POTENTIAL INFLUENCES OF WASTEWATER DISCHARGES ON AIMAKAPA POND AND NEARBY ANCHIALINE POOLS, KALOKO-HONOKOHAU NATIONAL HISTORIC PARK

October 23, 1998

WATER RESOURCES DIVISION

National Park Service - Department of the Interior
Fort Collins - Denver - Washington

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EXECUTIVE SUMMARY

The National Park Service is reviewing a range of wastewater treatment alternatives as part of the overall project package for the development of a new visitor center for Kaloko-Honokohau National Historic Park. Three alternatives being considered allow the discharge of wastewater to the park groundwater system. They include a septic tank with a leachfield, a septic tank with constructed wetlands, and seepage pits. The park and Pacific Area Office management have expressed concern that wastewater discharges to the park's groundwater system will ultimately degrade the water quality of anchialine ponds and fishponds which are identified as significant cultural and natural resources of the park. It is the purpose of this report to analyze the potential for impact to the water quality of Aimakapa Pond and nearby anchialine pools from the discharge-type alternatives. The analysis is based on assumptions about the delivery of nutrients and other pollutants to the ground water system and subsequent transport to the ponds. The analysis is intended to assist the National Park Service in determining the most appropriate wastewater treatment alternative for the new visitor center.

Water resources within Kaloko-Honokahau National Historic Park include dozens of unique anchialine pools that vary in size and depth and two larger waterbodies with anchialine characteristics, Kaloko and Aimakapa fishponds. The fishponds provide valuable habitat for federally endangered waterbirds and are also historically and culturally significant. Anchialine pools are inland bodies of water restricted to the tropics and subtropics that are surficially separated from the ocean but have measurable salinity, and demonstrate damped tidal fluctuations. Because their chemistries are intermediate between marine and freshwater environments, anchialine pools support unique aquatic biota, which are not found elsewhere in the world. Species found in the ponds include hypogeal anchialine shrimps and a wide variety of other amphipods and mollusks species. Recent investigations have revealed that portions of Aimakapa Pond and adjacent anchialine pools currently express symptoms of eutrophication, including seasonally prolonged depressed dissolved oxygen concentrations of 1 to 2 milligrams per liter, and elevated concentrations of nitrogen, phosphorus, and ammonia. The park also has experienced three outbreaks of avian botulism since 1995.

To estimate the potential impacts of a theoretical wastewater discharge on the water quality of Aimakapa Pond, a conceptual model of the system was developed which predicts the concentrations of selected pollutants in a theoretical mixing zone of Aimakapa Pond. The results of this modeling effort indicate that a discharging wastewater treatment system located near the new visitor center would impact Aimakapa Pond and adjacent anchialine pools by: (1) depressing dissolved oxygen below concentrations required to sustain critical stages of warm-water life; (2) increasing the current rate of ongoing eutrophication resulting in the enlargement of the physical zones of invasive vegetative species and increased and enlarged occurrences of algal blooms, and; (3) elevating ammonia to concentrations that exceed the Environmental Protection Agency's long-term criteria for toxicity. Because these impacts may threaten federally endangered aquatic life and waterbirds, it is recommended that the park and Denver Service Center consider conducting a Section 7 consultation with the U.S. Fish and Wildlife Service before building a septic or other discharging system at the visitor's center.

INTRODUCTION

Purpose and Need

The National Park Service (NPS) is currently reviewing a range of wastewater treatment alternatives as part of the overall project package for the development of a new visitor center for Kaloko-Honokohau National Historic Park (KAHO). Several alternatives considered by the Denver Service Center (DSC) focus on non-discharging systems (NPS, 1998). Representative examples of these alternatives include utilization of an existing municipal system, vault or chemical toilets, and evaporative lagoons. Three alternatives considered by DSC would ultimately allow the discharge of wastewater to the KAHO groundwater system, but are attractive from a fiscal and engineering standpoint. They include a septic tank with a leachfield, a septic tank with constructed wetlands, and seepage pits. KAHO and Pacific Area Office management have expressed concern that wastewater discharges to the park's groundwater system will ultimately degrade the water quality of culturally important anchialine pools and fishponds in the park. It is the purpose of this report to analyze the potential for impact to the water quality of Aimakapa Pond and nearby anchialine pools from the discharge-type alternatives. The analysis is based on assumptions about the delivery of nutrients and other pollutants to the groundwater system and subsequent transport to Aimakapa Pond and anchialine pools. The analysis is intended to assist the NPS in determining the most appropriate wastewater treatment alternative for the new visitor center.

Objectives

The objective of this paper is to characterize the condition of the aquatic resources at KAHO as reported in the literature; describe the hydrologic, hydrogeologic and biologic setting in the park; evaluate the potential influences of wastewater discharges on these aquatic resources; and present a synopsis of the regulatory framework required to implement any of the proposed wastewater treatment alternatives in Hawaii. Several assumptions are made in this analysis which are explained later in the paper, including: the potential disturbance of sensitive aquatic organisms from changes in groundwater flow and water chemistry, and little attenuation of contaminants between the site of the proposed park visitor center and Aimakapa Pond and the anchialine pools downgradient of the site. This paper will not evaluate the technical merits of the wastewater treatment alternatives being considered.

