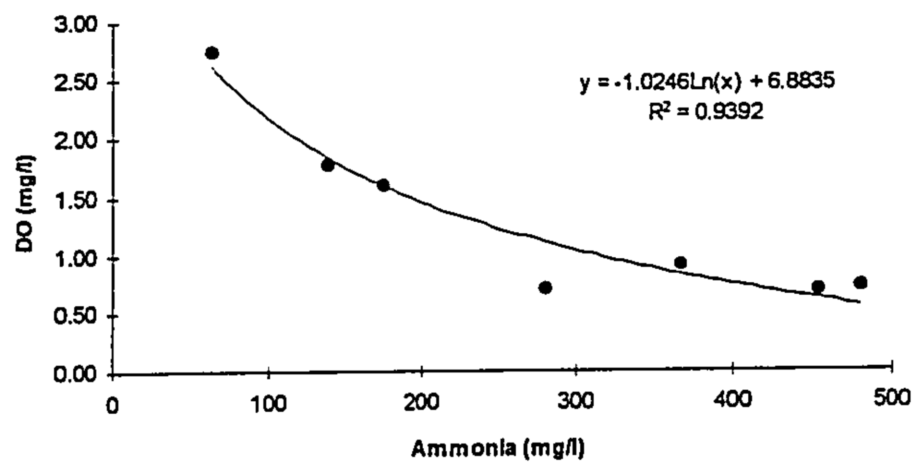


Figure 3-7. A Comparison of the Mean DO (mg/l) and Ammonia Levels (mg/l) In the Bottom Waters of Wahiawa Reservoir.

6. Agricultural Reuse

Since groundwater on Oahu is expected to be less available in the future, the demand for reclaimed water may increase significantly. In the long-term, high-quality reclaimed water may become a marketable resource.

The Board of Water Supply is concerned that agricultural reuse of reclaimed water over basal aquifers could, in the long-term, compromise the quality of potable groundwater. The DOH guidelines list five criteria to prevent degradation of aquifers:

1) reduce concentrations of pathogenic bacteria, parasites, and enteric viruses ...;
2) control the concentration of organic compounds ...;
3) control the concentration of inorganic chemicals, with the exception of nitrogen ...;
4) control the concentration of biostimulants such as nitrogen and phosphorus...;
5) application of reclaimed water over an aquifer which is used as the domestic water supply will be restricted to deficit water budget.

The proposed modifications to the Wahiawa WWTP will produce an effluent that achieves the first three criteria and, when combined with water in the reservoir, will yield better quality non-potable water. Results of quantitative modeling indicates that a longer outfall discharging at a deeper location in the reservoir coupled with process modifications at the plant would reduce nitrogen and phosphorus concentrations in the effluent. The fifth criterion, restricting application of reclaimed water over an aquifer which is used as the domestic water supply cannot be avoided if Dole is to continue its agricultural pursuits and use inexpensive non-potable water for irrigation purposes. Waialua Sugar Company and now Dole have been using reclaimed water for irrigation since 1929 and continues to do so. The Board of Water Supply is aware that over draft from improperly designed wells for sugar cane irrigation has resulted in increasing salinity of the Waialua aquifer (Ibid). Given the demise of sugar cane, there should be less draw down of groundwater with a resultant decrease in salinity. Over time, changes in salinity can be confirmed from chloride concentrations found in existing municipal wells or exploratory wells to be drilled in the area in the near future.

The quality of the secondary effluent (equivalent to R-2 water) produced at the Wahiawa WWTP complies with the effluent limitations contained in the expired NPDES permit for the plant. In the future, the Wahiawa WWTP will produce R-1 water for which there are more approved applications than R-2 water. The proposed project will continue to provide the end user with a high quality source of irrigation water for their diversified agricultural ventures in North Central Oahu and the North Shore.

SECTION 4
WASTEWATER DISPOSAL ALTERNATIVES

Between 1987 and 1997, the City and County of Honolulu completed several engineering and environmental studies that evaluated treatment and effluent disposal alternatives for the Wahiawa WWTP. These studies included:

- Final Environmental Impact Statement for the Waialua-Haleiwa Wastewater Facility Plan. Prepared by Belt Collins & Associates, May 1987.
- Report on the Wahiawa Wastewater Treatment Plant Diversion at Wahiawa, Oahu, Hawaii. Prepared by Calvin Kim & Associates, November 1992.
- Preliminary Environmental Assessment - Wahiawa Wastewater Treatment Plant Diversion. Prepared by Calvin Kim & Associates and Gerald Park Urban Planner, January 1994.
- Volume II Report on the Wahiawa Wastewater Treatment Plant Diversion at Wahiawa, Oahu, Hawaii-Tertiary Facilities. Prepared by Calvin Kim & Associates and Brown and Caldwell, October 1995.
- Final Environmental Impact Statement for the Supplemental Waialua-Haleiwa Wastewater Facility Plan. Prepared by Hydro Resources International, June 1996.
- Wahiawa Effluent Reuse for Central Oahu, Environmental Impact Statement Preparation Notice. Prepared by GMP Associates, December 1996.

Based on the above studies, nine treatment and disposal alternatives for the Wahiawa WWTP were evaluated to determine the most viable options for the City to consider. These alternatives were derived by considering and combining three basic variables: (1) the level of treatment; (2) method of treatment; and (3) the method of disposal. Primary treatment, secondary treatment (existing), or tertiary treatment were the three options that were possible with respect to the level of treatment. Among the different treatment methods, the wastewater could be treated biologically through conventional treatment mechanisms or through a constructed wetlands system. Once treated, the effluent could be discharged through four different disposal options which included: Wahiawa Reservoir (existing); a new North Shore Outfall; the existing Honouliuli Ocean Outfall; or direct agricultural reuse. The nine alternatives were discussed in an Environmental Impact Statement Preparation Notice for the Wahiawa Effluent Reuse for Central Oahu published in 1997.

The Joint Agency Wastewater Task Force developed several alternatives and further evaluated the three lead alternatives for treating and disposing of wastewater from the Wahiawa WWTP and the Schofield Barracks WWTP. The three lead alternatives were labeled Reuse Reservoir, Constructed Wetlands, and the Wahiawa Diversion Line. The City and U.S. Army selected the Wahiawa Diversion Line as the preferred alternative. Subsequent to this selection, the City and the Army were not able to jointly negotiate an agreement to the satisfaction of both parties (Department of the Army, 1999) and the City was left to proceed with a treatment and disposal solution alone.

In total and over a period of 12 years, the City, either on its own or jointly with the U.S. Army, developed twelve alternatives including a no action alternative for resolving its effluent disposal problem. The preferred alternative, which was recommended by the JAWWTF, was to divert flows entirely out of Central Oahu (Wahiawa Diversion Line). The alternatives are summarized below.

A. City and County of Honolulu Alternatives

Alternative 1: No Action (Continued Discharge of Effluent Into Wahiawa Reservoir Following Secondary Treatment)

The "No Action" alternative would continue the discharge of disinfected secondary treated effluent into Wahiawa Reservoir as is currently practiced. Under a no action alternative, the City faces the imposition of fines for discharging without an NPDES Permit in violation of the Clean Water Act.

Alternative 2: Discharge Effluent into Wahiawa Reservoir Following Conventional (Mechanical) Tertiary Treatment and Disinfection At An Upgraded Wahiawa WWTP.

The Wahiawa WWTP would be upgraded to provide tertiary facilities at the existing plant site. Additional unit processes would be constructed to produce R-1 quality effluent. Treated effluent would be discharged into the reservoir via a new outfall to be constructed at a deeper location.

Alternative 3: Reclamation for Agricultural Irrigation Following Conventional (Mechanical) Tertiary-Level Treatment at an Upgraded Wahiawa

Similar to Alternative 2, the Wahiawa WWTP would be upgraded to tertiary treatment by the addition of unit processes. However, instead of discharging the treated effluent into Wahiawa Reservoir, the effluent would be directly discharged into an irrigation system for agricultural reuse. During periods of extended wet weather, the reclaimed water may need to be discharged into Wahiawa Reservoir where it would be retained until needed for irrigation.

Alternative 4: Reclamation for Agricultural Irrigation Following Disinfection and Tertiary Treatment in a Constructed Wetland at the Dole Site

Secondary treated and disinfected effluent from the Wahiawa WWTP would be discharged into a constructed wetland for further nutrient removal. The area proposed for the construction of the wetlands is located between Kaukonahua Road and Kaukonahua Gulch approximately 3 miles to the northwest of the Wahiawa WWTP. This alternative was found to be cost prohibitive and would not meet the time constraint set by the Consent Decree.

Alternative 5a: Discharge Effluent into Wahiawa Reservoir Following Disinfection and Tertiary Treatment in a Constructed Wetland at the Galbraith Estate Site

Secondary treated and disinfected effluent from the Wahiawa WWTP would be discharged into a constructed wetland at the Galbraith Estate site just north of Wahiawa for further nutrient removal. Following wetland treatment, the effluent would be discharged into Wahiawa Reservoir through a new outfall located at a deeper location than the existing outfall. The current ditch systems would then convey water from Wahiawa Reservoir to sugar cane crops or diversified agricultural products for irrigation.

Opposition to the development of a wetland treatment system on productive agricultural lands and in proximity to culturally significant lands caused the City to withdraw this option.

Alternative 5b: Reclamation for Agricultural Irrigation Following Tertiary Treatment In a Constructed Wetland at the Galbraith Estate Site

As in Alternative 5a, disinfected secondary treated effluent from the Wahiawa WWTP would be discharged into a constructed wetland for further nutrient removal at the Galbraith Estate site. The effluent would then be directly discharged into an irrigation system for agricultural reuse.

This alternative was dropped from further consideration since the construction of wetlands on the Galbraith Estate lands was strongly opposed by members of the business community.

Alternative 6: Discharge Through the Deep Ocean Outfall at the Honouliuli WWTP

Untreated wastewater would be diverted from the Wahiawa WWTP to the Honouliuli WWTP for treatment and disposal through the Honouliuli ocean outfall or beneficial use for agricultural irrigation on the Ewa Plain. The Wahiawa WWTP would be converted to a preliminary treatment facility since secondary treatment would no longer be needed. A 14-mile pipeline would be constructed connecting the Wahiawa WWTP with the Honouliuli WWTP.

Alternative 7: Discharge Through a New Ocean Outfall in the Waialua-Haleiwa Area

Effluent from the Wahiawa WWTP would be transported via a diversion line to the Waialua-Haleiwa area and discharged through a new outfall into the ocean. The City had originally proposed the construction of a new ocean outfall in the Mokuleia area to dispose of the wastewater generated by the Waialua-Haleiwa community following treatment at a new centralized facility (Belt Collins & Associates, 1987). The outfall was proposed to extend approximately 3,600 feet offshore in Kaiaka Channel at a depth of 80 feet. The advantages to an ocean outfall include a permanent disposal option for the effluent with relatively low maintenance costs. However, the Mokuleia ocean outfall proposal was abandoned by the City since it was received with much criticism and strong opposition from the North Shore community. In addition it would be difficult and costly to build in a high surf area and construction could not meet the deadline set by the Consent Decree.

Alternative 8: Discharge Effluent into Wahiawa Reservoir After Being Treated in a Jointly Operated/Financed City and County of Honolulu-U.S. Army Tertiary Treatment Facility

Effluent from the Wahiawa WWTP and the Schofield Barracks WWTP would be treated at a new tertiary facility to be jointly planned, designed, constructed, and operated by the City and the U.S. Army. The effluent would be discharged into Wahiawa Reservoir through a new outfall to be located at a deeper location in the reservoir than the existing one. Water from Wahiawa Reservoir would then be conveyed through existing ditch systems for irrigation of diversified agricultural crops. Liability and cost issues could not be resolved in time and time constraints precluded working with the Army.

Alternative 9: Reclamation for Agricultural Irrigation After Being Treated in a Jointly Operated/Financed City and County of Honolulu-U.S. Army Tertiary Treatment Facility.

Similarly to Alternative 8, effluent from the Wahiawa WWTP and the Schofield Barracks WWTP would be treated at a new tertiary facility to be jointly planned, designed, constructed, and operated by the City and the U.S. Army. Following tertiary treatment, the reclaimed water would be applied to agricultural areas. The reclaimed water would need to be transported to an irrigation reservoir for temporary storage, or the water may be directly discharged into a ditch irrigation system for immediate use. Liability and cost issues could not be resolved in time and time constraints precluded working with the Army.

B. Joint Agency Wastewater Task Force Alternatives

Alternative 1: Reuse Reservoir Alternative

The Wahiawa WWTP would be upgraded to produce R-1quality effluent and continuously discharge the effluent into the Wahiawa Reservoir through a new deep outfall. Water from the reservoir would be conveyed to the existing irrigation ditch system owned by Dole for irrigation of sugar cane or diversified agriculture crops. This alternative is based on a computational water quality model initiated by the Army for the Wahiawa Reservoir which evaluated different treatment and disposal scenarios for the Wahiawa WWTP and Schofield WWTP. Results from the modeling indicated that the existing water quality of the Wahiawa Reservoir would be notably improved if R-1 effluent from the Wahiawa is discharged through a new, deeper outfall located in the same vicinity of the existing discharge (Towill, 1997).

Alternative 2: Constructed Wetlands

Under this alternative, a wetland/soil filter system would be constructed on approximately 270 acres of land owned by Dole to the north of Wahiawa. Effluent from the Wahiawa WWTP would be continuously discharged into this wetland/soil filter system for further nutrient removal. The effluent entering the wetland treatment system would need to be of R-1 quality in order to achieve the stringent water quality standards for streams. Thus, the Wahiawa WWTP would be upgraded to provide additional treatment processes.

Tailwater from the wetlands would be directed towards Dole's irrigation ditch system and would be used for irrigation of agricultural lands. If the tailwater was not used for irrigation, the DOH would not guarantee that discharge into Kaukonahua Stream would be allowed. During wet-weather conditions, the effluent would also be discharged directly into the stream. The constructed wetlands are expected to significantly reduce the nutrients from the effluent prior to discharge into the irrigation ditch or Kaukonahua Stream.

Alternative 3: Wahiawa Diversion Line

Wastewater would be diverted by pipeline from the Wahiawa WWTP to the Honouliuli WWTP for treatment and ocean disposal through the Honouliuli Ocean Outfall or reused for irrigation on the Ewa Plain. The Wahiawa WWTP eventually would be converted to a pump station with preliminary treatment providing screening, degritting, and flow equalization. The approximately 14 mile long pipeline would begin at the Wahiawa WWTP, cross under Wahiawa Reservoir, run parallel to Kunia Road and Fort Weaver Roads, and on to the Honouliuli WWTP.

Alternative 4: No Action

Effluent from the Wahiawa WWTP would continue to be discharged into Wahiawa Reservoir following its present level of secondary treatment. Under a no action alternative, the DOH will not issue an NPDES permit and the City faces the imposition of fines for discharging effluent without and NPDES permit in violation of the Clean Water Act.

SECTION 5
PERMITS AND APPROVALS

Authority	Permit
Federal	
US Army Corps of Engineers, Honolulu District	Department of the Army Permit for Activities in Waterways
State of Hawaii	
Board of Land and Natural Resources	Conservation District Use Application
Board of Land and Natural Resources	Dam Construction/Alteration Permit
Commission on Water Resources Management, DLNR	Instream Uses of Water: Petition to Amend Interim Instream Flow Standard, Permits for Stream Channel Alteration and Diversion Works
Department of Health	NPDES Permit
Department of Health	Effluent Discharge-Zone of Mixing Approval
Department of Health	Section 401 Water Quality Certification (WQC)
Department of Health	NPDES General Permits Discharge of Hydrotesting Water Discharges Associated with Construction Activities Discharges Associated with Construction Activities Dewatering
Department of Health	Variance From Pollution Controls
Department of Health	Variance to Treatment Unit Distance Requirements
Office of Planning	Hawaii Coastal Zone Management Program Federal Consistency
City and County of Honolulu	
Department of Planning and Permitting	Grubbing, Grading, and Stockpiling
Department of Planning and Permitting	Construction Dewatering Permit (Temporary)
Department of Planning and Permitting	Building Permit for Building, Electrical, Plumbing Sidewalk/Driveway and Demolition Work
Department of Planning and Permitting	Waiver of Requirements

SECTION 6
AGENCIES AND ORGANIZATIONS CONSULTED IN PREPARING THE ENVIRONMENTAL ASSESSMENT

The Draft Environmental Assessment for the Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment was published in the Office of Environmental Quality Control Environmental Notice of December 8, 1998 and December 23, 1998. Publication in the Environmental Notice initiated a 30-day public review period which ended on January 7, 1999. The Draft Environmental Assessment was mailed to agencies and organizations listed below. An asterisk * identifies agencies and organizations that submitted written comments during the comment period. All comment letters and responses are found in Appendix D.

Federal

U.S. Department of the Interior
    Fish and Wildlife Service
*U.S. Army Corps of Engineers, Honolulu Engineer District
*U.S. Army Garrison, Hawaii
U.S. Army Pacific
U.S. Department of Agriculture
    Natural Resources Conservation Service
U.S. Environmental Protection Agency, Region IX

State of Hawaii

Department of Agriculture
Department of Health
    *Environmental Management Division
Department of Land and Natural Resources
    Aquatic Resources Division
    *Commission on Water Resources Management
    *Historic Sites Division
    *Land Management Division
    *Division of State Parks
Department of Transportation
Office of Environmental Quality Control
Office of Hawaiian Affairs
Office of Planning
University of Hawaii
    Environmental Center
    Water Resources Research Center

City and County of Honolulu

*Board of Water Supply
*Department of Planning and Permitting
*Department of Facility Maintenance

Department of Transportation Services

Organizations and Individuals

Association of Freshwater Fishing Anglers
Del Monte Fresh Produce (Hawaii) Inc.
*Dole Food Company Hawaii/Wahiawa Water Company, Inc.
Earth Justice Legal Defense Fund
The George Galbraith Trust
Hawaii Freshwater Fishing Association
Hawaiian Civic Club of Wahiawa
Hawaiian Electric Company
ILWU Local 142
Honorable Rene Mansho, City Council
Honorable Mufi Hannemann, City Council
*Honorable Randall Iwase, 18th Senatorial District
Honorable Robert Bunda, 22nd Senatorial District
Honorable Marilyn Lee, 38th Representative District
Honorable Ron Menor, 39th Representative District
*Honorable Marcus Oshiro, 40th Representative District
Wahiawa Community and Businessmens Association
Wahiawa Neighborhood Board No. 26
Wahiawa Wastewater Advisory Committee

SECTION 7
DETERMINATION OF SIGNIFICANCE

Title 11, Chapter 200 (Environmental Impact Statement Rules), Administrative Rules of the State Department of Health, establishes criteria for determining whether an action may have significant effects on the environment (§11-200-12). The relationship of the proposed project to these criteria is discussed below.

1) Involves an irrevocable commitment to loss or destruction of any natural or cultural resource;

No natural or cultural resources are known to be located on the grounds of the Wahiawa WWTP.

Wahiawa Reservoir is a man-made resource for impounding irrigation water. Although designated Conservation and under the jurisdiction of the Department of Land and Natural Resources, there are no natural resources that would be lost or destroyed by construction in the reservoir. If necessary, measures will be implemented to keep aquatic life away from the construction area.

The reservoir is a popular freshwater fishing area stocked with freshwater game fish introduced by man.

2) Curtails the range of beneficial uses of the environment;

The proposed project will not curtail the use of Wahiawa Reservoir for fishing and other recreational pursuits. The site of the current outfall is a popular fishing spot because fish congregate at the surface discharge. Public access to the outfall and lakeside areas will continue to be allowed through a gate in the fence surrounding the treatment plant.

3) Conflicts with the state's long-term environmental policies or goals and guidelines as expressed in chapter 344, Hawaii Revised Statutes, and any revisions thereof and amendments thereto, court decisions or executive orders;

The project does not conflict with long-term environmental policies, goals, and guidelines of the State of Hawaii. The objectives of the proposed project are declared in the Consent Decree, to wit "to provide a long-term reliable solution for effluent disposal from the Wahiawa WWTP, to improve reservoir water quality, and to promote resource conservation through wastewater reclamation." These objectives and the actions to be taken to achieve the objectives, are consistent with applicable Chapter 344 policies and guidelines for controlling pollution, preserving natural resources, safeguarding the environment, and conserving and utilizing natural resources.

4) Substantially affects the economic or social welfare of the community or State;

The proposed project commits $10 million dollars of public funds to improve wastewater treatment for reclamation purposes. The project supports both State of Hawaii and City and County of Honolulu policy to promote the use of reclaimed water for non-potable application (agricultural irrigation for example) as a means to conserve Oahu's potable water supply. Dole Foods Hawaii is the principal user of reservoir water. The R-1 water to be produced provides them with a high quality source of water for their diversified agricultural ventures in north Central Oahu and the North Shore.

5) Substantially affects public health;

Short-term, construction related impacts on air quality and the acoustical environment are anticipated. Construction at the treatment plant site or in Wahiawa Reservoir will comply with all applicable public health regulations and measures to mitigate potential adverse impacts.

6) Involves substantial secondary impacts, such as population changes or effects on public facilities,

Substantial secondary impacts such as population changes or effects on public facilities are not anticipated. When the project is completed as stipulated in the Consent Decree, a four-year moratorium on sewer connections in Wahiawa may be lifted. The Wahiawa WWTP is designed to accommodate the current Development Plan population for Wahiawa and is currently operating below capacity. If new sewer connections are allowed, landowners and builders are expected to undertake primarily new residential construction within the service area. Connections to the sewer system will be allowed until such time that the City determines that the plant is nearing its treatment capacity. At that time, new connections will not be allowed or the capacity of the plant will have to be expanded.

7) Involves a substantial degradation of environmental quality;

Modifications to the treatment plant will be limited to the existing site which has been altered by construction of the existing treatment plant in 1929 and the additions and improvements made to the plant since that time.

Water quality in the reservoir will be degraded temporarily by construction of the underwater outfall. Bottom sediments will be disturbed and turbid conditions in the vicinity of the outfall are expected both during and following construction. Measures will be taken to confine suspended sediment to the work site. Following construction "normal" water conditions should be restored in several weeks. Most of the underwater section of the outfall will be placed atop the sloping bank to minimize ground disturbance.

8) Is individually limited but cumulatively has considerable effect upon the environment or involves a commitment for larger actions;

The R-1 water to be produced is the highest level of reclaimed water prescribed in DOH guidelines. R-1 water is considered safe for human contact whereas the present disinfected secondary treated effluent is not. If R-1 water is of higher quality than disinfected secondary effluent and the higher quality water is discharged into the reservoir, then improvements in the quality of the receiving waters can be expected. Modeling of a deep water outfall (rather than surface outfall) and analysis of the effect of R-1 water on water quality parameters indicate that water quality will improve over time with the better treatment, longer outfall, and deep water discharge. Improvements in water quality will be most evident in the surface waters of the reservoir (since the existing surface discharge will be removed) and sediment quality of the bottom of the reservoir should improve.

9) Substantially affects a rare, threatened or endangered species, or its habitat;

There are no rare, threatened or endangered flora and fauna or its habitat at the Wahiawa WWTP or in Wahiawa Reservoir. Beginning in the 1950s, the DLNR has and continues to stock the reservoir with freshwater sport fish. According to the DLNR, "the most difficult and serious issue in the reservoir is the unplanned introduction of alien species by private individuals."

10) Detrimentally affects air or water quality or ambient noise levels; or

During construction, ambient air quality will be affected by fugitive dust and some combustion emissions but can be controlled by measures stipulated in this Assessment. Construction noise will be pronounced during site preparation work at the treatment plant site but should diminish following site preparation and concrete work. Pile driving is required to secure the end of the outfall at a deeper location in the reservoir. Pile driving noise will be audible in locations surrounding the work site and may be "amplified" because of the gulch-like setting and the relative quiet of a waterside environment. Actual pile driving is projected to take approximately two weeks. With the exception of pile driving, construction activities will comply with air quality and noise pollution regulations of the State Department of Health.

Best Management Plans will be prepared to minimize construction runoff.

11) Affects or is likely to suffer damage by being located in an environmentally sensitive area such as a flood plain, tsunami zone, beach, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal waters.

The Wahiawa WWTP is not located in an environmentally sensitive area. Wahiawa Reservoir, which is fed by stream water, surface runoff, rainfall, and disinfected wastewater effluent, is considered an irrigation reservoir.

12) Substantially affects scenic vistas and viewplanes identified in county or state plans or studies; or,

The proposed improvements will not affect scenic vistas and view planes identified in County plans.

13) Requires substantial energy consumption.

Modifications to unit processes at the treatment plant will increase electrical loads for the facility. The projected future load of 503 KVA is much larger than available capacity on the present electrical system and existing service to the facility will need to be upgraded.

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APPENDIX A

DEFINITION AND ALLOWABLE USES OF R-1 WATER

Guidelines for the Treatment and Use of Reclaimed Water
Department of Health, November 1993

Revisions to the *Definitions of Reclaimed Water* in the Guidelines for the Treatment and Use of Reclaimed Water dated November 22, 1993.

"R-1 Water (Significant reduction in viral and bacterial pathogens)" means reclaimed water that has been oxidized, filtered, and disinfected to meet the following criteria:

A. A disinfection process that, when combined with the filtration process, has been demonstrated to reduce the concentration of plaque-forming units of F-specific bacteriophage MS2, or polio virus, per unit volume of water in the wastewater to one ten thousandth (1/10,000) of the initial concentration in the filter effluent throughout the range of qualities of wastewater that will occur during the reclamation process. A virus that is at least as resistant to disinfection as polio virus may be used for purposes of the demonstration.

B. Fecal coliform bacteria densities as follows:

(1) The median density measured in the disinfected effluent does not exceed 2.2 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed; and

(2) The density does not exceed 23 per 100 milliliters more than one sample in any 30-day period; and

(3) No sample shall exceed 200 per 100 milliliters.

"R-2 Water (Disinfected Secondary-23 Reclaimed Water)" means reclaimed water that has been oxidized, and disinfected to meet the following criteria:

A. Fecal coliform bacteria densities as follows:

(1) The median density measured in the disinfected effluent does not exceed 23 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed; and

(2) The density does not exceed 200 per 100 milliliters in more than one sample in any 30-day period.

"R-3 Water (Undisinfected Secondary Reclaimed Water)" means oxidized wastewater.

SUMMARY OF SUITABLE USES FOR RECLAIMED WATER

SUITABLE USES FOR RECLAIMED WATER	R1	R2	R3
IRRIGATION: (S)pray, (D)rip & Surface, S(U)bsurface, (A)ll=S D & U, Spray with (B)uffer, (N)ot allowed, /or			
Golf course landscape	A	U/B	N
Freeway and cemetery landscapes	A	A	N
Parks, elementary schoolyards, athletic fields and landscape around some residential property	A	U	N
Roadside and median landscape	A	U/B	N
Non-edible vegetation in areas with limited public exposure	A	AB	U
Sod farms	A	AB	N
Ornamental plans for commercial use	A	AB	N
Food crops above ground & not contacted by irrigation	A	U	N
Pastures for milking and other animals	A	U	N
Fodder, fiber, and seed crops not eaten by humans	A	AB	DU
Orchards and vineyard bearing food crops	A	D/U	DU
Orchards and vineyards not bearing food crops during irrigation	A	AB	DU
Timber and trees not bearing food crops	A	AB	DU
Food crops undergoing commercial pathogen destroying process before consumption	A	AB	DU
SUPPLY TO IMPOUNDMENTS: (A)llowed (N)ot allowed			
Restricted commercial impoundments	A	N	N
Basins at fish hatcheries	A	N	N
Landscape impoundments without decorative fountain	A	A	N
Landscape impoundments with decorative fountain	A	N	N
SUPPLY TO OTHER USES: (A)llowed (N)ot allowed			
Flushing toilets and urinals	A	N	N
Fire fighting	A	N	N
Commercial and public laundries	A	N	N
Cooling saws while cutting pavement	A	N	N
Decorative fountains	A	N	N
Washing yards, lots and sidewalks	A	N	N
Flushing sanitary sewer	A	A	N
High pressure water blasting to clean surfaces	A	N	N
Industrial process without exposure of workers	A	A	N
Industrial process with exposure of workers	A	N	N
Cooling or air conditioning systems without tower, evaporative condenser, spraying, or other features that emit vapor or droplets	A	A	N
Cooling or air conditioning systems with tower, evaporative condenser, spraying, or other features that emit vapor or droplets	A	N	N
Industrial boiler feed	A	A	N
Water jetting for consolidation of backfill material around piping for reclaimed water, sewage, storm drainage, and gas; and electrical conduits	A	N	N
Washing aggregate and making concrete	A	A	N
Dampening roads and other surfaces for dust control	A	A	N
Dampening brushes and street surfaces in street sweeping	A	A	N

Source: DOH, 1993.

APPENDIX B

REVIEW AND ASSESSMENT OF WAHIAWA RESERVOIR WATER QUALITY IN RELATION TO PROPOSED MODIFICATIONS TO THE WAHIAWA WWTP

Review and Assessment of Wahiawa Reservoir Water Quality in Relation to Proposed Modifications to the Wahiawa WWTP[1]

September 18, 1998 DRAFT *AECOS* No. 899

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Introduction

A considerable body of data has been collected for Wahiawa Reservoir over the past twenty-five years in an effort to characterize cause and effect relationships for water

[1] Report prepared for Calvin Kim and Associates/Gerald Park Urban Planner for the "Draft Environmental Assessment, Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment, Wahiawa, Oahu, Hawaii." This report will become part of the public record.

quality in this impoundment. Studies on this water body have ranged from topics dealing with the effects of sewage disposal on water quality, eutrophication potential of the sediments, fish toxicity, algal growth potential, and changes in sport fishery conditions. Over the course of time that these studies encompass, methodologies and techniques have changed thus making a strict comparison of some data difficult and, in some cases, impossible. Also, studies have been carried out at different periods of the year and at different locations within the reservoir. This report is therefore intended as a very general and preliminary assessment of historic and existing water quality conditions in Wahiawa Reservoir. An important feature of this document will be to identify long-term water quality trends in the impoundment and to determine how these trends impact present water quality.

Background

Wahiawa Reservoir, locally known as Lake Wilson, is a pair of narrow gulches drowned by the 1906 construction of a dam below the confluence of the North and South Forks of Kaukonahua Stream (State Perennial Stream Code 3-6-06.02) on the central plateau of O'ahu. The reservoir was built by the predecessors of the Waialua Sugar Company for the primary purpose of irrigating sugar cane fields lying to the north. The town of Wahiawa lies on the higher ground (an interfluve) between the two forks of Kaukonahua Stream, while Schofield Barracks and other military reservation lands extend to the west and south of the reservoir. Overflow from the dam enters Kaukonahua Stream which flows northward, joining Poamoho Stream to form Kiki`i Stream, the latter entering the ocean at Kaiaka Bay on the north shore of O`ahu.

The reservoir has a maximum capacity of about 2.5 billion gallons (Lum and Young., 1976) at a dam spillway elevation of 842 feet above mean sea level (MSL) (Moore et al., 1981). A rubber dam was installed over the spillway in the 1970s which increased the impoundment's capacity to about 3 billion gallons (Lum and Young, 1976). However, this device has fallen into disrepair and the reservoir capacity is once again at approximately 2.5 billion gallons (Loke, 1996).

Secondarily treated effluent from the Wahiawa Wastewater Treatment Plant (WWTP), located approximately 1 km southeast of the spillway, has been discharging into the South Fork of the reservoir since 1928 (Lum and Young, 1976). In 1968 a second treatment facility, the Whitmore Village Wastewater Treatment Plant (WVWTP), began discharging secondarily treated sewage effluents into the North Fork of the reservoir. In 1994, the effluents from the two treatment plants were combined and currently discharge into the surface waters of the South Fork at the WWTP discharge site (Loke, 1996). Average flow from the WWTP at the present time is approximately 2 mgd (RMTC, 1996).

In the 1950s, the Department of Land and Natural Resources (DLNR) began stocking Wahiawa Reservoir with sport fish. This imposed a third use on the impoundment, in addition to irrigation and waste disposal. By the early 1960s fish kills started to occur in the reservoir signaling the fact that the three uses of Wahiawa Reservoir were not strictly compatible and indicating that pollution or more specifically, eutrophication, was a concern that had to be reckoned with.

A common process in lakes, and impoundments such as Wahiawa Reservoir as they age is eutrophication whereby nutrients accumulate in these standing bodies of water. In the presence of warm water temperatures and sufficient sunlight, these nutrients are used by plants in the photosynthetic process to produce large standing crops of phytoplankton (algae suspended in the water) and attached or floating aquatic plants (both algae and vascular plants). The depth of light penetration may limit the depth of attached bottom plants; floating plants are not limited to shallower waters.

Eutrophication in lakes and reservoirs is both a natural and man-made phenomenon. Natural eutrophication is a slow, largely irreversible process associated with the gradual accumulation of organic matter and sediments in lake basins. This process is often accelerated in dammed river basins such as Wahiawa Reservoir where stream inputs, and hence sediment inputs, are often significantly greater than in natural lakes. Manmade eutrophication, or the anthropogenic introduction of nutrients to a water system (e.g., agricultural runoff, urban storm drainage, sewage effluents) is often a rapid, sometimes irreversible process of nutrient enrichment with resultant high plant (algal) biomass production. Over time, plant tissues die and settle to the bottom of the water body where the organic matter decays and recycles nutrients into the water column and/or the sediments. This process can lead to oxygen depletion in portions of the water column which can result in the mass killing of fish and other aquatic life.

Wahiawa Reservoir is especially susceptible to eutrophication as it possesses the three prerequisite characteristics for this process: (1) continuous elevated nutrient input from the Wahiawa Wastewater Treatment Plant (WWTP) together with stream and runoff inputs; (2) year-round high ambient light intensity to sustain high primary productivity levels; and (3) warm-water temperatures throughout the year which aid in maintaining high plant growth rates. By the time of the first comprehensive water quality study in Wahiawa Reservoir by Schmitt (1973), this water body was already in an advanced state of eutrophication. In this report we will review changes in water quality over this twenty-five year period and assess the current water quality status of the reservoir.

Nutrients

The nutrients of primary concern in water quality assessment of natural waters are nitrogen and phosphorus. These nutrients are typically present in pristine, unpolluted aquatic (oligotrophic) environments in amounts that regulate, or limit, plant growth; i.e., aquatic plant biomass will remain relatively low so long as nitrogen and phosphorus are supplied to the system in small, growth-limiting quantities.

Nitrogen

There are three environmentally important components of nitrogen in aquatic systems: *total nitrogen, ammonia, and nitrate/nitrite*. Total nitrogen is the sum of nitrate, nitrite, ammonia, and organic nitrogen levels in the environment. As such, it is a semi-conservative property and can be used to trace the migration of nitrogen through a water body; i.e., the amount entering the system, settling out on the bottom, and/or exiting the system downstream. Ammonia is a reduced nitrogen form (NH_4) which represents an intermediate breakdown product of organic nitrogen. Ammonia can serve as a major nitrogen source for plant growth. It also can be toxic to fish and other aquatic life under certain environmental conditions and at high concentrations. In the presence of sufficient oxygen levels, ammonia is rapidly oxidized to nitrate + nitrite ($NO_3 + NO_2$) in the aquatic environment, which is usually the primary nitrogen source for aquatic plant growth. A common measure of nitrogen in WWTP effluent is Total Kjeldahl Nitrogen (TKN). This is the nitrogen present as either ammonia or organic substances. An estimate of total nitrogen can be obtained by summing the nitrate, nitrite (or nitrate + nitrite), and TKN concentrations.

A summary of total nitrogen levels from various studies in Wahiawa Reservoir are given in Table 1. It must be kept in mind that these data represent collection from different numbers of stations, different station locations, and were collected under different time-frames. As such, these results must be interpreted with caution and should only be considered to represent general trends.

In the past twenty-five years TN levels in all three sections of Wahiawa Reservoir have displayed considerable variability. However, the surface TN levels recorded in 1973 (Schmitt, 1973) are quite comparable with those for 1995-96 (RMTC, 1996), suggesting that there has been little change in mean TN levels in these waters. Also, considering averages, there seems to be little difference in TN levels between the surface and deeper waters of Wahiawa Reservoir.

Mean TN concentrations in the North Fork of the reservoir have been consistently lower in both the surface and bottom waters over the years when compared with the Basin and South Fork levels. Interestingly, there was not a noticeable decrease in TN in the

North Fork after the sewage discharge from the Whitmore Village WTP was diverted to the Wahiawa WTP in March, 1994. However, data for the North Fork are scarce, except for the recent RMTC study (1996) and likely were not adequate to detect effects from the diversion.

Table 1. Geometric mean values for total nitrogen levels (mg/l) in the surface (epilimnion) and bottom (hypolimnion) waters of Wahiawa Reservoir

Year	Month	Depth	Basin	South Fork	North Fork	grand mean	Source
1973	Jan - Jun	surface	1.09	1.87	—	1.48	Schmitt, 1973
		bottom	*0.41*	*2.20*		*1.31*	
1973 - 74	Oct - Jul	surface	0.25	0.37	0.17	0.26	Young, et al. 1975
1975 - 76	Jun - Jan	surface	1.99	—	—	1.99	Lum, et al. 1976
		bottom	*1.95*	—	—	*3.72*	
1992	Oct	surface	2.32	0.90	0.40	1.21	Horne, 1992
		bottom	*1.00*	*0.44*	*0.40*	*0.61*	
1994	Sep - Dec	surface	1.17	1.17	0.17	0.84	AECOS, 1995
		bottom	*0.46*	—	—	*0.46*	
1995 - 96	May - Feb	surface	1.12	1.86	0.74	1.27	RMTC, 1996
		bottom	*1.10*	*1.11*	*0.55*	*0.92*	
grand mean		surface	1.32	1.23	0.37		
		bottom	*0.98*	*1.25*	*0.48*		

Young, et al. (1975) and Lum et al. (1976) reported evidence of seasonal variations in TN (and other nitrogen and phosphorus forms) related to water levels and thermal stratification in the reservoir. These issues will be addressed in a later section of this report.

Ammonia is utilized as a primary nitrogen source for phytoplankton and other aquatic plant growth. It is generated as an aquatic animal excretion product and as a breakdown product of organic matter by microbial processes. An important source of ammonia in Wahiawa Reservoir is WWTP effluent which discharges about 118 kg (260 lb) of ammonia (about 80% of the nitrogen in the effluent) into the reservoir each day.

The general distribution of ammonia in Wahiawa Reservoir is shown in Table 2. There is a tendency for ammonia levels to be higher in the bottom waters of all three sections of the reservoir. In an average sense, the highest levels of ammonia tend to occur in the basin waters and the lowest in the North Fork. There also appears to be a trend towards increasing ammonia levels over the years in the surface waters of the South Fork. This is not unexpected as nitrogen discharge from the WWTP has also increased over time (see below).

Table 2. Geometric mean values for ammonia levels (mg/l) in the surface (epilimnion) and bottom (hypolimnion) waters of Wahiawa Reservoir

Year	Month	Depth	Basin	South Fork	North Fork	grand mean	Source
1973	Jan - Jun	surface	0.16	0.86	—	0.51	Schmitt, 1973
		bottom	*0.18*	—		*0.18*	
1973 - 74	Oct - Jul	surface	0.07	0.06	0.09	0.07	Young, et al. 1975
1975 - 76	Jun - Jan	surface	0.22	—	—	0.22	Lum, et al. 1976
		bottom	*1.97*	—	—	*2.51*	
1992	Oct	surface	2.18	0.08	0.01	0.76	Horne, 1992
		bottom	*0.12*	*0.16*	*0.20*	*0.16*	
1994	Sep - Dec	surface	0.20	0.12	0.11	0.14	AECOS, 1995
		bottom	*0.10*	—	—	*0.10*	
1995 - 96	May - Feb	surface	0.11	0.23	0.02	0.12	RMTC, 1996
		bottom	*0.41*	*0.26*	*0.11*	*0.26*	
grand mean		surface	0.49	0.27	0.06		
		bottom	*0.56*	*0.21*	*0.16*		

Intuitively, one might expect the highest ammonia levels to occur in the South Fork because that is where contribution of high ammonia WWTP effluent is occurring. However, a consideration of the ammonia levels at stations on either side of the effluent discharge in the South Fork (Table 3) shows that ammonia concentrations fall off rapidly in the water. Interestingly, nitrate + nitrite levels tend to increase with distance from the discharge. Thus, while much of this ammonia may be consumed by phytoplankton, it appears that some portion is oxidized to nitrate + nitrite by nitrifying bacteria in the water column. This nitrification process has important consequences when considering a deep WWTP discharge site in the reservoir as it consumes dissolved oxygen. Dissolved oxygen levels in the hypolimnic waters of Wahiawa Reservoir are already low and the maintenance of aerobic conditions in these waters is essential.

At high pH levels (~pH = 9) and warm temperatures (25° C), conditions that frequently do occur in the surface waters of Wahiawa Reservoir, about one-third of the ammonia present is in its un-ionized form (Goldman and Horne, 1983). Un-ionized ammonia is toxic to fish (Horne, 1992). Whether un-ionized ammonia has played any role in past fish kills in the reservoir has not been determined. However, it can represent a potential threat to fish populations in the reservoir.

Table 3. Surface distribution of ammonia (mg/l) and nitrate+nitrite (mg/l) on either side of the WWTP discharge site.

Nutrient	S1A	Effluent	S2A	S3A
Ammonia	0.27	15.71	1.92	0.18
Nitrate+nitrite	0.55	0.09	0.63	0.76

There are, therefore, two negative impacts associated with the WWTP discharge of ammonia into Wahiawa Reservoir: (1) decrease in dissolved oxygen levels due to nitrification of ammonia to nitrate + nitrite; and (2) the potentially toxic effect of un-ionized ammonia on fishes. A report of Brown and Caldwell (1992) noted that nitrate + nitrite levels in the WWTP effluent are surprisingly low since the high wastewater temperatures (25° - 27° C) in Hawai'i usually cause nitrification to occur in most secondary treatment plants, producing higher effluent nitrate + nitrite and lower ammonia levels. It was determined that dissolved oxygen in the aeration tanks at the WWTP are maintained at a low level which inhibits the nitrification process. Thus, the environmental concerns for ammonia in the reservoir could presumably be corrected by enhancing dissolved oxygen levels in the aeration tanks at the WWTP.

Nitrate + nitrite, like ammonia, is a major nitrogen source for phytoplankton growth and productivity. The distribution of this nitrogen moiety in Wahiawa Reservoir is depicted in Table 4. Both the spatial and temporal distribution of this nutrient in the surface waters of the reservoir are quite variable. Nitrate + nitrite levels in the bottom waters have remained relatively constant and low over the years, possibly due to the low DO conditions which prevent nitrification of ammonia to nitrate + nitrite. There is some suggestion that nitrate + nitrite may be increasing in concentration in the surface waters with time in both the South and North forks of the impoundment.

Phosphorus

Phosphorus frequently regulates, or limits, the productivity of aquatic plants and algae in aquatic environments, especially in freshwater environments. We are principally interested in two forms of phosphorus in Wahiawa Reservoir: total phosphorus (TP) which, like TN, is a quasi-conservative property in aquatic systems and thus helps us to understand the paths that phosphorus follows in the reservoir; and orthophosphate which, in its dissolved form, is assimilated by plants and algae and transformed into living tissue (i.e., is taken up and converted to organic phosphorus).

Table 4. Geometric mean values for nitrate + nitrite levels (mg/l) in the surface (epilimnion) and bottom (hypolimnion) waters of Wahiawa Reservoir

Year	Month	Depth	Basin	South Fork	North Fork	grand mean	Source
1973	Jan - Jun	surface	0.61	0.32	—	0.46	Schmitt, 1973
		bottom	*0.10*	*0.02*		*0.06*	
1973 - 74	Oct - Jul	surface	0.06	0.02	0.08	0.08	Young, et al. 1975
1975 - 76	Jun - Jan	surface	0.59	—	—	0.59	Lum, et al. 1976
		bottom	*0.06*	—	—	*0.06*	
1992	Oct	surface	<0.01	0.01	<0.01	0.01	Horne, 1992
		bottom	*0.06*	*<0.01*	*0.06*	*0.04*	
1994	Sep - Dec	surface	0.36	0.54	0.09	0.33	AECOS, 1995
		bottom	*0.07*	—	—	*0.07*	
1995 - 96	May - Feb	surface	0.45	0.57	0.26	0.43	RMTC, 1996
		bottom	*0.03*	*0.14*	*0.12*	*0.10*	
grand mean		surface	0.35	0.29	0.11		
		bottom	*0.06*	*0.06*	*0.09*		

A summary of available TP values in Wahiawa Reservoir is given in Table 5. Unlike the nitrogen regime in Wahiawa Reservoir, there appears to have been a definite trend towards lower TP concentrations in both the surface and bottom waters over the past twenty-five years throughout the reservoir. The highest surface levels have typically occurred in the South Fork and the lowest in the North Fork. TP concentrations in the bottom water follow a similar pattern to those in the surface layer.

Orthophosphate is the form of phosphorus that is directly utilized by aquatic plants and algae to produce cell matter by primary production (i.e., photosynthesis). If it is not available in sufficient amounts, the rate of plant growth will be restricted. Historical values for orthophosphate levels in Wahiawa Reservoir are displayed in Table 6. Like TP, mean orthophosphate levels have decreased over the years to low levels with the highest concentrations presently occurring in the South Fork and the lowest levels in the North Fork in both surface and bottom waters of the reservoir.

Nutrient Limitation

The question can be posed as to which nutrient (nitrogen or phosphorus) is limiting in the Wahiawa Reservoir system; or put more correctly, which nutrient is "potentially" limiting in this system?