Past Water Quality Studies at KAHO

During the last 25 years, several studies have evaluated water chemistry and biology of anchialine pools on the Kona Coast of West Hawaii (Figure 1). A good bibliography of literature that pertains to these studies can be found in the report from a study at KAHO funded by the NPS's Water Resources Division (WRD)(Brock and Kam, 1997). This study characterized water quality and biology in surface waters. Another study conducted by the U.S. Geological Survey (USGS) assessed groundwater conditions which support anchialine resources (Oki et. al, in review). Other past studies of anchialine resources at KAHO include Kikuchi and Belshe (1971), Maciolek and Brock (1974), Kay et. al (1977), Maciolek (1987), and Chai (1991).

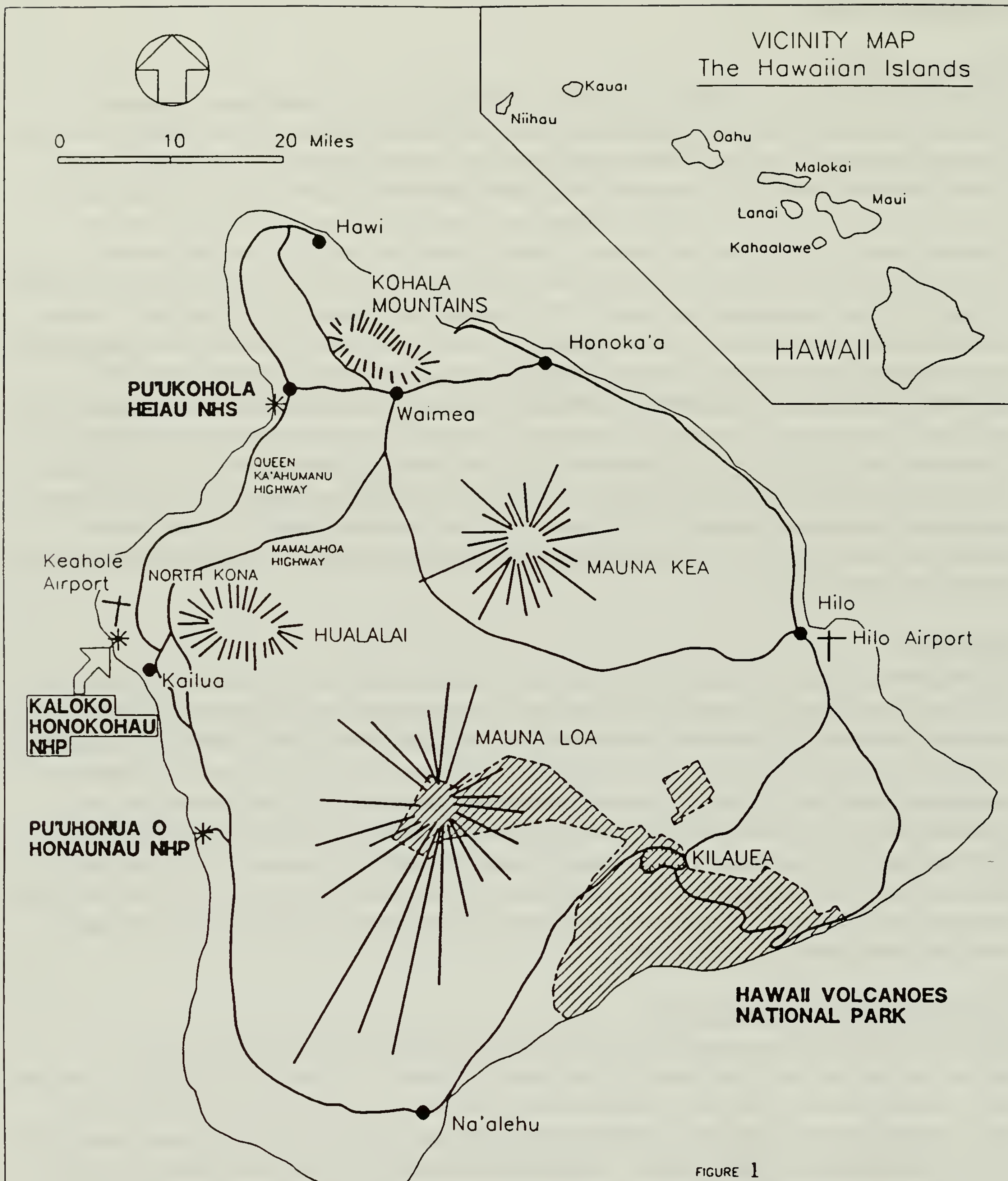

FIGURE 1
LOCATION
KALOKO–HONOKOHAU
NATIONAL HISTORICAL PARK
Hawaii

AQUATIC RESOURCES

Surface Water and Biology

Water resources within KAHO include dozens of unique anchialine pools that vary in size and depth and two larger waterbodies with anchialine characteristics, Kaloko and Aimakapa fishponds (Figure 2). The fishponds provide valuable bird habitat and are also historically and culturally significant. Anchialine pools are inland bodies of water restricted to the tropics and subtropics that are surficially separated from the ocean but have measurable salinity, and demonstrate damped tidal fluctuations. Because their chemistries are intermediate between marine and freshwater environments, anchialine pools support unique aquatic biota, which are not found elsewhere in the world. Species found in KAHO ponds include hypogeal anchialine shrimps Halocaridina rubra and Metabetaeus lohena, and native fishes such as the flagtail Kuhlia sandvicensis, tang Acanthurus triostegus, black spot sargeant Abudefduf sordidus, sleeper Eleotris sandwicensis, and goby Awaous stamineus (Brock and Kam, 1997). The ponds also support a wide variety of other amphipods and mollusks species.

Aimakapa Pond (Figure 3) has been described as the most valuable habitat for federally endangered waterbirds on Hawaii Island and one of the most valuable in the State (NPS, 1990). It is used throughout the year by the endangered Hawaiian stilt, and Hawaiian coot, as well as the black-crowned night heron and various waterfowl and shorebirds. As many as 25 species have been recorded as regular users at one time or another. Breeding blue-winged teal and pied-billed grebes have been reported in the area. Migrating birds use is important during the winter. Aimakapa Pond also provides habitat for several fish species, including mullet Mugil cephalus, milkfish Chanos chanos, and guppies (Family Poecilidae - alien). In recent years, Aimakapa Pond appears to be filling in with sediment and becoming more eutrophic (Bryan Harry, personal communication).

Groundwater

The primary source of groundwater flowing through KAHO is from subsurface flow originating from inland areas east of the park where recharge is greatest. Fresh groundwater moves from inland areas of recharge, mixes with saltwater, flows through the park, and ultimately discharges to the fishponds and to the ocean. The groundwater, fishponds, and anchialine pools in the park are hydraulically connected with each other. The source of water to the ponds is groundwater from the aquifer.

Surface and subsurface rocks in and near KAHO consist entirely of highly permeable volcanic rocks of recent origin (1,500 to 10,000 years old). Because of the relatively young age of the flows, soil development within the park is minimal. The main elements of lava flows contributing to high permeability are: (1) rubble associated with blocky aa flows, (2) voids along the contacts between flows, (3) cooling joints normal to flow surfaces, and (4) lava tubes associated with fluid pahoehoe flows.

In the park, artificial seawalls form Kaloko and Aimakapa fishponds. Near the shore, collapse features in the lava flows form the structure for anchialine pools. The water level in the ponds marks the position of the local groundwater table, which reflects hydraulic connection between