The limiting nutrient concept is based upon the premise that, for a given plant or algal population, the nutrient that is exhausted first, or reaches a minimum before other nutrients, will control the amount of plant biomass. To make this determination, Vollenweider (1983) has recommended the TN to TP ratio of 9:1 for phytoplankton as the dividing point in tropical lakes whereby lakes with TN:TP ratios greater than 9 are considered to be potentially phosphorus limited and those with ratios less than 9 are potentially nitrogen limited.

Table 5. Geometric mean values for total phosphorus levels (mg/l) in the surface waters (epilimnion) and bottom waters (hypolimnion) of Wahiawa Reservoir

Year	Month	Depth	Basin	South Fork	North Fork	grand mean	Source
1973	Jan - Jun	surface	—	1.10	—	1.10	Schmitt, 1973
		bottom	—	*0.48*	—	*0.48*	
1973 - 74	Oct - Jul	surface	0.26	0.36	0.15	0.26	Young, et al. 1975
1975 - 76	Jun - Jan	surface	0.17	—	—	0.17	Lum, et al. 1976
		bottom	*0.18*	—	—	*0.18*	
1992	Oct	surface	0.09	0.10	0.03	0.07	Horne, 1992
		bottom	*0.14*	*0.03*	*0.05*	*0.07*	
1994	Sep - Dec	surface	0.05	0.04	0.01	0.03	AECOS, 1995
		bottom	*0.04*	—	—	*0.04*	
1995 - 96	May - Feb	surface	0.05	0.10	0.03	0.06	RMTC, 1996
		bottom	*0.06*	*0.09*	*0.03*	*0.06*	
grand mean		surface	0.12	0.34	0.06		
		bottom	*0.11*	*0.20*	*0.04*		

Table 7 gives the historical TN:TP ratios for Wahiawa Reservoir. In the early 1970s nitrogen was the potentially limiting nutrient using Vollenweider's index. By 1975-76 phosphorus was the potentially limiting nutrient in an average sense, at least in the basin (Lum, et al. 1976). Actually, there was a distinct seasonal trend in the data of Lum et al. (1976) showing TN:TP ratios less than 9:1 during four of the eight month study of surface waters. TN:TP ratios in the bottom waters were greater than 9:1 on all sampling events.

In the 1990s TN:TP ratios have typically been above 9:1 in both the surface and bottom waters of all sections of the reservoir, indicating that phosphorus is presently the potentially limiting nutrient.

The shift from nitrogen to phosphorus as the potentially limiting nutrient in a system as large as Wahiawa Reservoir indicates that a major shift in the relative inputs of TN and TP has occurred over the past twenty-five years. A logical place to look for such changes is the WWTP. A summary of the historical characteristics of this effluent is shown in Table 8. There are several noteworthy trends in these data. First, TP levels in the WWTP effluents have dropped from an average of 7.5 mg/l in 1974 to 1.7 mg/l in 1996. This decrease in TP levels is primarily due to decreases in the influent waste waters levels which presently average 6.8 mg/l (RMTC, 1996) rather than any change in treatment within the plant. Thus, the current influent levels to the WWTP are less than the mean effluent values in 1974.

Table 6. Geometric mean values for orthophosphate levels (mg/l) in the surface waters (epilimnion) and bottom waters (hypolimnion) of Wahiawa Reservoir

Year	Month	Depth	Basin	South Fork	North Fork	grand mean	Source
1973	Jan - Jun	surface	0.38	0.44	—	0.41	Schmitt, 1973
		bottom	*0.06*	*0.44*	—	*0.25*	
1973 - 74	Oct - Jul	surface	0.11	0.13	0.05	0.10	Young, et al. 1975
1975 - 76	Jun - Jan	surface	0.09	—	—	0.09	Lum, et al. 1976
		bottom	*0.15*	—	—	*0.15*	
1992	Oct	surface	0.06	0.03	0.03	0.06	Horne, 1992
		bottom	*0.06*	*0.01*	*0.02*	*0.03*	
1994	Sep - Dec	surface	0.01	0.01	<0.01	0.01	AECOS, 1995
		bottom	*0.01*	—	—	*0.01*	
1995 - 96	May - Feb	surface	0.01	0.03	<0.01	0.01	RMTC, 1996
		bottom	*0.01*	*0.03*	*<0.01*	*0.02*	
grand mean		surface	0.11	0.13	0.02		
		bottom	*0.06*	*0.16*	*0.01*		

A second important feature of these data is the fact that WWTP effluent flow rates have increased from about 1.4 mgd in 1974 to about 2.0 mgd today. Thus, while TN levels have changed little over the years, the increase in flow rate has resulted in an 18% increase in TN loading to the reservoir or an additional 23 kg (50 lb) of TN per day. At the same time, since the decrease in TP in the WWTP has been large compared with the increase in discharge rates, TP loading to the reservoir has decreased approximately 68% since 1974 and presently accounts for about 13 kg (28 lb) of TP loading per day - a drop of nearly 27 kg (60 lb) per day since 1974. As a result of these changes, the TN:TP ratio has risen from 3.6 (potentially nitrogen limiting) in 1974 to 11.7 (potentially phosphorus limiting) in 1996.

External Nutrient Inputs

We can compare the influx of nutrients from the WWTP with other nutrient inputs to Wahiawa Reservoir. Lum and Young (1975), in their study of eutrophication and fish toxicity potentials in Wahiawa Reservoir, estimated the main sources of nutrient input to the impoundment. They utilized 16 years of stream flow and rainfall data from 1953 through 1968 when sufficient USGS stream gage data were available to estimate flows into both the North and South forks of Kaukonahua Stream. They assumed that 13% of the rainfall on the surrounding land area was added to the reservoir as runoff (Rosenau, Lubke, and Nakahara, 1971). In view of the fact that these data still represent the most comprehensive available for long-term rainfall and stream flow they are used here to estimate total inflows to Wahiawa Reservoir, combined with water quality data from *AECOS* (1995) to estimate nutrient concentrations in the stream inputs (Table 9).

Table 7. TN:TP ratios in the surface waters (epilimnion) and bottom waters (hypolimnion) of Wahiawa Reservoir

Year	Month	Depth	Basin	South Fork	North Fork	mean	Source
1973	Jan - Jun	surface	—	3.4	—	3.4	Schmitt, 1973
		bottom	—	4.6	—		
1973 - 74	Oct - Jul	surface	1.1	1.3	1.4	1.3	Young, et al. 1975
1975 - 76	Jun - Jan	surface	13.3	—	—	13.3	Lum, et al. 1976
		bottom	*19.8*	—	—	*20.6*	
1992	Oct	surface	25.2	8.9	16.0	16.7	Horne, 1992
		bottom	*7.0*	*15.7*	*14.0*	*12.2*	
1994	Sep - Dec	surface	22.1	31.6	13.0	22.2	AECOS, 1995
		bottom	*11.1*	—	—	*11.1*	
1995 - 96	May - Feb	surface	25.3	20.0	25.5	23.6	RMTC, 1996
		bottom	*18.2*	*12.4*	*16.4*	*15.7*	
grand mean		surface	17.4	13.0	14.0		
		bottom	*14.2*	*10.9*	*15.2*		

Table 8. Historical characteristics of WWTP effluents.

Year	Total N (mg/l)	Total P (mg/l)	Flow (mgd)	Total N (lb/day)	Total P (lb/day)	TN:TP ratio	Source
1974	23.7	7.5	1.4	277	87	3.2	Young, et al., 1975
1977	—	5.2	—	—	—	—	First West Engineers, 1979
1992	17.5	3.8	1.8	262	57	4.6	Brown & Caldwell, 1992
1996	19.6	1.7	2.0*	327	28	11.7	RMTC, 1996

In March, 1994 discharges from the Whitmore Village STP were diverted to the WWTP.

Table 9. External nutrient inputs to Wahiawa Reservoir.

Year	stream inputs Total N (kg/dayl)	stream inputs Total P (kg/dayl)	Runoff Total N (kg/dayl)	Runoff Total P (kg/dayl)	WWTP inputs Total N (kg/day)	WWTP inputs Total P (lb/day)	Total inputs Total N (kg/day)	Total inputs Total P (kg/day)	Total TN:TP ratio
1974	17	11	28	3	126	39	171	53	3.2
1992	"	"	"	"	119	26	164	40	4.1
1996	"	"	"	"	148	13	193	27	7.1

Aside from the WWTP discharge, the other major inputs to the reservoir surface water would be direct rainfall and storm runoff. Runoff into Wahiawa Reservoir is potentially a significant source of nutrients. However, because runoff from buildings, streets, and property represents "non-point source" inputs, it is difficult to quantify the nutrient inputs. Young, et al. (1975) estimated TN and TP loading to Wahiawa Reservoir from runoff based upon "typical urban" values given by Weibel, Anderson, and Woodward (1964). In calculating surface runoff area, Young et al. (1975) used an estimate of Wahiawa town (10.4 km^2) between the North and South forks of the reservoir. This value underestimated the total watershed by not including drainage areas north and south of the reservoir. We have recalculated the surface drainage area from recent aerial photographs and topographic maps (Figure 1).

The watershed boundary (the watershed of just the reservoir) is indicated by a dashed line in Figure 1. The watershed area above feeds into the reservoir via the two forks of Kaukonahua Stream, and inputs from this large area are treated under considerations of stream flow and stream water quality (stream inputs in Table 9). Within the reservoir watershed, land use is classified as either urban, agriculture, or rural. Urban land encompasses Wahiawa Town and Whitmore Village and is indicated in the figure as stippled gray areas. Agriculture lands comprise pineapple fields north of the reservoir designated in the figure by horizontal lines. Rural or undeveloped lands consist of some forested areas, but include part of a military practice area known as Schofield Barracks East Range and other significant open areas not classified as either urban or agriculture. These are unmarked in Figure 1.

Measurements taken off Figure 1 provide an estimate for the total reservoir watershed of 1271 ha (3,140 ac) or 12.71 km^2. Within this area, urban land comprises 42.8%, agriculture land 10.3%, and rural land 46.8% of the total area. From our calculations, the reservoir is estimated to be 115 ha (284 ac), or 19% of the rural land area.

At the time of the Young et al. (1975) study there was very little information available on nutrient levels in runoff. Table 10 represents revisions of the values in Table 9 based upon average nutrient concentrations in urban runoff for Mililani town (Yamani and Lum, 1985), in agricultural runoff from a Kunia pineapple field (Yim and Dugan,

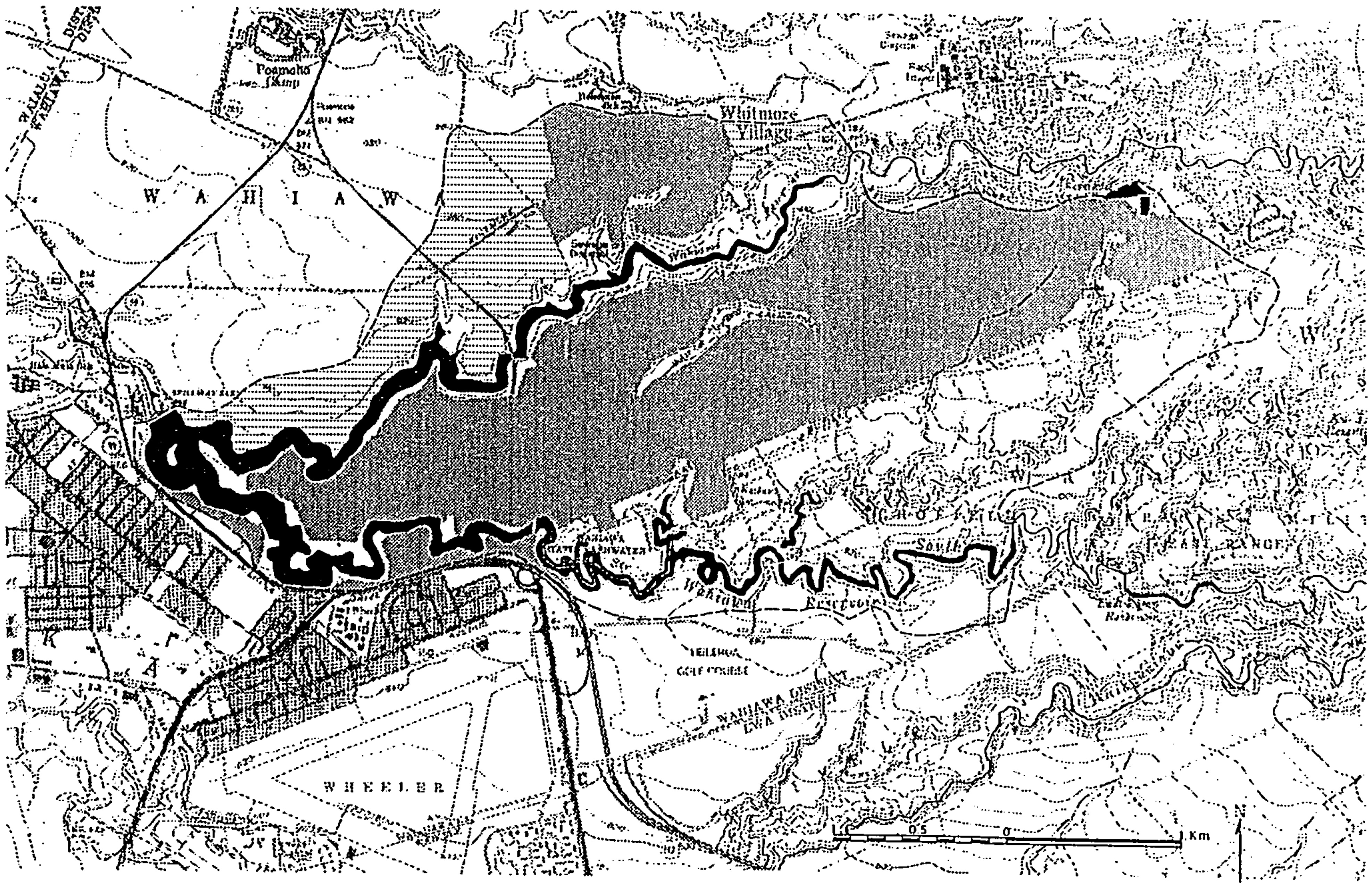

Figure 1. Land use map (urban, agriculture, and rural lands) of Wahiawa Reservoir (Lake Wilson) watershed.

1975), and for undeveloped land from a forested watershed in upper Manoa valley (Yim and Dugan, 1975).

Table 10. Revised nutrient loading estimates from runoff into Wahiawa Reservoir

Inputs		runoff area (km^2)	TN loading (kg/day)	TP loading (kg/day)	TN:TP	Source
WWTP		n/a	148	14	10.6	RMTC, 1996
Runoff						
	Urban	5.4	3.8	0.8		Yamane & Lum (1985)
	Agriculture	1.3	4.8	0.2		Yim & Dugan (1975)
	Rural	4.8	2.9	1.1		Yim & Dugan (1975)
Runoff Total		12.7	11.5	2.1	5.5	

The data in Tables 9 and 10 clearly demonstrate that the WWTP is the primary source of nutrients entering Wahiawa Reservoir. However, the relative proportions of TN and TP are markedly different between the recent WWTP effluent values and estimated land runoff values. Presently, both of these sources contribute to the surface water layer (the epilimnion) of the reservoir.

Chlorophyll α

One of the first and most apparent responses to high nutrient loading into sub-tropical impoundments, such as Wahiawa Reservoir, is an increase in phytoplankton standing crop. Phytoplankton is composed of single-celled primary producers (algae) that use the nutrients for photosynthesis to produce more cells (replicate themselves) and can reach very high biomass levels under certain conditions. Since these organisms all contain chlorophyll α, an essential pigment for photosynthesis, this parameter is often used to estimate the relative biomass, or standing crop, in aquatic environments.

Mean values for chlorophyll α levels in Wahiawa Reservoir are given in Table 11. These data exhibit considerable variability both temporally and spatially. The fact that mean levels of chlorophyll α have changed little between 1973-74 and 1995-96 suggests that the decrease in mean phosphorus concentrations over this same time period have had little or no effect on the phytoplankton standing crop in Wahiawa Reservoir. In other words, while phosphorus is the potentially limiting nutrient, it is presently supplied in quantities which do NOT limit phytoplankton biomass production in the reservoir.

Table 11. Geometric mean values for chlorophyll α concentrations (µg/l) in surface waters (epilimnion) of Wahiawa Reservoir

Year	Month	Basin	South Fork	North Fork	mean	Source
1973	Jun	276	125	—	201	Schmitt, 1973
1973 - 74	Oct - Jul	17	34	24	25	Young, et al. 1975
1992	Oct	103	56	15	58	Horne, 1992
1994	Sep - Dec	19	5	—	12	AECOS, 1995
1995 - 96	May - Feb	26	33	20	26	RMTC, 1996
grand mean		88	51	20		

An interesting feature of these data is the high chlorophyll α concentrations reported by Schmitt (1973). Schmitt measured chlorophyll α levels on two separate occasions in June of 1973, collecting a total of nine samples - all of which had levels consistently higher than those of later studies. This could be due to a "bloom" of phytoplankton at that time; blooms having been observed in the reservoir on numerous occasions (Devick, 1981). However, another possibility also exists. Schmitt had determined that the depth of the euphotic zone was 2.9 meters and collected his chlorophyll samples by timing the rate of descent of a weighted 1 gallon bottle until it reached this depth. He was, in effect, collecting an integrated chlorophyll sample. Subsequent studies have typically collected samples in the epilimnion by discrete sample from a depth of 0.5 m. The highest densities of phytoplankton in a thermally stratified water column are often found in, or just below, the thermocline in the oxygen minimum layer. It is, therefore, quite possible that Schmitt's chlorophyll estimates more closely represent actual conditions in the upper waters of the reservoir that those of later studies.

Since by definition there are sufficient nutrients to sustain high phytoplankton production rates in a eutrophic environment, one might logically pose the question: what will limit phytoplankton biomass in such systems? In Wahiawa Reservoir, as in other eutrophic, sub-tropical impoundments, it is usually light penetration through the water column that functionally limits primary production. As phytoplankton density increases from an abundant supply of nutrients, sunlight is attenuated more quickly as it passes through the water, eventually restricting effective photosynthesis to the upper few meters of the water column.

Secchi Disk Depth

Secchi disk depth represents a rough estimate of the depth of zero net primary productivity; i.e., the depth at which phytoplankton respiration equals oxygen production via photosynthesis. It is, of course, a measure of water clarity. Geometric mean values for Secchi disk depth are shown in Table 12. Note that Secchi disk depth decreases with increasing water cloudiness since the value represents the depth at which a black and white disk is no longer visible from above the water surface.

Table 12. Geometric mean Secchi disk depths (m) in Wahiawa Reservoir

Year	Month	Basin	South Fork	North Fork	mean	Source
1980 - 81	May - Jun	1.0	0.9	1.2	1.0	Devick, 1981
1995 - 96	May - Feb	1.2	1.0	1.1	1.1	RMTC, 1996
grand mean		1.1	1.0	1.2		

In an average sense, there is little variation in Secchi disk depth in any section of reservoir. Also, there has been little change in mean values with time. The mean Secchi disk depths in Wahiawa Reservoir are quite low (i.e., shallow) and indicate that net primary productivity in this impoundment is restricted to the upper meter or so (the euphotic zone) of the water column.

The significance of light limitation in Wahiawa Reservoir is that while phytoplankton may occur in dense numbers throughout much of the water column, the net production of dissolved oxygen is restricted to the upper meter or so. Put another way, phytoplankton below the upper meter of the water column will consume more oxygen than they produce. This can lead to oxygen depletion in the hypolimnion — a situation that can have serious consequences on the reservoir environment.

Dissolved Oxygen

Dissolved oxygen (DO) is one of the most important environmental parameters in lakes and reservoirs. DO is produced in the upper lighted layers of the impoundment by phytoplankton primary production (photosynthesis) during the day and is consumed by respiration processes of all living matter (with the exception of certain bacteria) in the impoundment twenty-four hours a day. When phytoplankton biomass becomes sufficiently large to restrict net oxygen production to the upper few meters of the water column, as has become the normal condition in Wahiawa Reservoir, DO depletion can result in anoxia and mass death in the system. In fact, oxygen depletion has been implicated in a number of fish kills in Wahiawa Reservoir (Young et al., 1975; Moore et al., 1981; Devick, 1981), especially when water levels are low due to irrigation drawdown.

The spatial distribution DO in Wahiawa Reservoir (Table 12) typically demonstrates relatively high levels in the epilimnic waters and low levels in the lower, or hypolimnion, portion of the water column; the two layers being separated by the thermocline which precludes mixing between these two water body layers. This differential is to be expected since the surface waters can be supplied with DO as the result of wind-mixing with the air and also as end-product of phytoplankton photosynthesis.

Table 12. Mean dissolved oxygen levels (mg/l) in the surface waters (epilimnion) and bottom waters (hypolimnion) of Wahiawa Reservoir

Year	Month	Depth	Basin	South Fork	North Fork	mean	Source
1973	Jan - Jun	surface	8.7	9.3	10.5	9.5	Schmitt, 1973
		bottom	*1.3*	*1.9*	*2.4*	*1.9*	
1975 - 76	Jun - Jan	surface	7.2	—	—	7.2	Lum, et al. 1976
		bottom	*0.7*	—	—	*0.7*	
1992	Oct	surface	13.2	12.0	9.6	11.6	Horne, 1992
		bottom	*<0.1*	*<0.1*	*2.1*	*0.7*	
1994	Sep - Dec	surface	8.8	7.0	7.8	7.6	AECOS, 1995
		bottom	*5.7*	—	—	*5.7*	
1995 - 96	May - Feb	surface	7.8	7.9	7.9	7.9	RMTC, 1996
		bottom	*0.4*	*1.9*	*3.2*	*3.1*	
grand mean		surface	9.1	9.1	9.0		
		bottom	*1.6*	*2.6*	*2.6*		

Temporally, one can expect considerable variability in DO levels in Wahiawa Reservoir, especially in the epilimnion, since DO concentrations will increase as the sun rises towards its zenith due to photosynthesis and then decrease as the sun moves lower in the sky. The lowest DO levels will be reached in the morning hours just before sunrise as the result of night-time respiration. This daily cycle is known as the diel or diurnal cycle of DO. Devick (1981) measured a diel cycle in the surface waters of Wahiawa Reservoir in December 1980 and found DO levels to range from a high of about 11.5 mg/l during the day to a low of about 4 mg/l at about 7:00 am in the morning. Thus, the range of DO levels shown in Table 12 for the surface waters likely represent various stages of the diurnal DO cycle rather than any long-term trends.