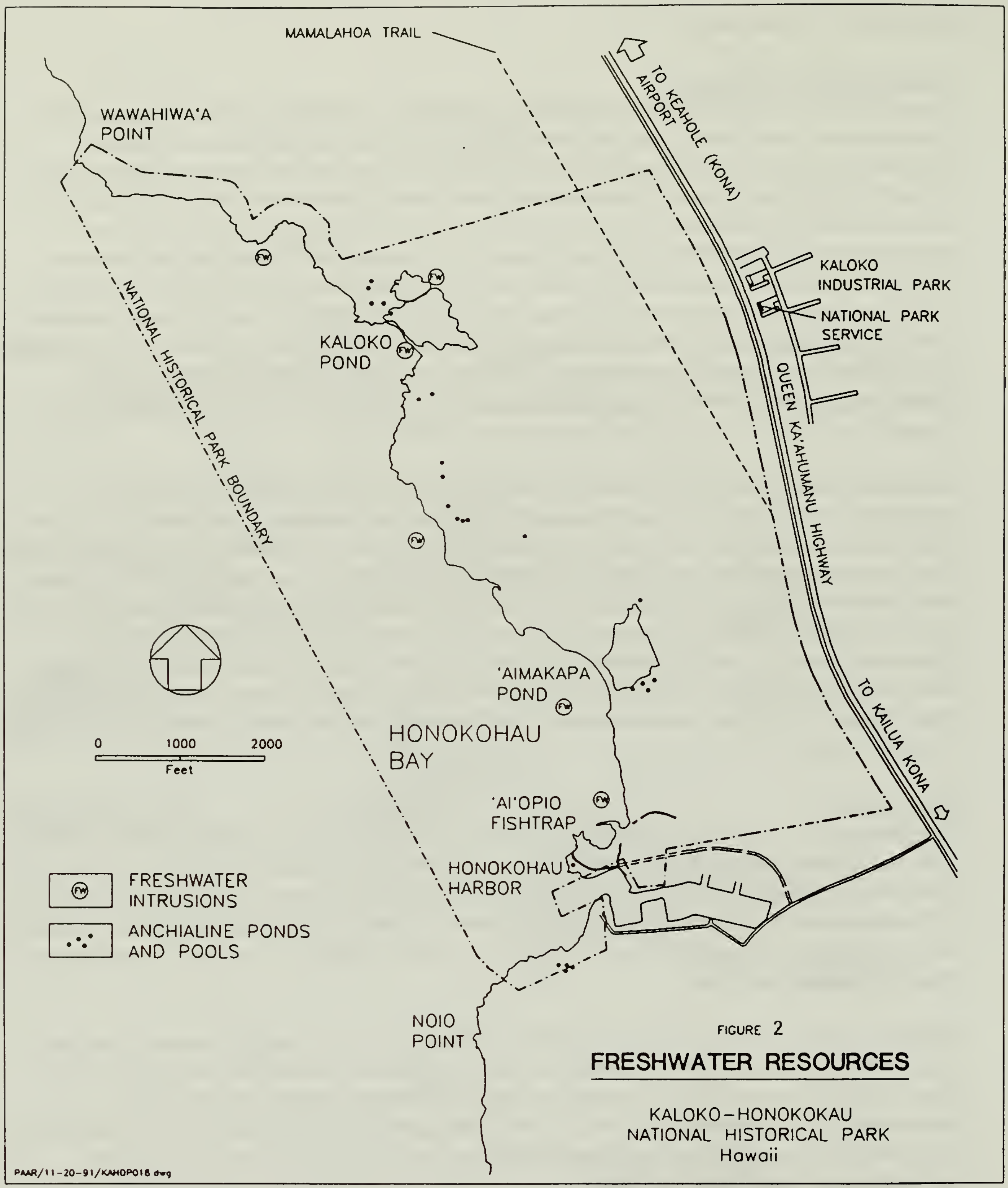

FIGURE 2

FRESHWATER RESOURCES

KALOKO-HONOKOKAU
NATIONAL HISTORICAL PARK
Hawaii

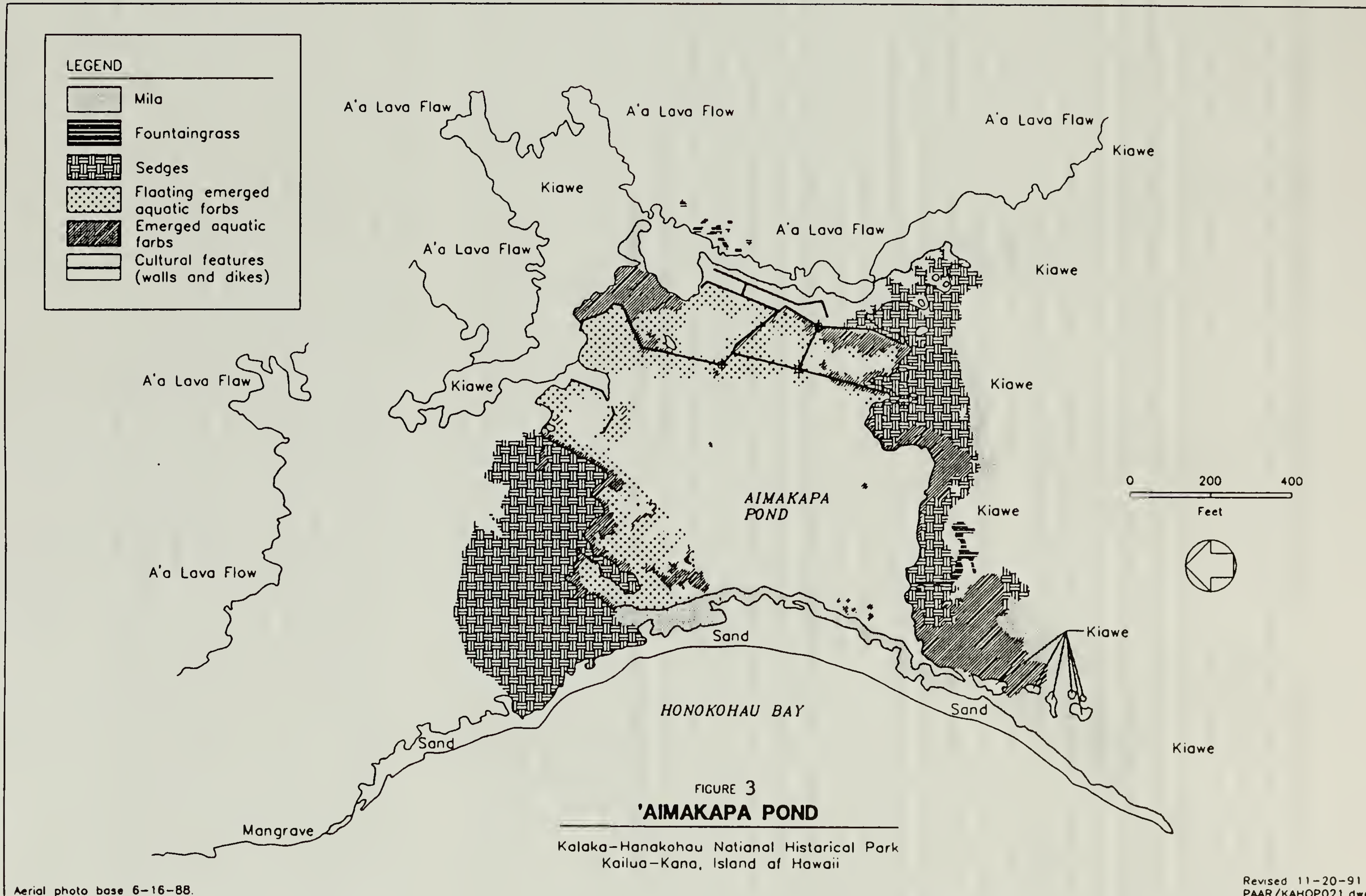

FIGURE 3
'AIMAKAPA POND
Kaloko-Honokohau National Historical Park
Kailua-Kona, Island of Hawaii

the groundwater system and surface water in the ponds. Because of the high permeability of the volcanic rocks and close proximity to the ocean, the ponds are brackish and the water level fluctuates with ocean tides.

On the basis of a groundwater flow model, Oki et. al (in review) estimated the horizontal hydraulic conductivity of the volcanic rocks in the vicinity of the park to be 7,500 feet per day (ft/d). Using measured groundwater level variations caused by ocean tides, Nance (1991) estimated the hydraulic conductivity of the volcanic rocks near Keahole Point, just north of the park, to range from 500 to 33,900 ft/d. As a comparison, the highly permeable glacial outwash aquifers of Cape Cod have a hydraulic conductivity of 200 to 400 ft/d.

Based on average water table elevations in the 3 monitoring wells constructed in the park, the water table slopes about 0.7 feet per mile toward the coast (west). During high tides, the flow of groundwater is reversed, flowing inland, and causing mixing of oceanic saltwater and brackish groundwater. Groundwater discharge from the aquifer is principally by diffuse subsurface discharge to the ocean and by discharge to ponds and wetlands near the coast.

Because groundwater flows rapidly through fractures and crevices in the lava, there is very little, if any, attenuation of contaminants or nutrients between sources (such as a leachfield) and discharge areas such as wetlands, fishponds, anchialine pools, and the ocean. Disposing of sewage effluent in a leachfield will result in mounding of groundwater beneath the leachfield and increase the flow rate of effluents toward the discharge areas. The distance from the proposed visitor center and associated leachfield to the ponds is about 1500 feet allowing quick easy access for nutrients and contaminants to move from the leachfield to the ponds.

WATER RESOURCE MANAGEMENT ISSUES

Eutrophication

Eutrophication from increased nutrients is one of the most common water quality problems in the United States in both lakes and coastal areas. Eutrophication can result in blooms of toxic algae and indirectly exacerbate disease problems, as well as drive down dissolved oxygen concentrations and cause changes in biodiversity. The General Management Plan/Environmental Impact Statement (GMP) for KAHO (NPS, 1994) identified eutrophication of anchialine pond resources as one of five major natural resource management issues at the park. Citing anecdotal observations, the GMP concluded that "Several of the anchialine ponds in the park show signs of severe pollution (smell, scum, heavy algae growth)....The natural rate of pond eutrophication is apparently being accelerated by man-caused pollution, erosion, and siltation and by the growth of alien vegetation." Indeed, subsequent scientific investigations by Brock and Kam (1997) documented that portions of Aimakapa Pond have seasonally prolonged depressed dissolved oxygen concentrations of 1 to 2 milligrams per liter (mg/L), well below the Environmental Protection Agency (EPA) long-term criteria of 4.0 mg/L for the support of warmwater aquatic life, potentially toxic concentrations of ammonia, and elevated nutrient concentrations. The data reported by Brock and Kam are evidence of existing eutrophication in an aquatic environment. It appears that the eutrophic conditions may be due to natural processes in the sediments, but anthropogenic causes cannot be ruled out.

Avian Botulism

Three outbreaks of avian botulism have been reported at Aimakapa Pond since 1995 (Chris Brand, personal communication). Avian botulism is a paralytic disease caused by the ingestion of a toxin produced by the bacteria Clostridium botulinum (Rocke, 1996). Outbreaks of avian botulism may be related to anaerobic, eutrophic aquatic environments. The bacteria are widespread in soil and require warm temperatures, a protein source, and an anaerobic environment in order to become active and produce toxin. Inputs of nutrients from human sewage in conjunction with fluctuating water levels may set up increased anaerobic activities in pond sediments, which could result in an indirect increased risk of avian botulism.

Contamination from Adjacent Activities

The park is concerned about the vulnerability of its aquatic resources to contamination from adjacent activities. KAHO is bordered by a light industrial park which houses 30-40 businesses including auto repair facilities, pest control businesses, manufacturing facilities, and retail shops (Figure 4). With regard to the flow of groundwater, these businesses are a maximum of 1,000 feet upgradient from the mauka boundary of the park. Because there is currently no sewer connection, the businesses dispose of their liquid wastes in underground injection wells, septic tanks, and cesspools. Groundwater flows through the underlying lava at a rapid rate. On the basis of information in the USGS report (Oki et. al, in review), we have calculated minimum flow velocities of 3.0 feet per day. In lava, because the potential for retardation of contaminants is low, liquid waste from the industrial park could move into groundwater underlying KAHO in less than a year.

WRD contacted the State of Hawaii, Department of Health, to determine if water quality in the park had been degraded by any past releases from the industrial park. The Superfund Site Assessment Program and the Hazardous Waste Branch have not documented any subsurface contamination from the industrial park. Underground storage tanks are most likely present in the industrial park. WRD currently is in the process of checking with the park to determine if any leaking or formerly leaking tanks are in the business park. The State of Hawaii, Department of Health Underground Injection Control Program reported that the County of Hawaii operates up to 24 Class V stormwater injection wells in the industrial park. These wells are typically five feet wide and 25 feet deep and route storm water underground from along roadsides. The Underground Injection Control Program also believes that a number of the business operate un-permitted shop drains for the disposal of wastewater and process water that lead directly underground. One complaint has been received by the Underground Injection Control Program about wastewater disposal from an auto body facility. The complaint was investigated informally by Department of Health and the operator was told to cease their practices.

The USGS detected phenol in all three groundwater monitoring wells that were completed in the park (Oki et. al, in review). The levels of phenol that were detected, 4-10 parts per billion (ppb), are below the State of Hawaii, Department of Health water quality standard of 170 ppb for acute toxity in saltwater (Chapter 11-54-04). A source for the phenol has not been identified; however, the stormwater and wastewater disposal practices could lead to the type of contamination that has been noted.

The detection of phenol indicates the vulnerability of the park to groundwater contamination. To reduce the potential to future vulnerability, the park or WRD may wish to recommend that the U.S. EPA and the State of Hawaii, Department of Health investigate the regulatory compliance of adjacent businesses. This will help to prevent releases to groundwater from upgradient industrial activities and will ensure that the park's extra effort to protect water resources are consistent with the activities of its neighbors.