Factors affecting DO levels in the hypolimnic waters of Wahiawa Reservoir are less well understood. It is generally agreed that DO is supplied to the hypolimnic waters principally by stream waters flowing into the North and South Forks of Kaukonahua Stream (Schmitt, 1973; *AECOS*, 1995; RMTC, 1997). As these relatively oxygen-rich waters (S. Kaukonahua = 7.8 mg/l, N. Kaukonahua = 8.9 mg/l; *AECOS*, 1995) enter the impoundment, they descend below the warmer (less dense) water surface waters of the reservoir and move towards the dam. Movement of this lower water mass towards the dam is enhanced by drawoff of water for irrigation purposes from the lower valves of standpipe system located in the reservoir basin near the dam. This practice of drawing water from the lower standpipe valves thus promotes the transport of DO into the bottom waters and helps to reduce the residence time of water in the hypolimnion. Stagnation and anaerobic conditions in the bottom waters of the reservoir are thus alleviated to some degree.

While the results of the RMTC study (1996) indicate that DO levels in the South Fork are intermediate between the North Fork and the basin waters (Table 12), a closer look at individual stations in this section of the reservoir (Table 13) reveals that Stations S1 and S2, on either side of the Wahiawa WWTP discharge, exhibit very low DO levels (< 0.10 mg/l) on most sampling occasions. Note that at the head-end of the reservoir on the South Fork (Station S4) DO levels are relatively high and then decrease progressively with distance from this point.

Table 13. Distribution of DO (mg/l) in the bottom waters of the South Fork of Wahiawa Reservoir (after RMTC, 1996).

	Station				
Month	S1		S2	S3	S4
May-25-95	0.06	E	0.11	0.49	8.2
Jun-19-95	0.06	F	0.10	1.23	4.23
Jul-11-95	0.05	F	0.09	2.23	6.71
Aug-03-95	0.05	L	0.08	3.87	6.01
Sep-05-95	0.05	U	0.29	2.58	4.35
Sep-26-95	0.04	E	0.09	0.11	4.66
Oct-17-95	0.11	N	0.78	1.41	4.49
Nov-15-95	0.05	T	0.07	0.22	4.91
Dec-05-95	0.06	S	0.04	2.32	3.50
Dec-27-95	0.04		0.06	1.76	3.19
Jan-16-96	0.05		0.06	1.41	3.39
Feb-14-96	0.07		0.05	0.10	2.75
Feb-29=96	6.71		5.59	4.05	5.68
mean	0.72		0.71	1.78	4.29

Factors influencing the depletion of DO in the hypolimnion include: (1) respiration by plants and animals; (2) decay of organic matter (principally phytoplankton and detritus) settling out of the euphotic zone; and (3) complex, little understood interactions with bottom sediments.

Maintaining aerobic conditions in the hypolimnion is crucial to the ecological well-being of the reservoir. The most apparent consequence of oxygen depletion in the bottom layer (i.e., anaerobic conditions) would be restriction of most plant and animal life to the upper few meters of the reservoir (the epilimnion). Other consequences are not as obvious. For example, under aerobic conditions the reservoir sediments have been shown to have an oligotrophic effect on the water mass (Lum and Young, 1976). Phosphorus is adsorbed by the sediment and nitrogen release from the sediment is inhibited by the development of a surface-oxidized layer. Further, the chemical oxygen demand (COD) of the water mass remains low. However, under anaerobic conditions, the measured COD was about 10 mg/l; enough demand to completely strip DO saturated water of its oxygen. Additionally, Young and Lum (1976) demonstrated that nitrogen, principally in the form of ammonia, and phosphorus could be released from the reservoir sediments under anaerobic conditions.

Other Considerations -- Flora and Fauna

Water Hyacinth

The water hyacinth, *Eichhornia crassipes*, is a wetland plant that was introduced into the Hawaiian Islands in the late 1800's (Wagner, Herbst, and Sohmer, 1990). Water hyacinth is adapted to a floating existence and typically grows over the surface of slow moving streams, ponds, and reservoirs. In shallow water, the plants may root in the bottom, but will suffer damage if water is withdrawn. The individual size of water hyacinth plants depends upon growing conditions: individual plants may be not much larger than a fist, or reach heights exceeding two feet (or a meter in some parts of the world).

Vegetative growth is by stolons: stem-like structures that produce new rosettes of floating leaves adjacent to the parent plant. Seeds are also produced, but vegetative growth can be so prolific that a few plants will eventually grow to cover all available water surface area if not checked. Once established, the area covered by water hyacinth can double in approximately 6 to 15 days (Harley, Julien, and Wright, 1997). Water hyacinth comes originally from the Amazon Basin of South America, but has been introduced around the world, usually as an ornamental plant. Escaped or introduced into freshwater lakes and canals, the hyacinth forms thick mats that reduce light, reduce dissolved oxygen, and alter the aquatic fauna and flora of the body of water. It is ranked by some "as the world's worst aquatic weed" (Charudattan, 1997) and is a serious pest everywhere in tropical regions, even in some parts of South America where the species is native. In tropical Africa it has become a serious threat to fisheries and navigation in even large bodies of water such as Lake Victoria (Hill, Waage, and Phiri, 1997; IRIN, 1997).

The ability of water hyacinth to "treat" water is well known and water hyacinth is used in macrophyte-based wastewater treatment systems (Brix, 1993). The value of water hyacinth in this regard comes from its high productivity in warm climates. Hyacinth may be used in a tertiary treatment system to remove nutrients, or in an integrated secondary and tertiary treatment system accomplishing both BOD reduction and nutrient removal. Organic matter in the waste stream adheres to the roots of the plant, reducing TSS and enhancing microbial transformations of nitrogen (nitrification-denitrification). Plants are harvested for maintenance purposes and for nutrient removal from the system.

While a population of water hyacinth growing in a body of water will accomplish these same functions, benefits to the aquatic ecosystem may be offset by various negative impacts, not the least of which is removal of excess growth to realize actual nutrient removal and maintain open water where fishing and/or commerce utilizes the water body. Dense mats of water hyacinth are composed of plants interwoven by their stolons. The plants are at least 90% water, so mats can weigh up to 200 tons per acre. Manual removal using knives, ropes, etc. to cut mats into pieces and drag them to the bank is arduous work and not practical even where manpower is plentiful and cheap (Harley, Julien, and Wright, 1997). Floating booms can achieve some success at limiting the spread of the plant to protect infrastructure, maintain shoreline access to water, and maintain boat access to landings, but active biomass removal must be sufficient to prevent the mass from eventually carrying the boom away.

Two other methods of control are commonly applied: chemical and biological. Chemical control entails application of herbicides, and has been practiced against water hyacinth since the early 1900s, mostly with limited long-term success. Even after the introduction of the phenoxy herbicides in the late 1940s, eradication of large infestations has been rare. By contrast, control of small infestations with herbicides has often been very effective, but is dependent upon maintaining long-term vigilance for appearance of regrowth or seedlings (Harley, Julien, and Wright, 1997). The current infestation in Wahiawa reservoir is being treated with herbicide sprays with limited success.

Biological control is the use of host specific natural enemies to reduce the population density of a pest. Biological control of water hyacinth was initiated by United States Department of Agriculture (USDA) in 1961. Several species of insects and fungi have been identified in South America as host-specific, potential control agents for water hyacinth. Biological control is regarded as the best long-term solution for heavy infestations in central Africa and Asia (Harley, Julien, and Wright, 1997), but should not be relied upon for control in Hawai`i. The introduction of exotic control species to Hawai`i for pests affecting commercial crops requires a long and expensive process. Water hyacinth is a pest in only a few locations in the Islands and economic losses to commerce from this pest are small, probably not justifying the cost and effort required to undertake a biological control agent.

Once a large area of surface is covered by dense water hyacinth growth, use of the water-body by water birds or fishermen becomes limited. A number of other problems are likely to accompany excessive water hyacinth cover. For example, free-floating macrophyte treatment systems often require mechanical aeration (Brix, 1993). Although hyacinth plants are effective at transporting oxygen down into their root zone (Jedicke, Furch, Saint-Paul, and Schlüter, 1989; Reddy, D'Angeelo, and DeBusk, 1989), shading by a floating mat reduces phytoplankton in the water column and growth of bottom plants. Since these submerged algae and aquatic macrophytes are significant contributors of oxygen to bottom waters in shallow bodies of water, dissolved oxygen below the root zone of the hyacinth can decline. Reduction of plant biomass below the mat can alter herbivore biomass (animals which feed on submerged plants) and potentially all of the other trophic levels in the system. The community of fishes in Wahiawa Reservoir is a complex of exotic species, including some of value to a recreational fishery (DLNR, 1991). How the various species populations would react beneficially or detrimentally to a significant proportion of the reservoir surface covered by hyacinth is too complicated to predict. In countries where significant native ecosystems exist, water hyacinth is regarded as having a potential to severely reduce aquatic biodiversity (IRIN, 1997).

Unless removed by water outflow or harvesting, water hyacinth plants killed by whatever means (natural, biological, or chemical treatment) will contribute decaying biomass to the reservoir bottom, reducing DO in deep water. At Wahiawa, significant quantities of hyacinth have gone over the dam in recent months, completely choking pools in Kaukonahua Stream immediately downstream with masses of decaying plant matter.

Fishes and Fishing

A portion of Wahiawa Reservoir is designated the Wahiawa Public Fishing Area and comprises approximately 120 ha (300 ac) of fishable water. Access is via Wahiawa State Freshwater Park along the South Fork of the reservoir (DLNR, 1990). In the 1950's the Department of Natural Resources (DLNR) stocked Wahiawa Reservoir with tilapia (*Oreochromis mossambica*) from Africa. Since that time, many additional species of imported fishes have been added, resulting in establishment of sport fisheries for tucanare, largemouth and smallmouth bass, bluegill, channel catfish, oscar, pongee, puntat, tilapia, and carp. In the 1970's it was estimated that the reservoir supported 400 tons of fish of which at least 300 tons were tilapia (Schmitt, 1973, citing W. Devick, Division of Fish and Game, pers. comm.). Table 14 lists fishes established in the reservoir from data acquired in the 1980's.

The armored catfish, *Pterygoplichthys multiradiatus,* was first detected in Wahiawa Reservoir in 1986 and by 1988 it had become one of the most abundant fishes in the reservoir. This fish has been characterized as a mud-eater (detritivore) that feeds on bacteria in the bottom mud (Lowe-McConnell, 1975). According to Devick (1988) this fish also consumes algae. This fish is especially abundant in the vicinity of the WWTP outfall (Devick, 1989).

Table 14. List of fish species established in Wahiawa Reservoir as of 1988 (After Devick, 1988)

Scientific Name	Common name	Abundance	Year and type of introduction
Tilapia mossambica	Tilapia	Extremely abundant	1952 - deliberate
Dorosoma petenense	Threadfin shad	Extremely abundant	1959 - deliberate
Tilapia melanotheron	Tilapia	Very abundant	1976 - accidental
Pterygoplichthys multiradiatus	Armored catfish	Very abundant	1986 - accidental
Chichla ocellaris	Tucunare	Abundant	1964 - deliberate
Micropterus salmoides	Largemouth bass	Abundant	1908 - deliberate
Ophicephalus striatus	Pongee snakehead	Abundant	1904 (est.) - deliberate
Xenentodon cancila	Stickfish	Abundant	1988 - accidental
Ictalurus punctatus	Channel catfish	Abundant	1959 - deliberate
Gambusia affinis	Mosquito fish	Abundant	1905 - deliberate
Tilapia macrochir	Tilapia	Common	1957 - deliberate
Micropterus dolomieu	Smallmouth bass	Common	1956 - deliberate
Clarias fuscus	Puntat chinese catfish	Common	1904 (est.) - deliberate
Cyprinus carpio	Koi carp	Common	1904 (est.) - deliberate
Lepomis macrochirus	Bluegill	Common	1946 - deliberate
Awaous stamineus	O'opu	Common	Native species
Carassius auratus	Goldfish	Unusual	1904 (est.) - accidental
Astronotus ocellatus	Oscar	Unusual	1958 - deliberate
Xiphophorus helleri	Swordtail	Unusual	1968 - accidental
Misgurnus anguillicaudatus	Dojo	Unusual	1904 (est.) - deliberate
Pterophyllum sp.	Angelfish	Rare	1982 - accidental
Colossoma macropomum	Pacu	Rare	1987 - accidental

The stickfish, *Xenentodon cancila*, also demonstrated a very large increase in population numbers in the reservoir in 1988. This fish is described by Devick (1988) as an aggressive top-level predator that is a threat to game fish production. Gut content analysis (Devick, 1989) revealed the following composition of prey species: tilapia (50%), threadfin shad (19%), mosquito fish (12%), pongee (12%), bass (6%), bluegill (1%).

Although detailed studies of fishes in the reservoir have not been conducted since the late 1980's, DLNR managers of the fishery attempt to keep tabs on the fishery through informal surveys of what fishes are being caught. Recently, another species of cichlid, *Hemichromis fasciatus* or jewel cichlid, was accidentally introduced to Wahiawa

Reservoir. This species is similar to the stickfish in being an aggressive predator on other species, including the juveniles of more desirable game fishes (Devick, pers. comm.).

It is not firmly established, but clear from what is generally known, that the WWTP discharge can contribute to conditions that result in fish kills. A list of fish kills in the reservoir through 1991 is provided as Table 15. Fish kills can result from specific toxic substances in the effluent (suspected in many cases) or from origins unknown (illegal dumping, for example). Fish kills can also result from eutrophication, a process whereby excess nutrients promote algal growth, resulting in unstable conditions in the water body with respect to dissolved oxygen and perhaps other properties. Excess algal growth can produce low oxygen in the water during the early morning hours, killing fish in the water column. High BOD in the effluent exacerbates this problem by further reducing DO. Excess algal production can alter water pH by removing dissolved CO_2. As pH increases in this case, the toxicity of ammonia in the water (some derived from the effluent discharge) increases and becomes harmful to fishes. Thus ammonia toxicity of the effluent varies with other conditions in the environment and my cause problems only occasionally.

Table 15. Documented fish kills in Wahiawa Reservior (After Brown & Caldwell, 1992)

Date	Comments
Nov-62	100,000 lb of fish killed; 90 percent of total population
Nov-68	18,000 lb of fish killed
Sep-72	3,000 lb of fish killed
Aug-86	200 tilapia killed; chlorine discharge suspected
May-87	8,000 tilapia killed; detergent-like suds and heavy stench in vicinity of outfall
Dec-87	3,000 tilapia killed; industrial waste suspected
Apr-88	2,000 tilapia, 10 channel catfish, 9 armored catfish killed; industrial waste suspected
May-88	9.000 tilapia killed; industrial waste suspected'
May-88	100 tilapia killed; industrial waste suspected
Jun-88	5,000 tilapia, 12 channel catfish, 26 armored catfish killed; industrial waste suspected
Aug-91	3,300 tilapia, 1 armored catfish killed; toxic substance suspected
Sep-91	100 tilapia, 1,000 threadfin shad killed; toxic substance suspected
Dec-91	1,500 tilapia killed; cause not determined

Water Quality Impacts Assessment

The waters of Wahiawa Reservoir can be divided, on the basis of temperature, into a warmer surface layer and a cooler deep, or bottom, layer. These two layers, or water masses, are typically separated by a thermocline: a horizontal layer in the water column where the temperature decreases noticeably over a relatively short change in depth. Since water density increases as temperature decreases, the surface (epilimnic) and deeper (hypolimnic) waters of Wahiawa Reservoir are essentially separated because the thermocline acts as a barrier to the transfer of physical and chemical properties between the two water masses throughout most of the year.

Thermal stratification in the reservoir has been shown to breakdown during unusually cool weather (Schmitt, 1973; Devick, 1981; Lum and Young, 1976), allowing mixing between surface and deep waters. Such events, however, appear to be rare and are quite transient, occurring in the early morning hours just before dawn (when surface waters are coolest) with the thermocline reforming during the daylight hours. Also, since temperatures in Wahiawa Reservoir are relatively warm, even during cool weather spells, a temperature difference as small as 0.5 C° over several meters depth is sufficient to maintain a thermocline and a barrier against mixing. This is due to the fact that the density of water decreases disproportionately with increase in temperature so that an increase from 26.5 to 27.5° C results in a density decrease equivalent to a change from 4 to 10° C at the lower end of the scale (Goldman and Horne, 1983; Payne, 1986). Thus relatively small differences in temperature in the range of 20 to 30° C can establish a stable thermocline.

The successful operation of a deep discharge site is predicated upon complete mixing of the relatively warm (less dense) effluent with cooler (denser) bottom water --that is, the effluent does not rise into the surface layer. Based upon the RMTC (1996) data, the difference in temperature between the effluent and bottom waters at Station S2B near the outfall ranged from 3.0 C° to 6.1 C°, with an average difference of 4.8 C°. Additionally, the depth of the deep water layer (bottom to surface layer) at Station 2B appears to vary between about 6 to 10 m (20 to 35 ft) depending upon water level and depth of thermocline. These may not represent extreme conditions for either temperature differential or minimum depth of the deep water layer in the reservoir. Throughout the following discussion, we assume that a condition of complete mixing of discharge effluent with the deep water is met. Because of the thermal stratification in the water column of Wahiawa Reservoir, we need to consider the effects of diverting WWTP effluent discharge from the surface to deeper water separately for the epilimnic and hypolimnic waters of the impoundment.

Impacts on Surface Waters

It is intuitively evident that diverting a surface discharge of WWTP effluent to deeper water will reduce nutrient loading in the surface (epilimnic) waters of the reservoir so long as the effluent is kept below the thermocline. Reducing the nutrient load should, in turn, result in a decrease in phytoplankton biomass. A reduction in phytoplankton biomass would trigger a decrease in TSS with the end result that there should be an increase in Secchi depth and a general improvement in water clarity in the epilimnion - at least in the vicinity of the WWTP.

The difficult question is how much of an improvement can be expected for various water quality parameters throughout the epilimnic waters of the reservoir? To address this question, we need to consider other inputs to the surface waters of Wahiawa Reservoir. Based upon evidence from several studies (Schmitt, 1973; *AECOS*, 1995; RMTC, 1966), it is now recognized that inflowing water of the North and South Forks of Kaukonahua Stream sink beneath the less dense surface waters of the reservoir to help form the hypolimnion. As such, these stream inputs do not contribute significantly to the water quality of the surface layer.

Aside from the WWTP discharge, the other major inputs to the reservoir surface water are direct rainfall and storm runoff. Quantities of total nitrogen and total phosphorus from runoff were estimated in Table 10. An 87 percent reduction in TP loading to the surface water of the reservoir could be realized by diverting the WWTP discharge below the thermocline. Because there are other possible sources of nutrient input to the reservoir than we have not accounted for, and because the runoff values used here may not strictly apply to the Wahiawa Reservoir watershed, we will assume a more conservative 70 percent reduction in TP level in estimating the potential effects of the WWTP effluent diversion on the surface water layer. Note from Table 10 that the relative proportions of TN and TP are markedly different between the WWTP and runoff inputs. Thus, upon diversion of the WWTP discharge to deeper water, it is likely that nitrogen will become the limiting nutrient in the epilimnic water of the reservoir -- a TN:TP ratio < 9:1 typically signifying nitrogen limitation in tropical fresh water lakes (Salas and Martino, 1991).

Assuming that phosphorus is the nutrient that regulates phytoplankton biomass levels in Wahiawa Reservoir, there should be also be a significant reduction in phytoplankton biomass in the impoundment. Figure 1 shows the mean distribution of phytoplankton biomass for 1995-1996 (RMTC, 1996), based upon an assumed chlorophyll α content of 1.15% of phytoplankton dry weight (Reynolds, 1984) for a mixed phytoplankton population composed primarily of chlorophytes and diatoms (types of phytoplankton organisms) as described by Schmitt (1973) as being the predominant phytoplankton types in Wahiawa Reservoir. Upon diversion of the WWTP effluents to a deep discharge, phytoplankton chlorophyll (and hence biomass) levels should fall, especially in the vicinity of the former discharge site; i.e., Station S2 and S1 (Figure 2).

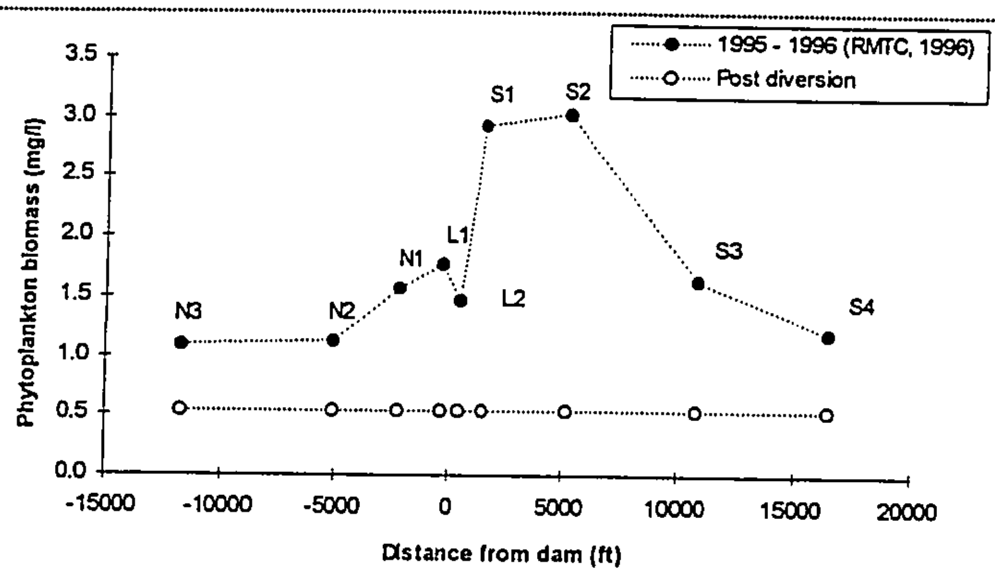

Figure 2. Estimated distribution of phytoplankton biomass currently and after diversion of surface WWTP effluent discharge into deep water in Wahiawa Reservoir.

The average chlorophyll α level in the reservoir is expected to decrease from about 26.3 μg/l (RMTC, 1996) to about 8 μg/l, resulting in a decrease of phytoplankton biomass from an average of about 4.5 mg/l to about 0.5 mg/l. While the post-diversion of phytoplankton biomass may not be evenly distributed throughout the impoundment as shown in Figure 2, it should be relatively uniform. Also, there may be some seasonal fluctuations in phytoplankton biomass. The time required to achieve this new equilibrium will likely be on the order of 1.5 to 2 resident times for the surface water mass, or about 40 to 55 days according to RMTC (1996).

TSS levels in the reservoir should also decrease (Figure 3). These decreases will also be most evident in the vicinity of the present outfall, but they will not be as dramatic as for chlorophyll. Thus, while there will be a small direct decrease in TSS from the diversion of the effluent itself, most of the TSS decrease will result from a decline in the phytoplankton population. We estimate that there could be about a 42 percent reduction in the reservoir as a whole following diversion of the WWTP effluent to a deep discharge site. Note that there is an increase in TSS at the upper ends of both forks of the reservoir. This results from mixing with the inflowing stream waters which contain relatively high particulate levels, especially from storm runoff. As with phytoplankton biomass, the time to realize this new equilibrium should be on the order of 40 to 55 days.