POTENTIAL WATER QUALITY IMPACTS FROM WASTEWATER DISCHARGES

Evaluation of Impacts to the Groundwater System and Aimakapa Pond

The new KAHO visitor facilities will be located approximately 1500 feet east of Aimakapa Pond (Figure 4). The capacity of the wastewater system for the visitor center will be 2,000 to 5,000 gallons per day, according to Henry Espinosa, Engineer, DSC. For the purposes of this analysis, it is assumed that a discharging wastewater treatment facility (such as a septic tank or seepage pit) is located in the general vicinity of the visitor center. The regional and local groundwater gradients in this area are from east to west, thus the most likely target waters for any wastewater-related pollutants are Aimakapa Pond, and several small anchialine pools that lie immediately to the west of the proposed visitor facilities. While this analysis will focus on the potential water quality impacts to Aimakapa Pond, WRD believes that similar, if not more severe, impacts could occur in the smaller anchialine pools.

Adequate treatment of the wastewater effluents from septic systems or seepage pits depends on the presence of acceptable soil conditions where most of the removal of nutrients and oxygen-depleting substances occurs. Lacking adequate assimilative capacities in the soil, the discharge of septic tank or seepage pit effluents would be very much like discharging raw sewage directly into groundwater. As documented elsewhere in this assessment, the soils at KAHO are not considered to be conducive for the proper attenuation and treatment of pollutants in wastewater effluent. Poor soils, coupled with a geohydrologic system that is conducive for the rapid down-gradient transport of any introduced pollutants, could create rapid adverse impacts to the water quality and biota in Aimakapa Pond and other anchialine pools.

To estimate the potential impacts of a theoretical wastewater discharge on the water quality of Aimakapa Pond, WRD developed a conceptual model of the system which entails routing the wastewater effluent into groundwater underlying the site of the septic system and leachfield or seepage pit, and then routing the groundwater-wastewater mixture into the pond. Final concentrations of selected constituents (dissolved oxygen, total nitrogen, total phosphorus, and ammonia) were determined by applying the following equation:

$$C = \frac{C1 \times V1 + C2 \times V2}{V1 + V2}$$

Where: C = Concentration of pollutant in the combined flows
V1 = Quantity of water in receiving water
C1 = Concentration of pollutant in V1
V2 = Quantity of water in influent
C2 = Concentration of pollutant in V2

This model is simplistic in that it only takes into account the effects of dilution on the concentrations of pollutants in a theoretical mixing zone. A mixing zone is an area in a stream or pond that is unavoidably polluted after an initial wastewater inflow. In many cases, the mixing zone is the area the concentrations of oxygen-depleting and toxic pollutants are at their maximum, and thus potential adverse impacts to aquatic flora and fauna are the most severe.