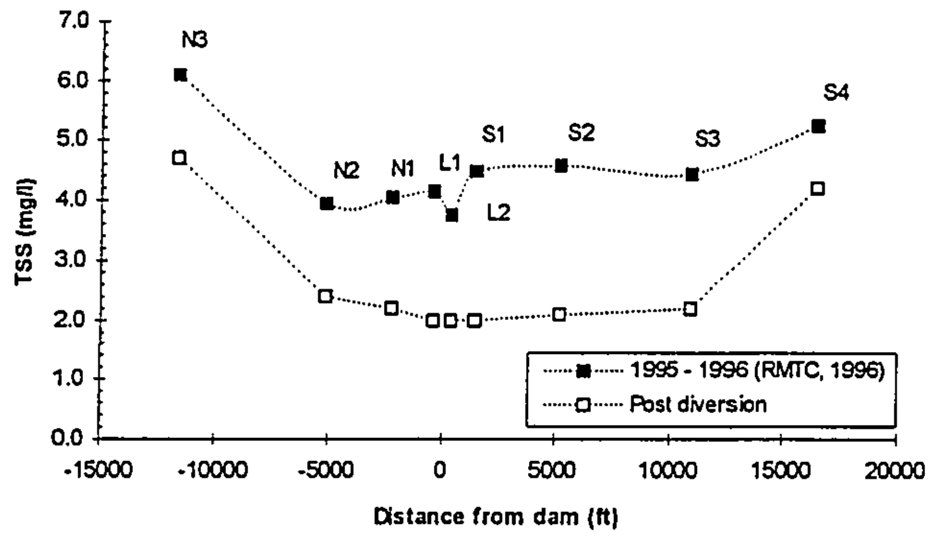

Figure 3. Estimated distribution of TSS currently and after diversion of surface WWTP effluent into deep water in Wahiawa Reservoir.

Finally, there will also be an increase in water clarity and, therefore, Secchi depth as the result of changes in the phytoplankton population. As above, the greatest increase in Secchi depth will be in the western portion of the southern fork of the reservoir (Figure 4). The average increase in Secchi depth for the reservoir on the whole should be on the order of about 22 percent, increasing from the present mean depth of 1.09 m to an average of about 1.33 m during the post-diversion period. Secchi depths at the upper ends of the reservoir will remain lower than the rest of the basin due to TSS inputs from the inflowing stream waters, especially during storm events.

So far, this discussion has focused on the expected effects of changes in particulate matter in the surface waters of Wahiawa Reservoir. However, changes in phytoplankton biomass levels could also effect dissolved oxygen (DO) levels since phytoplankton produce oxygen during the daylight hours and respire (i.e., consume oxygen) twenty-four hours per day. Further, changes in photosynthesis levels (i.e., primary productivity) might secondarily influence pH levels in the reservoir, as the uptake of carbon dioxide in photosynthesis tends to raise pH levels.

DO concentrations in the surface waters of the impoundment are largely regulated by the photosynthesis/respiration dynamics of the resident phytoplankton population, although mixing at the air-surface interface and animal respiration also influence DO levels to some unknown degree. A daily (or diurnal) cycle of DO in the reservoir is shown in Figure 5. DO decreases during the nighttime hours due to phytoplankton and animal respiration and then increases during the daylight hours due to photosynthesis. Note that respiration continues during the daylight hours, but is masked by the effects of photosynthesis.

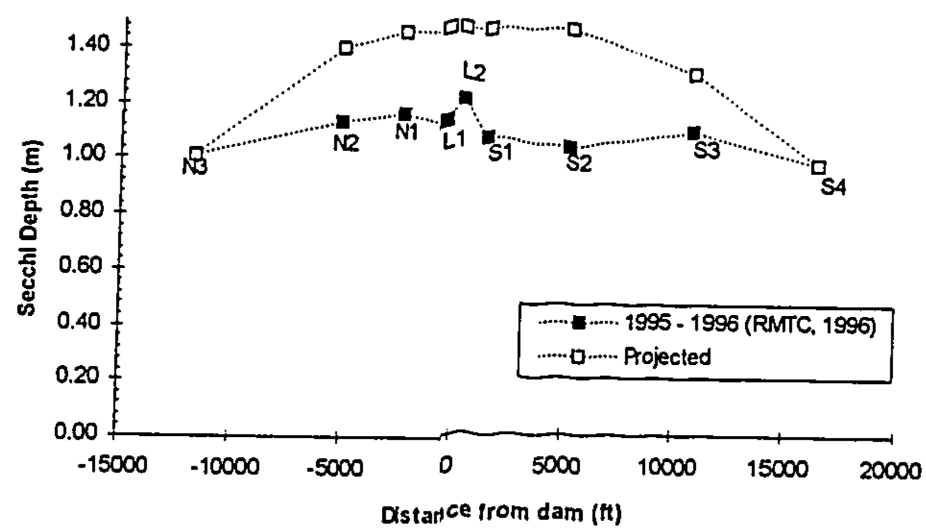

Figure 4. Estimated Secchi disk distribution presently and after diversion of surface WWTP effluent discharge to Wahiawa Reservoir.

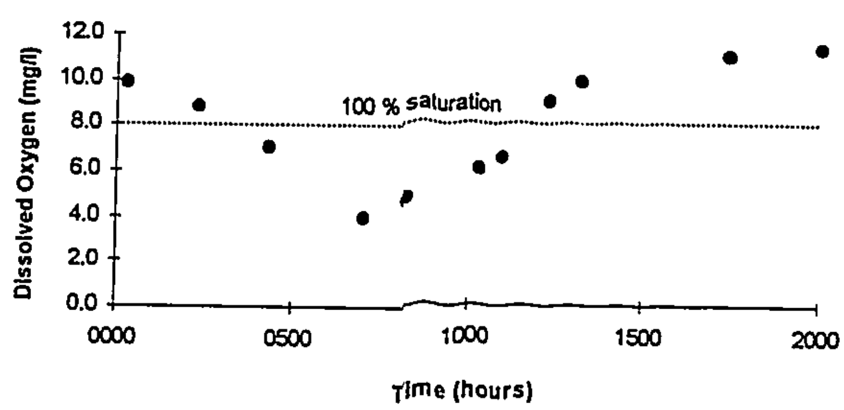

Figure 5. Diurnal cycle of DO in Wahiawa Reservoir - December 2-3, 1980 (after Devick (1981))

There is also a seasonal cycle in DO in the reservoir as shown in Figure 6 for 1995-1996 (RMTC, 1996) with mean concentrations peaking in the late Spring and decreasing into the Winter months. The mean concentrations of chlorophyll α, which largely determine DO levels in the reservoir, also display a seasonal pattern that is more variable than that of DO. The greater variability in chlorophyll distribution likely relates to its particulate nature and tendency to be patchy in distribution in time and space, whereas the dissolved oxygen would be more evenly distributed.

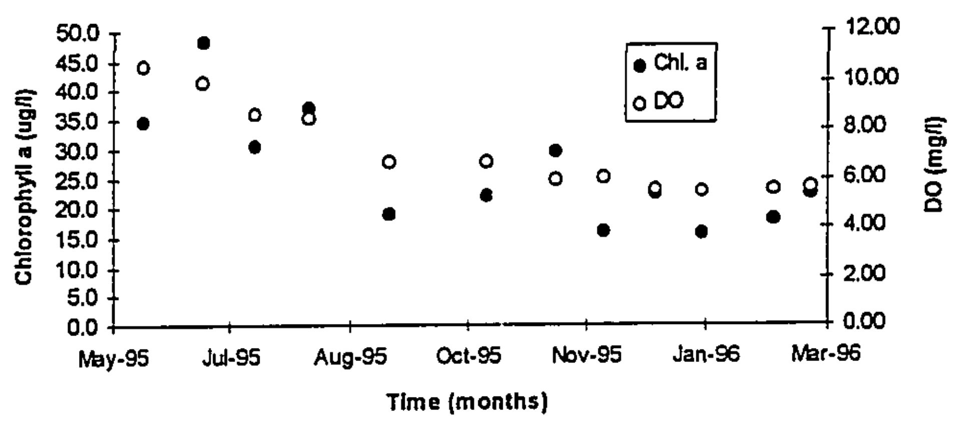

Figure 6. Seasonal mean distribution of chlorophyll α and DO in Wahiawa Reservoir (data from RMTC, 1996).

There is a significant correlation ($r = 0.84$; $\alpha = 0.553$ and d.f. = 11) between the mean seasonal distribution of chlorophyll α and DO at $P = 0.05$ with chlorophyll accounting for about 70 percent of the seasonal variation in DO (i.e., $r^2 = 0.7038$).

The decrease in chlorophyll and DO levels (Figure 6) over much of the sample period was somewhat expected. A similar trend was apparent for other parameters including TN and TP and may be related to a general increase in the water volume of the reservoir occurring between early June 1995 and March 1996. Young et al. (1975) noted a similar response between water quality parameters and water levels in the reservoir.

A comparison of DO per unit chlorophyll α with actual chlorophyll α concentrations demonstrates a marked decline in DO produced as chlorophyll levels increase in the reservoir (Figure 7). The implication here is that high chlorophyll (biomass) levels in the reservoir result in a self-shading effect to the extent that the production of DO from photosynthesis is restricted. In short, at high phytoplankton concentrations in the reservoir, light becomes a primary factor limiting primary productivity.

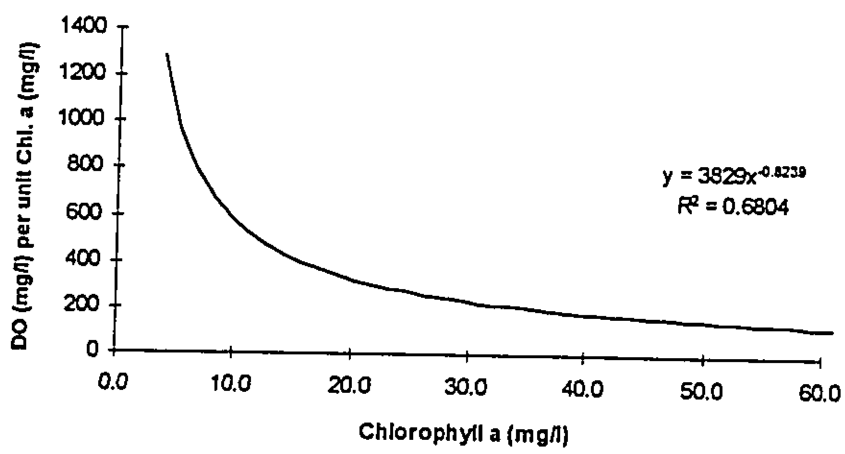

Figure 7. An index of DO per unit chlorophyll α versus chlorophyll α concentration in Wahiawa Reservoir.

The notion that primary productivity in the reservoir is light-limited is further supported by the vertical distribution of DO. A typical DO profile is shown in Figure 8. Note that DO decreases rapidly from the surface to a depth of about 4 meters as the penetration of light decreases due to absorption by particulate matter (detritus and phytoplankton). At a depth of 4 meters DO is nearly undetectable, indicating that respiration demands exceed the rate of photosynthesis due to lack of light. The increase in DO below 7 meters results from advective movement of cooler, denser water from the North and South forks of Kaukonahua Stream along the bottom of the reservoir.

An estimate of DO production as a function of chlorophyll α levels for Wahiawa Reservoir is shown in Figure 9 based upon data from the RTMC study (1996). The shape of the curve serves to point out an important feature of phytoplankton dynamics in the reservoir; i.e., at low phytoplankton biomass levels (low chlorophyll concentrations) there is a rapid increase in DO production (primary productivity) per unit increase in phytoplankton biomass. At a chlorophyll α concentration of about 8 μg/l, the relative increase in DO levels starts to slow perceptibly and indicates that primary productivity in the reservoir is now becoming limited by light availability due to self-shading of the phytoplankters. Therefore, a decrease in chlorophyll α levels from the present average of 26.3 μg/l to the projected level of about 8 μg/l following effluent diversion (see above) should result in a decrease in DO production from about 7.2 mg/l to about 5.3 mg/l. However, since DO respiration decreases linearly with chlorophyll α levels, there should be about a 2.5 factor decrease in respiration. The end result will likely be higher DO concentrations in the surface waters than presently exist.

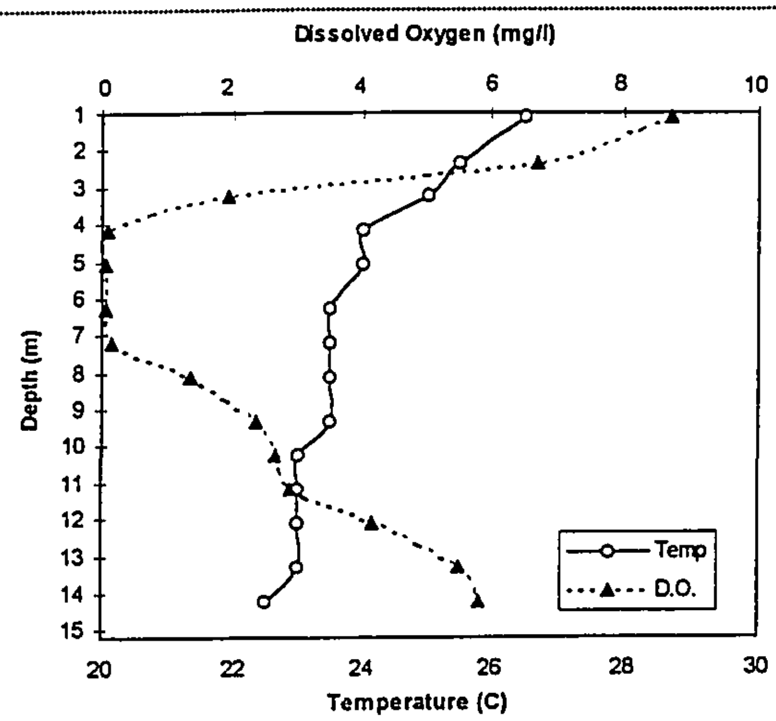

Figure 8. The vertical distribution of DO and temperature at Station 1 in the basin of Wahiawa Reservoir on October 19, 1994 (*AECOS*, 1995).

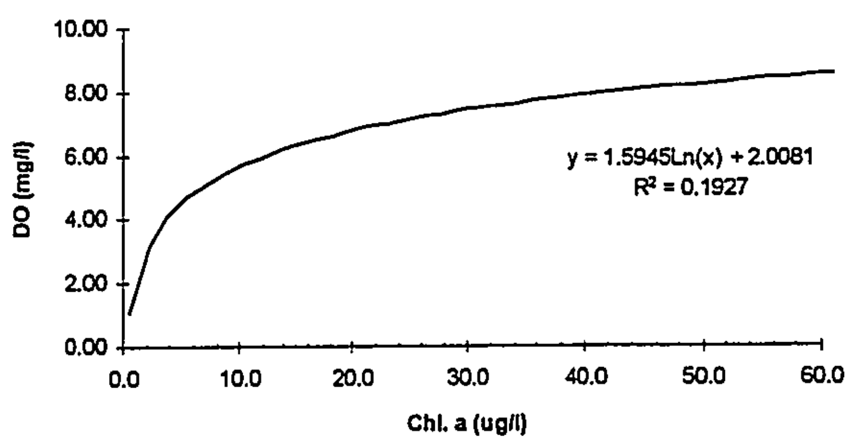

Figure 9. Estimated DO production as a function of chlorophyll α concentration in Wahiawa Reservoir.

Finally, the vertical profiles of DO in the reservoir (RMTC, 1996) show that DO concentrations are typically high in the upper 0.5 m of the water column and then fall to low levels by 3 m depth indicating that light limits net primary productivity (DO production) to the upper 3 m of the water column. The exception to this is found at Stations S4 and N3 where DO levels may remain high throughout the shallow water column. This is due to the input of stream water which contains relatively high DO levels upstream of these two stations, rather than from the effects of photosynthesis..

pH levels in eutrophic impoundments are often influenced by phytoplankton productivity, rising in proportion to the amount of carbon dioxide removed from the water column during photosynthesis (DO production). This is the case in Wahiawa Reservoir (Figure 10) where the mean pH on a given date can rise to levels greater than pH = 9. As discussed above, it is possible that DO levels in the reservoir will rise to higher concentrations in the post-diversion period. However, since this increase in DO will be a function of reduced phytoplankton respiration, there should be no concomitant rise in pH. In fact, if the mean DO concentration via photosynthesis is reduced to about 5.3 mg/l (see above) then mean pH levels should fall to about pH = 6.4.

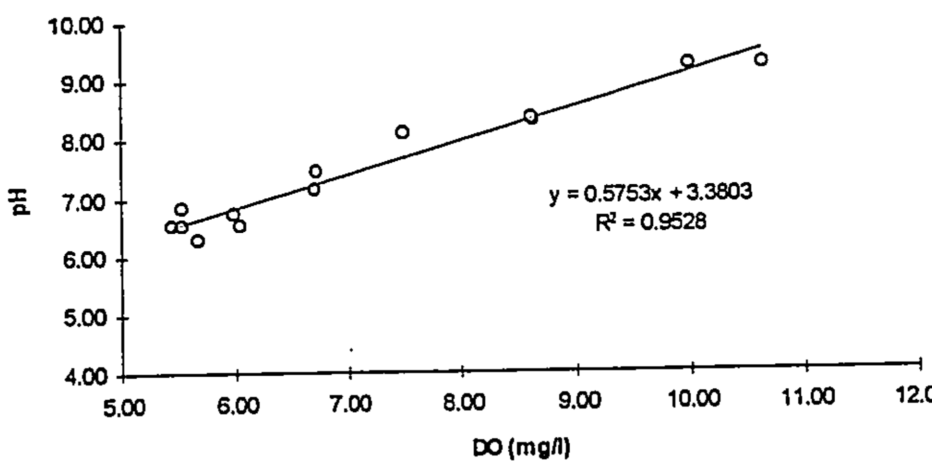

Figure 10. A comparison of mean DO and pH levels in Wahiawa Reservoir.

A careful reading of the above discussion reveals an apparent contradiction. We have stated that a reduction in phytoplankton biomass will result from a decrease in surface concentrations of phosphates upon diversion of the Wahiawa WWTP effluent. We then proceed to conclude that light presently limits photosynthesis in the surface waters of the impoundment. However, only one factor can be limiting at any given time. Light limits the ***rate***, or speed, at which primary productivity takes place in the reservoir. However, because the detention time of the surface waters is long (weeks) compared with the potential turnover rate, or doubling-time, for phytoplankton (a few days), phytoplankton biomass continues to accumulate in the reservoir; albeit, at a reduced rate compared with its potential. This biomass increase continues until the available nutrient resource (in the present situation, phosphorus) is depleted. Interestingly, after diversion of the effluent, nitrogen will be the nutrient in shortest supply in the surface waters of the reservoir.

The above discussion considers the most apparent factors which would influence water quality conditions in the epilimnion of Wahiawa Reservoir once the Wahiawa WWTP discharge is effectively diverted to deep water. There are many other factors which may ultimately contribute to the post-diversion water quality of the reservoir, but they are either poorly understood or we have no pertinent data upon which to base meaningful forecasts. Here, we will simply mention some of these factors.

The RMTC report (1996) notes that there is a net transport of bottom water towards the dam. A portion of this water meets the dam and then rises into the surface waters. The potential nutrient loading on the surface waters is not known at this time, but might prove to be an important source of nutrients and, hence, phytoplankton growth - more so during post-diversion conditions than at present.

There is also a potential for nutrient recycling in the epilimnion of the reservoir. For instance, the excretion of soluble urea products by fish and/or zooplankton would provide additional nitrogen for phytoplankton growth. Remember, in the post-diversion situation, nitrogen is predicted to become the limiting nutrient in the surface layer.

Changes in nutrient availability in the epilimnion may result in a shift in phytoplankton composition that could influence higher trophic levels to some unknown degree. Further, the responses of higher trophic levels (i.e., herbivores and carnivores) to a marked reduction in the phytoplankton population and/or qualitative changes in the phytoplankton composition is unknown.

Impacts on Bottom Water

The main environmental/water quality issue in the diversion of the Wahiawa WWTP effluent to the bottom waters of Wahiawa Reservoir is the maintenance of aerobic conditions in the hypolimnion. Periods of prolonged oxygen depletion, or anaerobic conditions, within this water layer could lead to detrimental changes in sediment/bottom water chemistry and restrict animal and plant life to the epilimnic or surface waters of the reservoir. It could also result in the entrainment of anaerobic waters in the irrigation waters drained from the reservoir.

The distribution of DO in the bottom waters under the present regime of a surface discharge from the WWTP is shown in Figure 11. There is notable decrease in DO concentration moving from the upstream stations of both forks of the reservoir towards the dam. The higher average DO concentration at Station N3 on the north fork, as compared with Station S4 on the south fork, probably results from higher DO inputs from North Kaukonahua Stream (mean = 8.9 mg/l) as compared with the South Kaukonahua Stream (mean = 7.8 mg/l) (*AECOS*, 1995). The decrease in DO levels moving down the South Fork of the reservoir is greater than that for the North Fork and reaches a minimum at about Station S2 while levels in the North Fork continue to decrease into the basin waters at Stations L2 and L1.

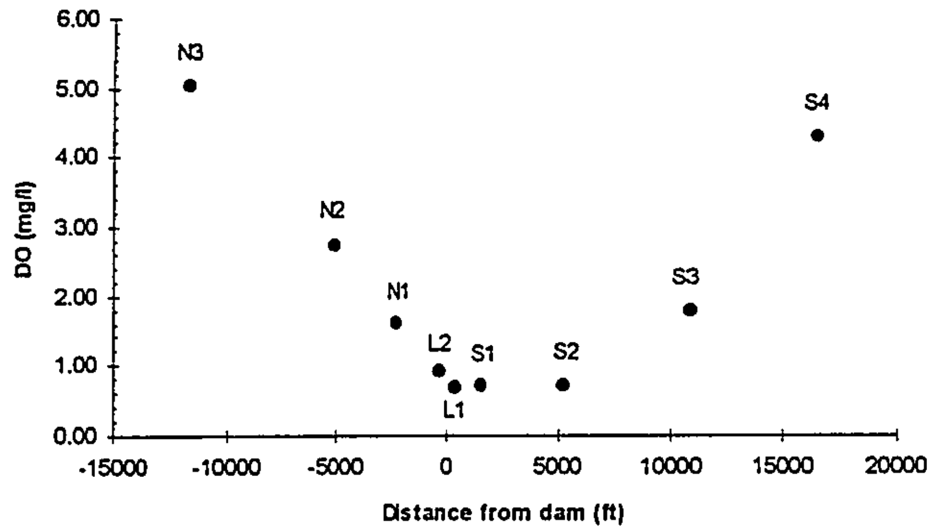

Figure 11. Mean distribution of DO (mg/l) in the bottom waters of Wahiawa Reservoir (data from RMTC, 1996)

The difference in DO patterns between the two arms of the reservoir is due to the effects of the WWTP discharge on the hypolimnic waters of the south fork. Since the epi- and hypolimnic waters of the reservoir are separated by a thermocline, nutrients must be transported into the bottom waters as particulate matter by settling through the thermocline. (Nutrients in a soluble form will not pass through the thermocline.) This particulate matter could include TSS emanating directly from the discharge, as well as phytoplankton which convert inorganic nitrogen and phosphorus from the effluents into biomass and then sink into the hypolmnion. This particulate material is then subject to breakdown and decay back into its soluble inorganic nitrogen and phosphorus components.

In the case of nitrogen, organic nitrogen is first broken down into ammonia (Manahan, 1994). In the presence of oxygen, ammonia can be further oxidized (nitrified) by two groups of bacteria. *Nitrosomonas* bacteria bring about the conversion of ammonia to nitrite and *Nitrobacter* mediate the oxidation of nitrite to nitrate (Loke, 1966). The distribution of various nitrogen components in the hypolimnion of Wahiawa Reservoir are shown in Figure 12.

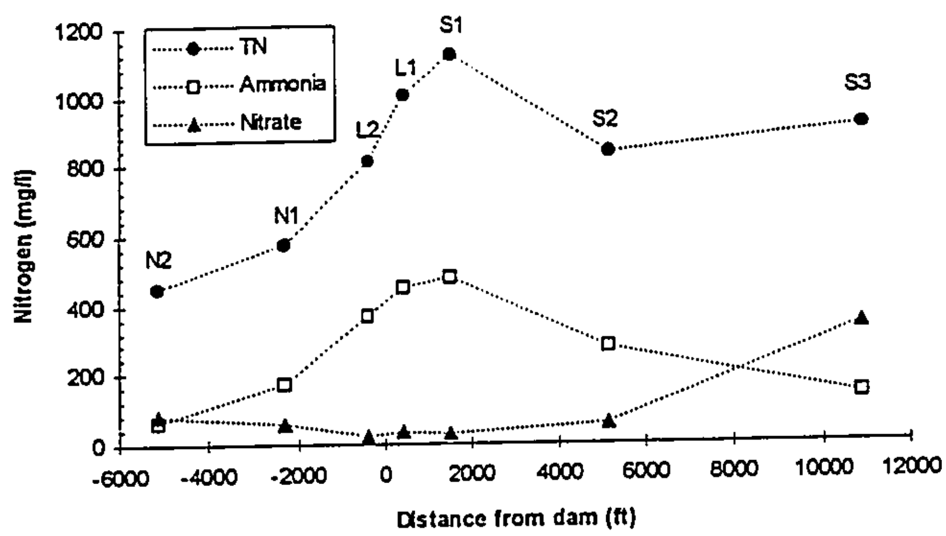

Figure 12. Mean distribution of various nitrogen forms (mg/l) in the bottom waters of Wahiawa Reservoir (data from RMTC, 1996)

Notice that the mean distribution of ammonia in the bottom waters pretty well mimics that of TN, except at Station S3, while nitrate levels are very low in areas of low DO concentration (Figure 10) and rise somewhat as DO levels increase; especially at Station S3. Since ammonia is the first breakdown product of organic nitrogen, it appears that production of ammonia is consuming most of the available DO in the hypolimnion. This is supported by a comparison of mean ammonia and DO distribution in the bottom waters (Figure 13) which demonstrates a significant correlation ($r = 0.969$; at $P = 0.05$ with d.f. = 6 and $\alpha = 0.707$).

Thus, most of the DO consumption in the hypolimnion can be accounted for by the aerobic breakdown of organic nitrogen material to ammonia. Nitrification of ammonia to nitrate + nitrite is suppressed throughout much of the reservoir due to low DO levels.

The diversion of WWTP effluent from the surface to the bottom water of the reservoir will change the form in which it's nutrient components are introduced into the hypolimnion. Presently, effluent nutrients are converted to phytoplankton and rain down into the hypolimnion as particulate organic matter. Effluents discharged directly to the bottom waters will be primarily in the form of soluble inorganic matter, particularly in view of effluent filtration for compliance with R-1 water quality. Based upon current discharge characteristics (RMTC, 1996) about 80% of the nitrogen will be in the form of ammonia and less than 1% will be as nitrate + nitrite. This would require less DO demand to convert organic nitrogen to ammonia than is presently required and might even allow for the oxidation of some ammonia to nitrate + nitrite before DO is depleted in the hypolimnion.

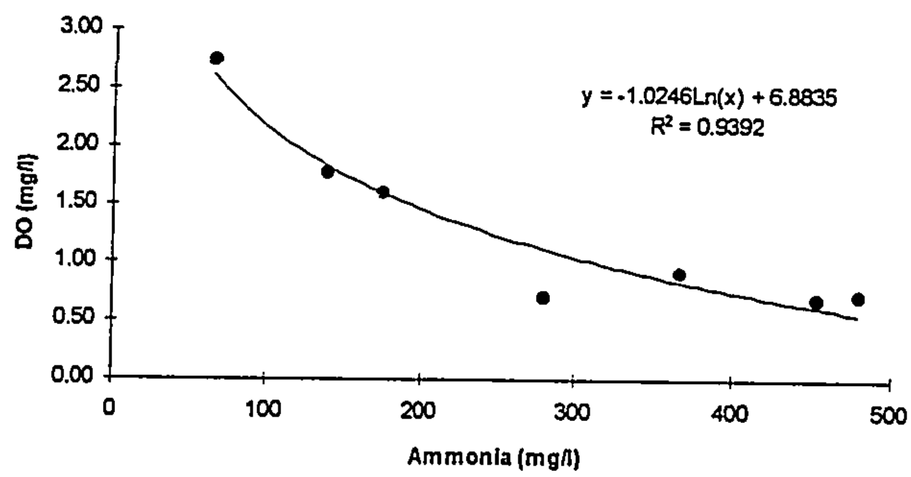

Figure 13. A comparison of the mean DO (mg/l) and ammonia levels (mg/l) in the bottom waters of Wahiawa Reservoir.

An environmentally more attractive scenario would be to convert the ammonia to nitrate + nitrite before it is discharged to the bottom waters. Brown and Caldwell (1992) note that the effluent levels of ammonia from the WWTP are uncharacteristically high due to maintenance of low DO levels in the aeration tanks which prohibits nitrification of ammonia to nitrate + nitrite. Increasing aeration in the WWTP could produce an effluent that is relatively low in ammonia and high in nitrate + nitrite. This would afford two major benefits to the hypolimnion: (1) the DO demand for nitrification of ammonia to nitrate + nitrite would be minimized; and (2) high levels of nitrate + nitrite would provide a secondary oxidizing agent in the event that DO depletion occurs.

Nutrient levels in the hypolimnion can also be influenced to some degree by interaction with the sediments. There are two basic types of sediment in Wahiawa Reservoir; those that are introduced with stream inputs and runoffs and are the typical latosols found in Hawaii (Sherman, 1955), and the high organic particulate matter produced in the epilmnion that rains down through the water column to the bottom. A decrease in organic particulate matter transported from the epilimnion to the hypolimnion by diverting the WWTP discharge to the bottom waters would also result in some improvement to the reservoir sediments.

Young et al. (1975) found that the nutrient levels in sediments, especially near the present outfall and in the basin, were significantly elevated. Lum and Young (1976) noted that these sediments had organic carbon and organic nitrogen levels similar to that of partially stabilized domestic sludge with a significant nitrogen release potential. Under anaerobic conditions, the chemical oxygen demand (COD) generated by these sediments increased about 10 mg/l. This would be sufficient to deoxygenate DO-saturated water (Lum and Young, 1976). The latosol-derived sediments, on the other hand, have low organic and inorganic nutrient levels by comparison, and thus little potential for nutrient release to the water column. They also exert little COD, and have a high iron to phosphorus ratio (Sherman, 1955) which promotes the sorption of phosophorus from the water column to their surfaces (Jensen, et al., 1992). Therefore, reducing the input of organic particulate matter from the epilimnion (possibly up to 40 percent - see above) by diverting the outfall to the bottom waters would diminish the release of potential DO demand and nitrogen from the sediments.

Impacts on Biota

Water Hyacinth

Strictly speaking, reduction of nutrient inputs is not a satisfactory method of control of excessive water hyacinth growth (Harley, Julien, and Wright, 1997). However, there is no doubt that nutrients promote the growth of water plants like the hyacinth, and reduction of nutrient inputs from point sources and non-point sources will have an impact on growth rates. Removal of nutrients from the surface layer will be of benefit to water hyacinth control so long as plant population size is kept in check. However, any time the population of plants reaches a size at which mechanical removal becomes impractical, the contribution of nutrients from the Wahiawa WWTP becomes largely immaterial. The plant will continue to spread and be a nuisance.

Fishes and Fishing

It is clear that while the nutrient subsidy supplied by the WWTP discharge probably favors at least some species extant in Wahiawa Reservoir (Mozambique tilapia and armored catfish, are examples), relationships among the various fish species are complex and unsettled because of continuing introductions of new species. *Hemichromis fasciatus*, unknown in the reservoir a decade ago, is now the most abundant juvenile fish in shallow water. Mozambique tilapia also remain very abundant. The ultimate consequences to the recreational fishery of any changes in the nature of the WWTP discharge cannot be predicted. Removal of the nutrient subsidy represented by the discharge would more than likely result in smaller populations of some or all species, but changes are not likely to be proportional. Changing the location of the outfall to deeper water could have similar impacts or no impact on absolute numbers of fish species. Improved water clarity could be advantageous to predator species, but populations of predator species are highly dependent upon prey species numbers.

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APPENDIX C

PRE-ASSESSMENT CONSULTATION CORRESPONDENCE

Dole Food Company Hawaii
1116 Whitmore Avenue Wahiawa, Hawaii 96786

RECEIVED 6-24-98

June 22, 1998

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814-3021

Re: Pre-Assessment Consultation Per Your Letter Dated June 18, 1998

Dear Mr. Park:

This confirms our request to participate in the Environmental Assessment for the Proposed Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment project. Our involvement is based on these highlights.

1. The Wahiawa Water Company, Inc. (WWCI) is a wholly-owned subsidiary of the Waialua Sugar Company, Inc. (WSCI). Dole Food Company, Inc. (Dole) is the parent corporation of WSCI.

2. The Wahiawa Reservoir, a.k.a. Lake Wilson, was built in 1905 by WWCI for irrigation purposes. The Wahiawa irrigation ditch extends from Wahiawa to the North Shore area.

3. The WWCI owns 385 acres and leases 142 acres from the Galbraith Estate for the Wahiawa Reservoir land area. Ownership of the dam and spillway is split at the old stream bed.

4. Most importantly, a 1929 Sewer Outfall perpetual easement agreement between the WWCI and the City and County of Honolulu to allow the Wahiawa Sewage Treatment Plant to discharge undiluted effluent directly into the Wahiawa Reservoir.

5. A 1957 Cooperative Agreement with the State of Hawaii to allow public access and pole fishing by permit from the State DLNR.

Dole has been actively involved in matters concerning wastewater disposition and agricultural irrigation use. It is most fitting and proper to ask to be included in your planning process. We look forward to receiving more definitive information as they become available for our review and opportunity to provide inputs into the final product.

Please call me at 621-3201, fax 621-7410 or e-mail george_wada@na.dole.com. Thank you and aloha.

Sincerely,

George T. Wada
Director, Finance

GTW:paa

c: Jerry D. Vriesenga
Robert Miyasaki

The Senate
The Nineteenth Legislature
of the
State of Hawaii

HONOLULU, HAWAII 96813

June 22, 1998

RECEIVED 6-24-98

Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814

Dear Mr. Park: Gerald

Thank you for your letter of June 18, 1998 regarding the Environmental Assessment for the Proposed Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment project. At this time I do not have any comments on the project.

I sincerely appreciate you taking the time to keep me apprised of the project.

Sincerely,

Randy Iwase
State Senator

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET 11TH FLOOR • HONOLULU HAWAII 96813

RECEIVED 6-26-98

ENV 98-135

June 22, 1998

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Ste. 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

Subject: Pre-Assessment Consultation (PAC)
Wahiawa Wastewater Treatment Plant Modification
and Outfall Adjustment

We have reviewed the subject PAC document and have no comments to offer at this time.

Should you have any questions, please contact Mr. Alex Ho, Environmental Engineer, at 523-4150.

Very truly yours,

for JONATHAN K. SHIMADA, PhD
Director and Chief Engineer

DEPARTMENT OF TRANSPORTATION SERVICES

CITY AND COUNTY OF HONOLULU

RECEIVED 7-1-98

TSP6/98-03793R

June 30, 1998

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

Subject: Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment

In response to your June 19, 1998 letter, we reviewed the information provided. At this time, we have no comments regarding the subject project. We look forward to receiving a copy of the draft environmental assessment.

Should you have any questions regarding this matter, please contact Faith Miyamoto of the Transportation System Planning Division at 527-6976.

Sincerely,

CHERYL D. SOON
Director

cc: Mr. Robert Miyasaki, Department of Wastewater Management

BENJAMIN J. CAYETANO
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

KAZU HAYASHIDA
DIRECTOR

IN REPLY REFER TO
STP 8.8638

June 30, 1998

RECEIVED 7-2-98

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

Subject: Pre-Assessment Consultation
Wahiawa Wastewater Treatment Plan Modifications and Outfall Adjustment
TMK: 7-3-7: 2

Thank you for your transmittal of June 19, 1998.

The proposed project will not have an impact on our State transportation facilities.

We appreciate the opportunity to provide comments.

Very truly yours,

KAZU HAYASHIDA
Director of Transportation

DEPARTMENT OF PLANNING AND PERMITTING
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET, 7TH FLOOR • HONOLULU, HAWAII 96813
Phone: (808) 523-4414 • Fax: (808) 527-6743

JEREMY HARRIS
MAYOR

JAN NAOE SULLIVAN
DIRECTOR

LORETTA K.C. CHEE
DEPUTY DIRECTOR

RECEIVED 7.7.98

July 6, 1998

98-04470(ASK)
'98 EA Comments Zone 7

Mr. Gerald Park
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814

Dear Mr. Park:

Pre-Assessment Consultation
Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment

This is to acknowledge receipt of your June 19, 1998 letter regarding preparation of a Draft Environmental Assessment for the Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment. Please forward a copy of this document for our review.

We recommend that the affected communities be involved in the planning process.

Very truly yours,

For JAN NAOE SULLIVAN
Director of Planning
and Permitting

JNS:am

BENJAMIN J. CAYETANO
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
STATE HISTORIC PRESERVATION DIVISION
33 SOUTH KING STREET, 6TH FLOOR
HONOLULU, HAWAII 96813

MICHAEL D. WILSON, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

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

RECEIVED 7.10.98

July 7, 1998

Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814-3021

LOG NO: 21761 ✓
DOC NO: 9806EJ37

Dear Mr. Park:

SUBJECT: Chapter 6E-8 Historic Preservation Review – Preparation of an Environmental Assessment Preparation for the Proposed Wahlawa Wastewater Treatment Plant Modifications and Outfall Adjustment Project Wahiawa, Wahiawa, O'ahu
TMK: 7-

Thank you for the opportunity to comment during the preparation of an EA for this project. The City and County of Honolulu Department of Wastewater Management and the Department of Health, State of Hawaii, have agreed to modify the wastewater treatment process at the existing Wahiawa Wastewater Treatment Plant. Reclaimed effluent will be discharged into Wahiawa Reservoir through the existing outfall. A review of our records shows that there are no known historic sites at the outfall location. Therefore, we believe that this project will have "no effect" on historic sites.

Should you have any questions, please feel free to call Elaine Jourdane at 587-0014.

Aloha,

Don Hibbard, Administrator
State Historic Preservation Division

EJ:je

PLANNING DEPARTMENT
CITY AND COUNTY OF HONOLULU

RECEIVED 7-8-98

ET 6/98-1250

July 6, 1998

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814

Dear Mr. Park:

Environmental Pre-Assessment Consultation
Wahiawa Wastewater Treatment
Plant Modifications and Outfall Adjustments

This is in response to your letter dated June 19, 1998. We have reviewed the information provided and offer the following comments:

- The Draft Environmental Assessment (DEA) should include discussion on all applicable City and County of Honolulu Development and General Plan Objectives and Policies, impacts on water quality and biota in Wahiawa Reservoir and Kaukonahua Stream, and impacts on diversified agriculture with the availability of reclaimed effluent of R-1 quality.

- Proposed upgrades at the existing Wahiawa Wastewater Treatment Plant is consistent with the Central Oahu Development Plan Public Facilities Map (DPPFM). Ordinance 96-35, approved by City Council in April 1996, placed a wastewater treatment plant modification symbol on the Central Oahu DPPFM to recognize proposed improvements to the Wahiawa Wastewater Treatment Plant.

  The adjustment of the existing outfall to a lower elevation in the Wahiawa Reservoir would be considered a minor improvement and would not require a DPPFM amendment.

Should you have any questions, please contact Eugene Takahashi of our staff at 527-6022.

Yours very truly,

PATRICK T. ONISHI
Chief Planning Officer

PTO:lh

c: Department of Design and Construction
Division of Planning and Programming
Attn: Robert Miyasaki

PACIFIC CENTURY TRUST

RECEIVED 7-14-98

July 11, 1998

Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, HI 96814-3021

Dear Mr. Park:

RE: George Galbraith Trust #120008404 (RE0015504)
Wahiawa Wastewater Treatment Plant

Thank you for your recent letter regarding the proposed Wahiawa Wastewater Treatment Plant modifications.

Several questions for now -- 1) How will the R-1 Water affect the quality of water in the reservoir 2) When will the draft environmental assessment be ready?

We look forward to hearing from you soon, and feel free to call me at 538-4563 if you wish to discuss the matter further.

Sincerely,

PACIFIC CENTURY TRUST

Sharman Noguchi
Assistant Vice President

cc: J. Alexander, VP

THE INSTITUTIONAL SERVICES GROUP OF BANK OF HAWAII
POST OFFICE BOX 3170 • HONOLULU, HI 96802-3170 • TEL (808) 538-4444 • FAX (808) 538-4693

DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM

OFFICE OF PLANNING
235 South Beretania Street, 6th Flr., Honolulu, Hawaii 96813
Mailing Address: P.O. Box 2359, Honolulu, Hawaii 96804

Tel: (808) 587-28
Fax: (808) 587-28

Ref. No. P-7556

RECEIVED 7-16-98

July 13, 1998

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814

Dear Mr. Park:

Subject: Pre-Assessment Consultation Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment Wahiawa, Oahu, Hawaii

Since the project is situated in the Coastal Zone Management (CZM) area, we suggest that an assessment of the project's consistency to the CZM objectives and policies, Chapter 205A, Hawaii Revised Statutes, be incorporated into the draft environmental assessment. If there are any questions, please contact Steve Olive of our CZM Program at 587-2877.

Sincerely,

Rick Egged
Director
Office of Planning

BOARD OF WATER SUPPLY

CITY AND COUNTY OF HONOLULU
630 SOUTH BERETANIA STREET
HONOLULU, HAWAII 96843
PHONE (808) 527-6180
FAX (808) 533-2714

July 13, 1998

RECEIVED 7-16-98

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

Subject: Your Letter of June 19, 1998 on the Pre-Assessment Consultation Phase for the Wahiawa Wastewater Treatment Plant Modifications and <u>Outfall Adjustment Project, Wahiawa, Oahu, TMK: 7-3-07: 04</u>

Thank you for the opportunity to review the document for the proposed treatment plant modifications.

We have the following comments to offer:

1. We understand that the level of wastewater treatment is being increased from R-2 to R-1 and that there exists significant dilution, over 5 to 1 ratios, within the Wahiawa Reservoir.

2. R-1 reclaimed effluent, as defined by the Department of Health, significantly reduces viral and bacteriological pathogens and coliform bacteria. However, minerals, such as nitrates, are not addressed. Therefore, the Environmental Assessment (EA) should discuss mineral content in the reclaimed water and the environmental effects to the reservoir, the reclaimed application areas and the underlying potable aquifer.

3. We suggest a risk assessment be conducted to assess the continued disposal of wastewater into the Wahiawa reservoir upon the quality of surface and groundwater in Wahiawa and Waialua.

4. Water quality data of the existing and proposed effluent should be provided as well as data on the reservoir water at the spillway.

5. Areas where reclaimed effluent will be applied, should be indicated on a map in relation to existing and proposed groundwater wells in Waialua and Kawailoa. Groundwater flow direction should also be shown.

6. The EA should discuss the benefits and impacts of deepening the sewage outfall into the Wahiawa Reservoir. There are eutrophication concerns due to oxygen depletion and nitrogen loading caused by the effluent.

7. The existing water system is presently adequate to accommodate the proposed project.

8. The availability of water will be determined when the Building Permit Application is submitted for our review and approval. If water is made available, the applicant will be required to pay our Water System Facilities Charges for resource development, transmission and daily storage.

9. There is an existing 2-inch water meter currently serving the treatment plant site.

10. If a three-inch or larger water meter is required, the construction drawings showing the installation of the meter should be submitted for our review and approval.

11. The on-site fire protection requirements should be coordinated with the Fire Prevention Bureau of the Honolulu Fire Department.

12. Board of Water Supply approved reduced pressure principle backflow prevention assemblies are required installations immediately after all water meters serving the site.

If you have any questions, please contact Barry Usagawa at 527-5235.

Very truly yours,

BROOKS H. M. YUEN
Acting Manager and Chief Engineer

cc: Department of Environmental Services

DEPARTMENT OF THE ARMY
HEADQUARTERS, UNITED STATES ARMY GARRISON, HAWAII
SCHOFIELD BARRACKS, HAWAII 96857-5000

REPLY TO ATTENTION OF

Directorate of Public Works

RECEIVED 7-18-98

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street
Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

This is in response to your letter (enclosed) dated June 19, 1998, subject: Pre-Assessment Consultation, Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment, Wahiawa, Oahu, Hawaii.

The 25th Infantry Division (Light) & U.S. Army Hawaii, like the City and County of Honolulu (CCH), is also developing a project to produce reclaimed quality treated wastewater. The Schofield Barracks Wastewater Treatment Plant (SBWWTP) would be upgraded to produce R-1 quality effluent. Reuse alternatives include irrigating our golf courses, providing irrigation water for agriculture industries and discharging to Wahiawa Reservoir.

We would like to work closely with the CCH regarding the location of the proposed deep outfall and be informed of any water quality issues within the reservoir.

To avoid confusion, we want to emphasize that the SBWWTP presently does not discharge into the Wahiawa Reservoir. Our secondary treated wastewater is currently discharged directly into Dole Foods Company's irrigation ditch downstream of the reservoir.

If there are any questions, please contact Mr. Walter Nagai, Environmental Division, Directorate of Public Works at 656-2878, extension 1059.