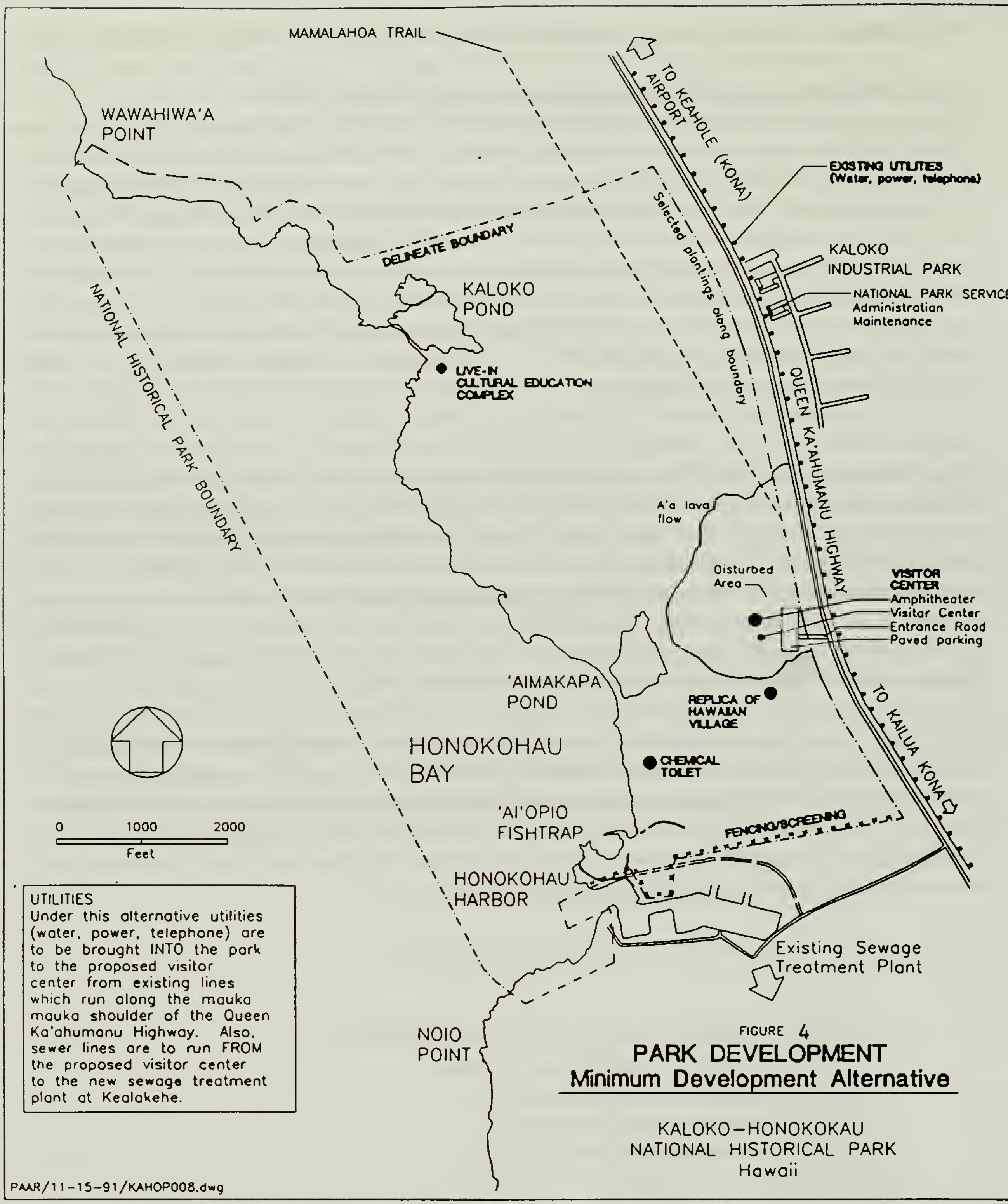

FIGURE 4
PARK DEVELOPMENT
Minimum Development Alternative

KALOKO-HONOKOKAU
NATIONAL HISTORICAL PARK
Hawaii

The model does not account for more complex chemical and physical reactions that may occur through biological assimilation, oxidation, or reduction of any of the pollutants. The model requires estimates of groundwater and surface-water inputs and water quality characteristics of the septic tank effluent, groundwater, and Aimakapa Pond. In all cases, WRD utilized existing information from reports by the USGS (Oki et.al, in review) and Brock and Kam (1997), or design specifications from DSC.

Conceptual Model Results and Discussion

Model inputs and the predicted water quality impacts to a theoretical mixing zone in Aimakapa Pond are presented in Table 1. The model calculations indicate that the release of wastewater effluent to the KAHO groundwater system will further depress dissolved oxygen concentrations, increase the size of the existing eutrophic zones as well as the rates of eutrophication, and increase ammonia concentrations to potentially toxic levels for aquatic life. Individual assessments of the significant aspects of these impacts are presented below.

TABLE 1 – Predicted Water Quality Impacts to Aimakapa Pond

LOCATION	Water Volume (gallons/day)	Dissolved Oxygen (mg/L) High/Med./Low	Total Dissolved Nitrogen (mg/L-N)	Total Dissolved Phosphorus (mg/L-P)	Ammonia (mg/L-N)
Septic Effluent[1]	5000[2]	1.00	85	20	50
Groundwater[3]	40,000[4]	1.06	0.93	0.05	0.45
Aimakapa Pond (Baseline)[3]	3,000,000[5]	7.85/3.82/1.90	0.96	0.11	0.10
Aimakapa Pond (Predicted)	N/A	7.74/3.78/1.89	1.1	0.14	0.19

[1] Water quality characteristics: Geraghty and Miller, 1980

[2] Henry Espinosa, personal communication

[3] Water quality data: Brock and Kam, 1997

[4] Oki et. al (in review) constructed a computer model of the groundwater flow system in the vicinity of the park. For average 1978 groundwater pumping rates, the estimated rate of groundwater flow within the boundaries of the park is about 3 million gallons per day per mile of coastline. Groundwater flow through the park, at the current pumping rates, is estimated to be about 2 million gallons per day. If we assume that a leachfield is about 100 feet wide and groundwater flow through the park is uniform, the estimated groundwater flow volume under the leachfield is 57,000 gallons per 100 foot of aquifer width for groundwater pumping at 1978 rates and 38,000 gallons per 100 foot of aquifer width for groundwater pumping at 1997 rates.

[5] The mixing zone for Aimakapa Pond was defined as the water in contact with the eastern-most shoreline where the most likely zone of groundwater seepage is located. The representative volume of water in this zone was defined as 20 percent of the total volume of the pond calculated as follows: 653,400 ft^2 (15 acres) x 3 ft (average depth) = 1.96 million ft^3 or 14.66 million gallons x 1/5 = approximately 3 million gallons.

Dissolved Oxygen: The concentration of dissolved oxygen is one of the most critical of all water quality parameters to aquatic life. Dissolved oxygen levels in water must be maintained to provide sufficient available oxygen for aquatic life, as well as provide for the adequate oxidation of natural and anthropogenic sources of organic contamination without depleting the dissolved oxygen resource to the point of harming aquatic life. Baseline dissolved oxygen concentrations measured by Brock and Kam (1997) in Aimakapa Pond indicate that a sinusoidal seasonal relationship exists for this parameter. Six measurements taken from the mixing zone of the pond between 1994 and 1996 reveal an extreme fluctuation in dissolved oxygen from a maximum concentration of 7.85 mg/L in March of 1994 to a minimum concentration of 1.90 mg/L in March of 1995. Intermediate concentrations of 5.36 mg/L, 2.30 mg/L, 2.62 mg/L, and 3.82 mg/L were recorded during August 1994, June 1996, July 1996, and October 1996, respectively. The extreme fluctuations in the baseline characteristic necessitates that the impacts of the septic effluent discharge be evaluated for representative maximum, intermediate, and minimum dissolved oxygen concentrations in the Aimakapa Pond mixing zone.

Maximum, intermediate, and minimum dissolved oxygen concentrations are predicted to decline from 7.85 mg/L, 3.82 mg/L, and 1.90 mg/L to 7.74 mg/L, 3.78 mg/L, and 1.89 mg/L, respectively. The one-day dissolved oxygen criterion (EPA, 1986) for the protection of warmwater aquatic life is 5.0 mg/L for early life stages and 3.0 mg/L for other life stages. Based on these benchmarks, it appears that during certain periods represented by the maximum baseline concentration, Aimakapa Pond could assimilate the predicted wasteloads.