Sincerely,

Barry N. Totten
Colonel, U.S. Army
Director of Public Works

Enclosure

Copy Furnished:

Commander, 25th ID (L) & U.S. Army, Hawaii, Schofield Barracks, Hawaii 96857-6000
Commander, 25th ID (L) & U.S. Army, Hawaii, Attn: APVG-JA, Schofield Barracks, HI 96857-6000
Commander, U.S. Army Garrison, Hawaii, Schofield Barracks, Hawaii 96857-5000
Commander, U.S. Army Pacific, Attn: APEN-EV, Fort Shafter, Hawaii 96858-5100
Dr. Kenneth Sprague, City and County of Honolulu, Department of Environmental Services,
650 South King Street, Honolulu, Hawaii 96813

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

REPLY TO
ATTENTION OF

July 15, 1998

Programs and Project Management
Division

RECEIVED 7-18-98

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii [illegible]

Dear Mr. Park:

In response to your inquiry dated June 19, 1998, Subject: Pre-Assessment Consultation, Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment, Wahiawa, Oahu, Hawaii, the Environmental Assessment should address problems associated with disinfectant resistant viruses that may be introduced into the Wahiawa Reservoir.

Questions concerning the above may be directed to Mr. David Lindsey at 438-6946.

Sincerely,

For Ray H. Jyo, P.E.
Deputy Chief, Programs and
Project Management Division

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

July 14, 1998

LD-NAV
Ref.:WHTPMOA.RCM

RECEIVED 7-21-98

Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

SUBJECT: Review : Pre-Assessment Consultation
Proposal : Wahiawa Wastewater Treatment Plant Modification and Outfall Adjustment
Applicant : Gerald Park Urban Planner, on behalf of the Department of Wastewater Management, City and County of Honolulu
Location : Wahiawa, Island of Oahu, Hawaii

Thank you for the opportunity to review and comment on the proposed Wahiawa Wastewater Treatment Plant Modification and Outfall Adjustment project.

Our State Historic Preservation Division has informed us that a review of their record shows that there are no known historic sites at the existing Outfall. Therefore, they believe that the project will have no effect on historic sites.

Our Oahu District Land Office respectfully recommends that there be no discharge into the Wahiawa Reservoir for reason that Wahiawa Reservoir is a Recreational Facility. An alternative would be to have the discharge piped down Kunia Road to the Ewa disposal plant.

Should you have any questions, please feel free to contact Nicholas A. Vaccaro of the Land Division Support Services Branch at 587-0438.

Very truly yours,

DEAN Y. UCHIDA
Administrator

c: Oahu Land Board Member
Oahu District Land Office

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

JUL 21 ...

RECEIVED 7.23.98

Ref.:LD-PEM

Ref.:WWTPMOA.RCM

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

Subject: Request for Comments - Pre-Assessment Consultation, Wahiawa Wastewater Treatment Plant Modification and Outfall Adjustment, Wahiawa, Oahu

The following is additional comments regarding the Pre-Assessment Consultation for subject project:

Commission on Water Resource Management

If the scope of the project includes the alteration of the bed or banks of Kaukonahua Stream (Wahiawa Reservoir), the applicant must obtain a stream channel alteration permit pursuant to Hawaii Revised Statues §174C-71.

Thank you for the opportunity to review the Pre-Assessment Consultation for the subject project, we have no further comments to offer at this time. Should you have any questions, please contact Patti Miyashiro of my staff at 587-0430.

Very truly yours,

Dean Y. Uchida
Administrator

c: Oahu District Land Office
CWRM

PHONE (808) 594-1888

FAX (808) 594-1865

STATE OF HAWAI'I
OFFICE OF HAWAIIAN AFFAIRS
711 KAPI'OLANI BOULEVARD, SUITE 500
HONOLULU, HAWAI'I 96813

RECEIVED 7.23.98

July 14, 1998

Mr. Gerald Park
Urban Planner
1400 Rycroft Street
Honolulu, HI 96814-3021

Subject: Pre-Assessment Consultation, Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment, Wahiawa, Island of Oahu

Dear Mr. Park:

Thank you for your letter notifying us of your intent to prepare an environmental assessment (EA) for the Proposed Wahiawa Wastewater Treatment Plan Modifications and Outfall Adjustment project.

The Office of Hawaiian Affairs (OHA) has no objections at this time to the proposed EA. But OHA intends to thoroughly review the EA once it is available for public review. Because of the scope of the project, OHA expects the applicant to fully address several potential adverse impacts on (i) quality of nearby water resources, (ii) flora and fauna, and (iii) archaeological resources. In addition, the applicant should address short- and long-term plans for the utilization of "R-1" water.

Please contact Colin Kippen (594-1938), LNR Officer, or Luis Manrique (594-1758), should you have any questions on this matter.

Sincerely yours,

Randall Ogata
Administrator

Colin Kippen
Officer,
Land and Natural
Resources Division

cc: Board of Trustees
OEQC

BENJAMIN J. CAYETANO
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF HEALTH
P.O. BOX 3378
HONOLULU, HAWAII 96801

LAWRENCE MIIKE
DIRECTOR OF HEALTH

In reply, please refer to:

July 28, 1998

95-244E/epo

RECEIVED 7.30.98

Mr. Gerald Park
Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

Subject: Pre-Environmental Assessment
Wahiawa Wastewater Treatment Plant Modification
and Outfall Adjustment
Wahiawa, Oahu
TMK: 7-3-07: 2

Thank you for allowing us to review and comment on the subject project. We do not have any comments to offer at this time. However, we would like to review a copy of the Draft Environmental Assessment.

Sincerely,

BRUCE S. ANDERSON, Ph.D.
Deputy Director for
Environmental Health

USDA

United States
Department of
Agriculture

Natural
Resources
Conservation
Service

P.O. Box 50004
Honolulu, HI
96850

RECEIVED 8.12.98

Our People...Our Islands...In Harmony

August 11, 1998

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

Subject: Pre-Assessment Consultation - Wahiawa Wastewater Treatment Plant, Modifications and Outfall Adjustment, Wahiawa, Oahu, Hawaii

We have reviewed the above document and have no comments to offer at this time.

Thank you for the opportunity to review this document.

Sincerely,

KENNETH M. KANESHIRO
State Conservationist

APPENDIX D

ENVIRONMENTAL ASSESSMENT
COMMENTS AND RESPONSES

DEPARTMENT OF FACILITY MAINTENANCE

CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET, 11TH FLOOR • HONOLULU, HAWAII 96813
Phone: (808) 523-4341 • Fax: (808) 527-5857

JEREMY HARRIS
MAYOR

JONATHAN K. SHIMADA, PhD
DIRECTOR AND CHIEF ENGINEER

ISIDRO M. BAQUILAR
DEPUTY DIRECTOR

IN REPLY REFER TO:
PRO 98-228

December 9, 1998

RECEIVED 12-11-98

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

Subject: Draft Environmental Assessment
<u>Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment</u>

Thank you for allowing us the opportunity to review the environmental assessment. However, we do not have any comments.

If you have any questions, please call Laverne Higa at 527-6246.

Very truly yours,

for Jonathan K. Shimada, PhD
Director and Chief Engineer

LH
cc: Robert Miyasaki, DDC

The Senate
The Nineteenth Legislature
of the
State of Hawaii

STATE CAPITOL
HONOLULU, HAWAII 96813

December 14, 1998

RECEIVED 12-16-98

Gerald Park
Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96813

Dear Mr. Park:

Thank you for your letter of December 7, 1998 and for the copy of the Draft Environmental Assessment for the Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment Wahiawa, Oahu, Hawaii, for the Department of Design and Construction, City and County of Honolulu.

At this time I have no comments regarding the project.

Again, thank you for the copy of the Environmental Assessment.

Sincerely,

Randy Iwase
State Senator

BENJAMIN J. CAYETANO
GOVERNOR OF HAWAII

RECEIVED 12-24-98

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

CHAIRPERSON
MICHAEL D. WILSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTY DIRECTOR
GILBERT S. COLOMA-AGARAN

December 18, 1998

Mr. Gerald Park
1400 Rycroft Street
Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

Subject: Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment - Wahiawa, Oahu, Hawaii

Thank you for allowing our division to comment on subject project's draft environmental assessment.

If our reading of the documentation is correct, the project would result in the discharge of equal or better quality of water than is currently entering Lake Wilson.

Inasmuch as these same waters are used for recreational boating/fishing, it is hoped that the project design can minimize, if not eliminate, prior occurrences of fish kill (overabundant algae, toxic substances or industrial waste). While potential health hazards can become apparent if large quantities of dead fish end up on the banks as the waters edge or floating on the lake, the greater concern should be for the unwitting fishers who might be eating contaminated catch that had not yet developed any evidence of concern.

As the Wahiawa Freshwater State Park provides a ready point of entry for boaters/fishermen throughout Lake Wilson, we request that procedures at the plant provide for posting of warning signs at our park, whenever pollution levels in the vicinity of the outfall warrants posting elsewhere around the lake.

Sincerely,

RALSTON H. NAGATA
State Parks Administrator

DEPARTMENT OF DESIGN AND CONSTRUCTION
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET, 2ND FLOOR
HONOLULU, HAWAII 96813
PHONE: (808) 523-4564 • FAX: (808) 523-4567

JEREMY HARRIS
MAYOR

RANDALL K. FUJIKI, AIA
DIRECTOR

ROLAND D. LIBBY, JR., AIA
DEPUTY DIRECTOR

March 17, 1999

DCP 99-162

Mr. Ralston Nagata, Administrator
Division of State Parks
Department of Land and Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Nagata:

Subject: Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment Wahiawa, Oahu, Hawaii

Thank you for reviewing the Draft Environmental Assessment prepared for the subject project. Your suggestion that procedures at the plant provide for the posting of warning signs at Wahiawa Freshwater Park to alert boaters/fishermen if and when pollution levels pose a health hazard will be considered by the Department of Design and Construction.

We appreciate the participation of State Parks, Department of Land and Natural Resources, in the environmental assessment process. If you have any questions, please contact Mr. Bill Liu of my staff at 527-6871.

Very truly yours,

For RANDALL K. FUJIKI
Director

cc: Calvin Kim & Associates

DEPARTMENT OF THE ARMY
HEADQUARTERS, UNITED STATES ARMY GARRISON, HAWAII
SCHOFIELD BARRACKS, HAWAII 96857-5000
DEC 2 2 1998

REPLY TO ATTENTION OF

RECEIVED 12-24-98

Directorate of Public Works

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street
Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

Thank you for your letter dated December 7, 1998 transmitting the Draft Environmental Assessment for the Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment project for my review and comments.

I have reviewed the Draft Environmental Assessment and ask that all references to the effect that the Army could not secure the necessary funds for a joint project with the City not be mentioned. Rather, that the City and the Army were not able to jointly negotiate an agreement to the satisfaction of both parties.

The Army remains open to any partnerships with the City to provide a regional solution to water reclamation in Central Oahu.

If there are any questions, please contact Mr. Clifton Takenaka, Environmental Division, Directorate of Public Works, 656-2878, ext. 1049.

Sincerely,

Barry N. Totten
Colonel, U.S. Army
Director of Public Works

Copies Furnished:

Commander, 25th Infantry Division (Light) and U.S. Army, Hawaii, ATTN: APVG-DCS, Schofield Barracks, HI 96857-6000
Commander, 25th Infantry Division (Light) and U.S. Army, Hawaii, ATTN: APVG-JA, Schofield Barracks, HI 96857-6016
Commander, U.S. Army, Pacific, ATTN: APEN-EV, Fort Shafter, HI 96858-5100
Commander, U.S. Army Garrison, Hawaii, ATTN: APVG-GC, Schofield Barracks, HI 96857-5000

DEPARTMENT OF DESIGN AND CONSTRUCTION
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET, 2ND FLOOR
HONOLULU, HAWAII 96813
PHONE: (808) 523-4564 • FAX: (808) 523-4567

JEREMY HARRIS
MAYOR

RANDALL K. FUJIKI, AIA
DIRECTOR

ROLANDO D. LIBBY, JR., AIA
DEPUTY DIRECTOR

March 17, 1999

DCP 99-166

Colonel Barry Totten, Director
Directorate of Public Works
Building 104
Wheeler Army Airfield
US Army Garrison Hawaii
Schofield Barracks, Hawaii 96857-5013

Dear Colonel Totten:

Subject: Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment
Wahiawa, Oahu, Hawaii

Thank you for reviewing the Draft Environmental Assessment for the subject project. As requested in your letter, references to the effect that the Army could not secure the necessary funds for a joint project with the City will be revised to read "the City and the Army were not able to jointly negotiate an agreement to the satisfaction of both parties".

We appreciate the participation of the United States Army Garrison, Hawaii in the environmental assessment review process. If you have any questions, please contact Mr. Bill Liu of my staff at 527-6871.

Very truly yours,

For RANDALL K. FUJIKI
Director

cc: Calvin Kim & Associates

STATE OF HAWAII

DEPARTMENT OF LAND AND NATURAL RESOURCES

HISTORIC PRESERVATION DIVISION

December 22, 1998

RECEIVED 1-6-99

Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814-3021

LOG NO: 22686 ✓
DOC NO: 9812EJ17

Dear Mr. Park:

SUBJECT: Chapter 6E-8 Historic Preservation Review -- Draft Environmental Assessment for the Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment Project
Wahiawa, Wahiawa, O'ahu
TMK: 7-3-07:01, 02; 7-1-01:por. 8, por. 20, 21

We previously commented during the preparation phase for the DEA on this project. We stated that we believe that this project will have "no effect" on historic sites, and these comments are included in Appendix C of the DEA.

If you have any questions please call Elaine Jourdane at 692-8027.

Aloha,

Don Hibbard, Administrator
State Historic Preservation Division

EJ:jk

c: Robert Miyasaki, Department of Design and Construction, Division of Planning and Programming, City & County of Honolulu, 650 South King St., Hon., HI 96813

JAN-25-1999 10:21 FROM WASTEWATER MGMT PLSC/ELC TO 99-27485 P.01

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

January 6, 1999

RECEIVED DEPT OF DESIGN & CONSTR C & C OF HONOLULU 99 JAN -8 PM 1:28

RECEIVED '99 JAN -8 P3:46 DESIGN & CONSTRUCTION DIVISION OF PLANNING & PROGRAMMING

REPLY TO ATTENTION OF
Environmental Branch
Engineering Division

Department of Design and Construction
Division of Planning and Programming
650 South King Street
Honolulu, Hawaii 96813

Gentlemen:

The following are our review comments on your Draft Environmental Assessment (EA) for the Wahiawa Wastewater Treatment Plant (WWTP) Modification and Outfall Adjustment at Wahiawa, Oahu, Hawaii.

On page 1-3, 4th paragraph, your Draft EA states the U.S. Army would upgrade the Schofield WWTP to produce R-1 water quality and convey the effluent to the Honouliuli WWTP. For your information, the U.S. Army has considered R-2 and pre-treatment effluent water quality.

We have no further comments at this time. If you have any further questions, please contact Mr. Edward Yamada, Project Manager at 438-5421.

Sincerely,

James L. Bersson, P.E.
Chief, Engineering Division

Post-it® brand fax transmittal memo 7671	# of pages ▸ 1
To G. Park	From B. Liu
Co. G Park Pln	Co. DDC - Pln
Dept.	Phone # 527-6871
Fax # 942-7405	Fax # 523-4472

TOTAL P.01

Dole Food Company Hawaii
1116 Whitmore Avenue Wahiawa, Hawaii 96786

JERRY D. VRIESENGA
PRESIDENT

RECEIVED 1-7-99

January 5, 1999

Mr. Robert Miyasaki
Department of Design and Construction
Division of Planning and Programming
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

Dear Mr. Miyasaki:

Following a review of the draft environmental assessment for the Wahiawa Wastewater Treatment Plant and outfall adjustment, the Dole Food Company has some concerns which we feel will have to be addressed. Our concerns deal with the existing outfall easement as it relates to the proposed outfall relocation and with proposed changes in wastewater monitoring set up by the Department of Health which will have an impact on Dole's agricultural operations. With regard to the wastewater facility, we have no comments and feel that the change from R-2 to R-1 effluent will be a positive move.

The existing outfall easement is over Dole owned land (TMK 7-3-07:01; 178.625 acres). The indenture was dated January 18, 1929 and a second indenture was dated April 10, 1967. Neither of the two agreements contain a relocation provision. The draft environmental assessment does not mention the subject of the ownership of the underlying land for the new outfall nor mention the disposition of the existing easement. This issue will have to be resolved, but the resolution will be affected by our other concern.

The second concern that we have is far more complex than the easement issue. The draft environmental assessment mentions the change from R-2 to R-1 and the positive impact this has as far as reuse options are concerned. As far as reuse is concerned, this is true. The assessment does not mention that the Department of Health is moving from reuse <u>guidelines</u> to reuse <u>rules</u> and that diversified agriculture will have to monitor the potential impact of effluent reuse on

ground water quality. This applies to either R-2 or R-1 effluent. This change will add additional costs to our agricultural operations. The fact is, Dole does not need effluent to fill its irrigation needs and therefore will not be willing to accept added costs associated with the use of effluent. The options to resolve this issue include (1) disposition of the effluent on the down stream side of the dam, (2) get the rules modified to reflect the dilution effect of the stream water and eliminate the need for testing, (3) make anticipated testing costs part of a new easement agreement, or (4) include testing costs as part of the treatment plant's operating costs.

Please feel free to call me at 621-3200 to discuss any questions you might have relative to our concerns.

Sincerely,

Jerry D. Vriesenga

JDV:paa

Cc: Gerald Park

DEPARTMENT OF DESIGN AND CONSTRUCTION
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET, 2ND FLOOR
HONOLULU, HAWAII 96813
PHONE: (808) 523-4564 • FAX: (808) 523-4567

JEREMY HARRIS
MAYOR

RANDALL K. FUJIKI, AIA
DIRECTOR

ROLANDO D. LIBBY, JR., AIA
DEPUTY DIRECTOR

DCP 99-168

March 17, 1999

Mr. Jerry D. Vriesenga, President
Dole Food Company Hawaii
1116 Whitmore Avenue
Wahiawa, Hawaii 96786

Dear Mr. Vriesenga:

Subject: Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment
Wahiawa, Oahu, Hawaii

Thank you for reviewing the Draft Environmental Assessment prepared for the subject project. We offer the following responses to your comments in the order presented.

Outfall Easement

The area of the new easement and acknowledgment that the City will be requesting a new easement for the outfall from the Wahiawa Water Company, owners of TMK: 7-7-03: 01, will be included in the Final Environmental Assessment.

The Division of Land Survey and Acquisition, Department of Design and Construction, City and County of Honolulu should have or will be contacting Dole Food Company Hawaii about obtaining an easement for the proposed outfall. Disposition of the existing easement can be discussed during the negotiations for a new easement.

Reuse Guidelines

The concerns you raise about diversified agriculture having to monitor the impact of effluent reuse on groundwater quality and the potential for additional costs to your agricultural operation are a concern of the City. While a movement to change the Department of Health Reuse Guidelines to Rules cannot be resolved during the environmental assessment process, this is a major issue for individuals and companies engaged in diversified agriculture, the City and County of Honolulu, and the State of Hawaii. The City is willing to meet with you and effluent reuse regulators to discuss a mutually agreeable resolution to this issue.

We appreciate the participation of Dole Food Company Hawaii in the environmental assessment process. Your comments and our responses will be included in the Final Environmental Assessment. If you have any questions, please contact Mr. Bill Liu of my staff at 527-6871.

Very truly yours,

For RANDALL K. FUJIKI
Director

cc: Calvin Kim & Associates

DEPARTMENT OF PLANNING AND PERMITTING
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET • HONOLULU, HAWAII 96813
PHONE: (808) 523-4414 • FAX: (808) 527-6743

JEREMY HARRIS
MAYOR

JAN NAOE SULLIVAN
DIRECTOR

LORETTA K.C. CHEE
DEPUTY DIRECTOR

RECEIVED 1-7-99

1998/CLOG-893
'98 EA Comments Zone 7(ST)

January 7, 1999

MEMORANDUM

TO: RANDALL K. FUJIKI, DIRECTOR
DEPARTMENT OF DESIGN AND CONSTRUCTION

ATTN: ROBERT HIYASAKI

FROM: JAN NAOE SULLIVAN, DIRECTOR
DEPARTMENT OF PLANNING AND PERMITTING

SUBJECT: DRAFT ENVIRONMENTAL ASSESSMENT (EA): WAHIAWA WASTEWATER TREATMENT PLANT MODIFICATIONS AND IMPROVED OUTFALL, WAHIAWA, OAHU
TAX MAP KEYS: 7-1-1: PORS. 8, 20 AND 21; 7-3-7: 1 AND 2

We have reviewed the Draft EA for the above-referenced project received on December 8, 1998, and have the following comments:

SECTION 2.A.12 - Land Use Controls

County

The existing facility and the adjacent corporation yard have been the subject of a joint development pursuant to Conditional Use Permit No. 90/CUP1-23. Since the corporation yard required relief from required off-street parking, we anticipate that any floor area additions to the wastewater treatment plant will require waivers from required parking. We also note that additional waivers will be required for the two (2) secondary clarifiers along the south boundary which will encroach into the required 15-foot required yard.

State

We note that the new outfall construction will occur within Lake Wilson which is designated within the State Conservation District. As such, a Conservation District Use Application (CDUA) may be required for this work. The Department of Land and Natural Resources should be consulted on this matter.

We have no other comments to offer at this time. Should you have any questions, please contact Steve Tagawa of our Coastal Lands Branch at Extension 4817.

JAN NAOE SULLIVAN
Director of Planning
and Permitting

JNS:am

cc: Gerald Park Urban Planner
Office of Environmental Quality Control

posse doc no.1427

DEPARTMENT OF PLANNING AND PERMITTING
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET • HONOLULU, HAWAII 96813
PHONE: (808) 523-4414 • FAX: (808) 527-6743

JEREMY HARRIS
MAYOR

JAN NAOE SULLIVAN
DIRECTOR

LORETTA K.C. CHEE
DEPUTY DIRECTOR

RECEIVED

ET 12/98-2393

January 4, 1999

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

Draft Environmental Assessment for Wahiawa
Wastewater Treatment Plant Modifications
and Outfall Adjustment, Wahiawa, Oahu, Hawaii

Thank you for giving us the opportunity to review the Draft Environmental Assessment (DEA) for the proposed Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment project. We have reviewed the subject document and provide the comments below for your consideration.

- As recommended in our July 6, 1998 letter to you, the Environmental Assessment should include discussion on all applicable City and County of Honolulu Development Plans and General Plan Objectives and Policies.
- We have no additional comments to offer at this time.

Should you have any questions, please contact Eugene Takahashi of our staff at 527-6022.

Sincerely,

JAN NAOE SULLIVAN
Director of Planning and Permitting

JNS:js
c: Department of Design and Construction
OEQC

DEPARTMENT OF DESIGN AND CONSTRUCTION
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET, 2ND FLOOR
HONOLULU, HAWAII 96813
PHONE: (808) 523-4564 • FAX: (808) 523-4567

JEREMY HARRIS
MAYOR

RANDALL K. FUJIKI, AIA
DIRECTOR

ROLANDO D. LIBBY, JR., AIA
DEPUTY DIRECTOR

DCP 99-165

March 17, 1999

MEMORANDUM

TO: MS. JAN NAOE SULLIVAN, DIRECTOR
DEPARTMENT OF PLANNING AND PERMITTING

FROM: For RANDALL K. FUJIKI, DIRECTOR
DEPARTMENT OF DESIGN AND CONSTRUCTION

SUBJECT: WAHIAWA WASTEWATER TREATMENT PLANT MODIFICATIONS AND OUTFALL ADJUSTMENT WAHIAWA, OAHU, HAWAII

Thank you for reviewing and offering comments to the Draft Environmental Assessment prepared for the subject project. We offer the following responses to your comments in the order presented.

Section 2.A.12-Land Use Controls

County

Thank you for informing us that the Wahiawa WWTP and the adjacent Wahiawa Corporation Yard were developed under joint development. The Department of Design and Construction will be requesting waivers from: 1) the parking requirements created by additional floor area in the proposed Operations Building, and 2) the yard requirement to allow two proposed secondary clarifiers to encroach into the 15-foot side yard.

Public health regulations (§11-62-23.1(c)) require existing and proposed treatment units, except for completely enclosed, locked and ventilated equipment rooms, to not be located within 25 feet from any property lines. The City and County of Honolulu will seek relief from this provision from the Department of Health, State of Hawaii.

<u>State</u>

The Department of Land and Natural Resources has confirmed that Wahiawa Reservoir is within the State Conservation District and a Conservation District Use Permit will be required for work in the Conservation District.

<u>Development Plans and General Plan Objectives and Policies</u>

We have reviewed the Oahu General Plan objectives and policies to identify relationships between the general plan and the proposed project. Two policies under the Transportation and Utilities Policy Set have a direct bearing on the proposed project. The policies are:

Objective B, Policy 6

Support programs to recover resources from solid-waste and recycle wastewater.

Although the proposed project is not a wastewater recycling project, modifications to the Wahiawa WWTP will improve the quality of the current discharge and, in combination with the deep outfall, to the water quality of Wahiawa Reservoir. The R-1 water to be produced at the plant will be discharged into Wahiawa Reservoir and used for agricultural irrigation.

Objective D, Policy 4

Evaluate the social, economic, and environmental impact of additions to the transportation and utility systems before they are constructed.

The Draft Environmental Assessment prepared for the subject project is consistent with this objective and policy.

The general plan policy cited in Section 1, page 1-6, of the Draft Environmental Assessment is not applicable. The policy was part of a set of general plan amendments being considered by the City Council at about the time the Draft Environmental Assessment was being published. The amendment package subsequently was "filed" by the City Council.

We appreciate the participation of the Department of Planning and Permitting in the environmental assessment process. Your comments and our responses will be included in the Final Environmental Assessment. If you have any questions, please contact Mr. Bill Liu of my staff at 527-6871.

cc: Calvin Kim & Associates

HOUSE OF REPRESENTATIVES
STATE OF HAWAII
STATE CAPITOL
HONOLULU, HAWAII 96813

RECEIVED 1.8.99

January 8, 1999

Mr. Gerald Park
Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814

Re: Wahiawa Wastewater Treatment Plant Upgrade

Dear Mr. Park:

Being that the City and County of Honolulu is currently under a consent decree, which mandates certain changes in the treatment and discharge of effluent from the Wahiawa Wastewater Treatment Plant into Wahiawa Reservoir, I have no objections to any of the proposals. With the development of Wahiawa Freshwater Park as a premier recreational asset for Oahu's residents and visitors, any steps taken to ensure improved water quality in the reservoir should be encouraged.

My main concern is that adequate periodic monitoring for excess nutrients in any effluent discharged into Wahiawa Reservoir must be ensured, especially during and after times of heavy rains when an overflow is most likely to occur. Excess nutrients undoubtedly contributed to the recent bloom of water hyacinth in the reservoir, and will continue to pose a threat to the maintenance of the reservoir's ecological balance without such monitoring.

Sincerely yours,

REP. MARCUS OSHIRO
40th Distict (Wahiawa-Whitmore Village)

MO:dk

DEPARTMENT OF DESIGN AND CONSTRUCTION
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET, 2ND FLOOR
HONOLULU, HAWAII 96813
PHONE: (808) 523-4564 • FAX: (808) 523-4567

JEREMY HARRIS
MAYOR

RANDALL K. FUJIKI, AIA
DIRECTOR

ROLAND D. LIBBY, JR., AIA
DEPUTY DIRECTOR

DCP 99-163

March 17, 1999

The Honorable Marcus Oshiro
40th Representative District
House of Representatives
State Capitol
415 South Beretania Street
Honolulu, Hawaii 96813

Dear Representative Oshiro:

Subject: Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment
Wahiawa, Oahu, Hawaii

Thank you for reviewing the Draft Environmental Assessment prepared for the subject project. We offer the following responses to your comments.

The Consent Decree allows for continued discharge of treated effluent provided effluent does not exceed the interim discharge limits shown in Table 1-1 (Section 1, pg. 1-4) of the Draft Environmental Assessment. The Consent Decree also mandates the City to monitor effluent parameters. The specified parameters and monitoring frequency are Total Nitrogen (once/week), Total Phosphorus (once/week), and Fecal Coliform Bacteria (once/week). The City is also required to report all fish kills to the Department of Health within 24 hours.

In addition, the City has to comply with all monitoring requirements and other conditions of NPDES Permit No. HI 0020125 which expired in March, 1994; except that the City shall comply with the more stricter effluent limitations and Fecal Coliform Bacteria monitoring set forth in the Consent Decree which supersedes the effluent limitations and Fecal Coliform Bacteria requirements in the NPDES Permit.

In the long-term, construction of flow-equalization facilities should accommodate wet-weather flow rates in excess of 6.5 million gallon per day. The facilities would store excess wet-weather flow until it can be treated and discharged.

We appreciate your participation in the environmental assessment process. Your comments and our responses will be included in the Final Environmental Assessment. If you have any questions, please contact Mr. Bill Liu of my staff at 527-6871.

Very truly yours,

For RANDALL K. FUJIKI
Director

cc: Calvin Kim & Associates

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
LAND DIVISION
PO BOX 621
HONOLULU, HAWAII 96809

JAN 8 1999

RECEIVED 1.2.99

REF: PS:EH

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street
Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:
Subject: Wahiawa Wastewater Treatment Plant Draft Environmental Assessment (DEA)

We have reviewed the subject DEA and confirm that, as identified on page 2-8, Wahiawa Reservoir is designated within the State Conservation District, Resource Subzone. As such, the proposed project will require a Conservation District Use Permit.

Thank you for the opportunity to comment on this matter. Should you have any questions, or require further assistance, please contact staff planner Ed Henry at 587-0380.

Very truly yours,

Dean Uchida,
Administrator

DEPARTMENT OF DESIGN AND CONSTRUCTION
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET, 2ND FLOOR
HONOLULU, HAWAII 96813
PHONE: (808) 523-4564 • FAX: (808) 523-4567

JEREMY HARRIS
MAYOR

RANDALL K. FUJIKI, AIA
DIRECTOR

ROLAND D. LIBBY, JR., AIA
DEPUTY DIRECTOR

DCP 99-167

March 17, 1999

Mr. Dean Y. Uchida, Administrator
Land Management Division
Department of Land and Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Uchida:

Subject: Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment Wahiawa, Oahu, Hawaii

Thank you for confirming that the proposed project is located with the State Conservation District and a Conservation District Use Permit ("CDUP") is required. We will be contacting your staff to discuss the submittal requirements for a CDUP.

We appreciate the participation of the Land Division, Department of Land and Natural Resources, in the environmental assessment process. If you have any questions, please contact Mr. Bill Liu of my staff at 527-6871.

Very truly yours,

For RANDALL K. FUJIKI
Director

cc: Calvin Kim & Associates

BOARD OF WATER SUPPLY
CITY AND COUNTY OF HONOLULU
630 SOUTH BERETANIA STREET
HONOLULU, HAWAII 96843
PHONE (808) 527-6180
FAX (808) 533-2714

January 6, 1999

RECEIVED 1-13-99

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

Subject: Your Letter of December 7, 1998 Regarding the Draft Environmental Assessment for the Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment Project, Wahiawa, Oahu, TMK: 7-3-07: 04

Thank you for the opportunity to review and comment on the Draft Environmental Assessment (EA) for the proposed treatment plant modifications.

Our comments of July 23, 1998 during the Pre-Assessment Consultation Phase are still applicable and included in Appendix C of the Draft EA.

If you have any questions, please contact Barry Usagawa at 527-5235.

Very truly yours,

CLIFFORD S. JAMILE
Manager and Chief Engineer

Pure Water ... our greatest need - use it wisely

BOARD OF WATER SUPPLY
CITY AND COUNTY OF HONOLULU
630 SOUTH BERETANIA STREET
HONOLULU, HAWAII 96843
PHONE (808) 527-6180
FAX (808) 533-2714

July 13, 1998

RECEIVED 7-16-98

Mr. Gerald Park
Gerald Park Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

Subject: Your Letter of June 19, 1998 on the Pre-Assessment Consultation Phase for the Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment Project, Wahiawa, Oahu, TMK: 7-3-07: 04

Thank you for the opportunity to review the document for the proposed treatment plant modifications.

We have the following comments to offer:

1. We understand that the level of wastewater treatment is being increased from R-2 to R-1 and that there exists significant dilution, over 5 to 1 ratios, within the Wahiawa Reservoir.
2. R-1 reclaimed effluent, as defined by the Department of Health, significantly reduces viral and bacteriological pathogens and coliform bacteria. However, minerals, such as nitrates, are not addressed. Therefore, the Environmental Assessment (EA) should discuss mineral content in the reclaimed water and the environmental effects to the reservoir, the reclaimed application areas and the underlying potable aquifer.
3. We suggest a risk assessment be conducted to assess the continued disposal of wastewater into the Wahiawa reservoir upon the quality of surface and groundwater in Wahiawa and Waialua.
4. Water quality data of the existing and proposed effluent should be provided as well as data on the reservoir water at the spillway.
5. Areas where reclaimed effluent will be applied, should be indicated on a map in relation to existing and proposed groundwater wells in Waialua and Kawailoa. Groundwater flow direction should also be shown.
6. The EA should discuss the benefits and impacts of deepening the sewage outfall into the Wahiawa Reservoir. There are eutrophication concerns due to oxygen depletion and nitrogen loading caused by the effluent.
7. The existing water system is presently adequate to accommodate the proposed project.
8. The availability of water will be determined when the Building Permit Application is submitted for our review and approval. If water is made available, the applicant will be required to pay our Water System Facilities Charges for resource development, transmission and daily storage.

Mr. Gerald Park
Page 2
July 13, 1998

9. There is an existing 2-inch water meter currently serving the treatment plant site.

10. If a three-inch or larger water meter is required, the construction drawings showing the installation of the meter should be submitted for our review and approval.

11. The on-site fire protection requirements should be coordinated with the Fire Prevention Bureau of the Honolulu Fire Department.

12. Board of Water Supply approved reduced pressure principle backflow prevention assemblies are required installations immediately after all water meters serving the site.

If you have any questions, please contact Barry Usagawa at 527-5235.

Very truly yours,

BROOKS H. H. YUEN
Acting Manager and Chief Engineer

cc: Department of Environmental Services

DEPARTMENT OF DESIGN AND CONSTRUCTION
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET, 2ND FLOOR
HONOLULU, HAWAII 96813
PHONE: (808) 523-4564 • FAX: (808) 523-4567

JEREMY HARRIS
MAYOR

RANDALL K. FUJIKI, AIA
DIRECTOR

ROLAND D. LIBBY, JR., AIA
DEPUTY DIRECTOR

DCP 99-161

March 17, 1999

MEMORANDUM

TO: MR. CLIFFORD S. JAMILE, MANAGER AND CHIEF ENGINEER
BOARD OF WATER SUPPLY

FROM: for RANDALL K. FUJIKI, DIRECTOR
DEPARTMENT OF DESIGN AND CONSTRUCTION

SUBJECT: WAHIAWA WASTEWATER TREATMENT PLANT MODIFICATIONS AND OUTFALL ADJUSTMENT WAHIAWA, OAHU, HAWAII

Thank you for reviewing and offering comments to the Draft Environmental Assessment prepared for the subject project. We offer the following responses to your comments made in your letter dated July 13, 1998.

1. The combined inflows into Wahiawa Reservoir from the North and South Forks of Kaukonahua Stream average 56.8 mgd (Mink and Yuen, March 1995). Water quality modeling studies by R.M. Towill Corp. have used a conservative inflow of 25 mgd. Dilution should be far higher than the 5 to 1 ratio indicated.

2. The treatment of the wastewater to a R-1 standard will result in an higher quality effluent with some nutrient removal. However, nutrient removal facilities for nitrogen and phosphorus are not part of this project, which is solely to produce a R-1 quality effluent and to deepen the outfall. The discharge of the effluent near the bottom of the reservoir will have significant beneficial impact in the surface waters of the Wahiawa Reservoir (R.M. Towill and Wells and Berger, 1996 and 1997).

The Wahiawa WWTP has been discharging into the Wahiawa Reservoir since 1927. The reservoir water in turn is used to irrigate the agricultural lands of Waialua Sugar Co. (Dole Food Co.). The U.S. Army discharges 4.2 mgd of secondary effluent directly into the irrigation system below the reservoir. These discharges over the long period of use have not shown any measurable impact upon the aquifer.

3. The risk assessment for this project is not warranted for the following reasons:

   a. The Wahiawa WWTP is an existing facility that has been discharging its effluent into Wahiawa Reservoir since 1927.

   The Wahiawa WWTP is not being expanded and there is no increase in the design flow.

   The project is to improve the water quality of the discharge, which will be beneficial to the water quality in Wahiawa Reservoir. The project goal is to meet the conditions imposed by the Department of Health under the Consent Decree.

   d. An analysis of just the Wahiawa WWTP impacts on the aquifer would be inconclusive. The overall problem needs to be analyzed and all discharges by others included.

4. The studies regarding existing water quality data and the benefits of deepening the outfall were developed by the R.M. Towill Corp. in their report <u>Water Quality Standards for Wastewater Disposal, Central Oahu</u>, September 1997. Their conclusions have been accepted by the Department of Health and they have mandated that the City deepen the outfall. In addition, the water quality of the reservoir will be monitored before, during and after construction to ascertain the water quality impacts and to determine whether further improvements are warranted.

5. The water from Wahiawa Reservoir is used to irrigate the fields of the former Waialua Sugar Co. The possible areas that could be irrigated with Wahiawa Reservoir water and the location of the BWS wells have been added to the EA.

6. This project is being undertaken to reduce the eutrophication problems in the Wahiawa Reservoir.

We appreciate the participation of the Board of Water Supply in the environmental assessment process. Your comments and our responses will be included in the Final Environmental Assessment. If you have any questions, please contact Mr. Bill Liu of my staff at 527-6871.

cc: Calvin Kim & Associates

BENJAMIN J. CAYETANO

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT
P.O. BOX 621
HONOLULU, HAWAII 96809

MICHAEL D. WILSON

ROBERT G. GIRALD
DAVID A. NOBRIGA
LAWRENCE H. MIIKE
RICHARD H. COX
HERBERT M. RICHARDS, JR.

TIMOTHY E. JOHNS

RECEIVED 1.14.99

January 6, 1998

Mr. Gerald Park, Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

SUBJECT: Draft Environmental Assessment, Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment

Thank you for the opportunity to review the subject document. Our comments related to water resources are marked below.

In general, the CWRM strongly promotes the efficient use of our water resources through conservation measures and use of alternative non-potable water resources whenever available, feasible, and there are no harmful effects to the ecosystem. Also, the CWRM encourages the protection of water recharge areas which are important for the maintenance of streams and the replenishment of aquifers.

[X] We recommend coordination with the county government to incorporate this project into the county's 20-year Water Use and Development Plan, which is subject to regular updates.

[ ] We recommend coordination with the Land Division of the State Department of Land and Natural Resources to incorporate this project into the 20-year State Water Projects Plan, which is subject to regular updates.

[X] We are concerned about the potential for ground or surface water degradation/contamination and recommend that approvals for this project be conditioned upon a review by the State Department of Health and the developer's acceptance of any resulting requirements related to water quality.

[ ] A Well Construction Permit would be required before this well(s) is constructed and/or a Pump Installation Permit would be required before ground water is pumped from the well(s) for this project.

[ ] The proposed water supply source for the project is located in a designated water management area, and a Water Use Permit from the CWRM would be required prior to use of this source.

[ ] Groundwater withdrawals from this project may affect streamflows. This may require an instream flow standard amendment.

[X] If the proposed project diverts additional water from streams or if new or modified stream diversions are planned, the project may need to obtain a stream diversion works permit and petition to amend the interim instream flow standard for the affected stream(s).

[X] If the proposed project performs any work within the bed and banks of a stream channel, the project may need to obtain a stream channel alteration permit and a petition to amend the interim instream flow standard for the affected stream(s).

[X] OTHER:

- It is the policy of the Commission on Water Resource Management to promote the viable and appropriate reuse of reclaimed water in so far as it does not compromise beneficial uses of existing water resources.

If there are any questions, please contact the Commission staff at 587-0240.

Sincerely,

TIMOTHY E. JOHNS
Deputy Director

LN:ss

DEPARTMENT OF DESIGN AND CONSTRUCTION
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET, 2ND FLOOR
HONOLULU, HAWAII 96813
PHONE: (808) 523-4564 • FAX: (808) 523-4567

JEREMY HARRIS
MAYOR

RANDALL K. FUJIKI, AIA
DIRECTOR

ROLAND D. LIBBY, JR., AIA
DEPUTY DIRECTOR

DCP 99-164

March 17, 1999

Mr. Edwin T. Sakoda, Acting Deputy Director
Commission on Water Resources Management
Department of Land and Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Sakoda:

Subject: Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment
<u>Wahiawa, Oahu, Hawaii</u>

Thank you for reviewing the Draft Environmental Assessment prepared for the subject project. In response to your comments we offer the following:

1. Project plans will be forwarded to City agencies responsible for the 20-year Water Use and Development Plan.

2. Project plans for modifications to the Wahiawa WWTP and for construction of the deep outfall will be submitted to the Department of Health for their review and approval.

3. No stream diversion is planned.

4. We will forward correspondence to the Commission on Water Resources Management requesting a determination if Wahiawa Reservoir is considered a man-made impoundment for agricultural water or a stream (Kaukonahua Stream). Application for a Stream Channel Alteration Permit will be submitted if needed.

5. No response required.

We appreciate the participation of the Commission on Water Resources Management, Department of Land and Natural Resources, in the environmental assessment process. If you have any questions, please contact Mr. Bill Liu of my staff at 527-6871.

Very truly yours,

For RANDALL K. FUJIKI
Director

cc: Calvin Kim & Associates

BENJAMIN J. CAYETANO
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF HEALTH
P.O. BOX 3378
HONOLULU, HAWAII 96801

BRUCE S. ANDERSON, Ph.D., M.P.H.
[redacted]
DIRECTOR OF HEALTH

In reply, please refer to:

January 27, 1999

95-244F/epo

RECEIVED 1-29-99

Mr. Gerald Park
Urban Planner
1400 Rycroft Street, Suite 876
Honolulu, Hawaii 96814-3021

Dear Mr. Park:

Subject: Draft Environmental Assessment (DEA)
Wahiawa Wastewater Treatment Plant
Modification and Outfall Adjustment
Wahiawa, Oahu
TMK: 7-3-7: 2

Thank you for allowing us to review and comment on the subject project. We have the following comments to offer:

Clean Water Branch

1. In the DEA, on page ii, first paragraph, no. 3, and on page 1-5, second sentence, it states, "...the city shall reclaim 2.0 mgd of wastewater from the Wahiawa Wastewater Treatment Plant."

   This statement should be clarified, because the Consent Decree (Civil No. 94-1896-05) in Section 8A states that the City shall complete construction and begin operation of a system to reclaim all the wastewater from the Wahiawa Wastewater Treatment Plant (WWTP), now about 2.0 mgd. The Department of Health (DOH) interprets this to mean that all the effluent from the plant is to be reclaimed.

2. The DEA does not address the source of hydrogen sulfide (H2S) odor from the bottom of the Wahiawa Reservoir. H2S odors from the Wahiawa dam area have been a source of many citizen complaints to the Department of Health (DOH) during the past several years.

   It appears that H2S is released from the bottom of the reservoir through a tunnel at the bottom of the dam into

an irrigation flume. This H2S discharge is what residents from the condominiums near the dam and motorists driving near Wilikina Drive have complained about. At times, when the air is humid and still, the odor of H2S has been extremely heavy.

The upgraded WWTP and deep outfall should reduce the nutrient loading to the lake and reduce the amount of H2S being produced. However, this has not been addressed in the DEA.

If you have any questions regarding these comments, please contact Mr. Denis Lau, Chief, Clean Water Branch at 586-4309.

Sincerely,

GARY GILL
Deputy Director for
Environmental Health

c: CWB
Robert Miyasaki

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JEREMY HARRIS
MAYOR

RANDALL K. FUJIKI, AIA
DIRECTOR

ROLAND D. LIBBY, JR., AIA
DEPUTY DIRECTOR

DCP 99-160

March 17, 1999

Bruce Anderson, Ph.D., M.P.H.
Director of Health
Department of Health
State of Hawaii
P.O. Box 3378
Honolulu, Hawaii 96801

Dear Dr. Anderson:

Subject: Wahiawa Wastewater Treatment Plant Modifications and Outfall Adjustment
Wahiawa, Oahu, Hawaii

Thank you for reviewing the Draft Environmental Assessment prepared for the subject project. In response to your comments we offer the following:

Reclamation

We will revise the statements in the Draft Environmental Assessment which suggest that the City would reclaim 2.0 million gallons of wastewater. The City also interprets the language of the Consent Decree to mean all the effluent from the Wahiawa plant is to be reclaimed, not only 2.0 million gallons.

Hydrogen Sulfide Odor

The City is aware of the hydrogen sulfur odor problem and the complaints made by residents of the condominium overlooking the Wahiawa Dam. The problem does not stem entirely from the Wahiawa WWTP which is too far away from the Wahiawa Dam but also from a presumed thick layer of sediment and decaying organic matter at the bottom of the reservoir in the vicinity of the Dam. The cause of odor and why it is pronounced in this area of the reservoir was not studied in the Environmental Assessment. As you indicated, the upgraded treatment process and deep water outfall should reduce nutrient loading into the lake and the amount of H_2S being produced. In the absence of background data, we are not able to empirically ascertain the potential reduction in H_2S.

We appreciate the participation of the Department of Health in the environmental assessment review process. If you have any questions, please contact Mr. Bill Liu of my staff at 527-6871.

Very truly yours,

For RANDALL K. FUJIKI
Director

cc: Calvin Kim & Associates