Long-term discharges of sewage effluent to Aimakapa Pond; however, most likely would have direct deleterious, and possibly lethal, effects on aquatic life during the time that dissolved oxygen concentrations are near the critical EPA one-day benchmarks of 5.0 mg/L and 3.0 mg/L, or the seven-day benchmark of 4.0 mg/L. Overall, the periods that the pond experiences dangerously depressed oxygen levels would be prolonged beyond those that now occur.

Nitrogen and Phosphorus: The productivity and trophic state of natural waters are related to the nutrient matter that enters them. While small quantities of nitrogen and phosphorus in their various forms are essential for the proper functioning of healthy aquatic ecosystems, enrichment by one or both of the nutrients can lead to nuisance algal blooms and eutrophication of a waterbody. An additional consideration for reduced nitrogen species is their oxidation in natural waters, thus further depleting the dissolved oxygen resource.

Concentrations of total dissolved nitrogen and phosphorous in Aimakapa Pond are predicted to increase from 0.96 mg/L to 1.1 mg/L and 0.11 mg/L to 0.14 mg/L, respectively. EPA has not formally proposed national criteria for these nutrients relative to eutrophication. However, EPA has published a finding indicating that in order to prevent accelerated or cultural eutrophication, concentrations of total phosphorus should not exceed 0.025 mg/L in freshwater lakes or reservoirs (EPA, 1986). In addition, published reports that have evaluated estuarine and freshwater systems indicate that the amounts of nitrogen and phosphorus needed to produce abundant algal blooms are relatively small. In general, lakes with mean annual total nitrogen and phosphorus concentrations greater than 0.8 mg/L and 0.1 mg/L, respectively, exhibit algal blooms and nuisance weed growths during the growing season. For estuaries and brackish coastal waters, various territories have established a total nitrogen standard of 0.4 mg/L for waters having aquatic life propagation as the use or as one of the uses (EPA, 1988).

Ammonia: Total ammonia concentrations in Aimakapa Pond are predicted to increase from 0.10 mg/L to 0.19 mg/L. The predicted concentration exceeds the 1989 EPA aquatic life criteria for ammonium in saltwater of 0.18 mg/L (corrected for representative water temperature of 30°C, salinity of 10 ‰ , and pH of 8.5 in Aimakapa Pond)(EPA 1989).

Wastewater Discharge Regulations and Water Quality Standards

The State of Hawaii, Department of Health, regulations for wastewater disposal (Chapter 11-62-31.1) state that individual wastewater systems "may be used as a temporary on-site means of wastewater disposal in lieu of wastewater treatment works" where the total wastewater flow does not exceed 15,000 gallons per day. Therefore, any of the options that the park is currently considering are allowed under the regulations. These options eliminate discharge to the subsurface and include recirculating chemical toilets, vault toilets, pump and haul, composting, and discharge to a lined evaporative pond. If the park were to consider an on-site, individual wastewater system, the following conditions would apply:

(a) 10,000 square feet of land area must be available for each system
(b) cesspools are not allowed for public buildings
(c) approval of an operation and maintenance manual
(d) certification of operation in accordance with (c)
(e) following an inspection, a written authorization by the Director, State of Hawaii, Department of Health.

The anchialine pools and fishponds at KAHO are classified by the State of Hawaii, Department of Health as inland brackish waters, Class 1.a (Chapter 11-54-03). The water quality standards state "it is the objective of Class 1 waters that these waters remain in their natural state with an absolute minimum of pollution from any human-caused source. Waste discharge into these waters is prohibited". The intent of the park to prevent discharge also is supported in the preamble to the wastewater discharge regulations (Chapter 11-62-01) which states "a goal has been established such that the construction of wastewater disposal systems depositing untreated sewage into the environment will not be allowed after the year 2000." Further impetus for zero discharge is provided by a report (West Maui Watershed Management Advisory Committee, 1997) which discourages the use of shallow injection wells and cesspools. In the West Maui report, the use of these methods of disposal are linked, although inconclusively, to nuisance algal blooms along the Maui coastline. The report concludes that 87% of the nitrate in West Maui groundwater comes from application of fertilizer; however, where agriculture is not practiced, cesspools contribute elevated levels of phosphorus and nitrate in groundwater.

CONCLUSIONS AND RECOMMENDATIONS

KAHO anchialine pools and fishponds constitute significant cultural and natural resources that support federally threatened and endangered flora and water fowl. Because the operation of a wastewater treatment system at the visitor center discharging to groundwater would degrade the water quality of the anchialine pools and Aimakapa Pond, WRD recommends that the park and DSC consider conducting a Section 7 consultation with the U.S. Fish and Wildlife Service before building a septic or other discharge system at the visitor center. Specific threats that should be examined are:

1. Dissolved oxygen concentrations would be depressed. Given existing sinusoidal seasonal fluctuations, dissolved oxygen concentrations would be depressed to below concentrations required to sustain critical stages of warmwater life. An indirect impact of the prolonged periods of pond anoxia is the increased risk of avian botulism outbreaks. Avian botulism is caused by the ingestion of a nerotoxin produced by the bacterium Clostridium botulinum type C (Rocke, 1996). This organism is a strict anaerobe, meaning that the organism metabolizes only in environments that lack oxygen. The bacterium forms dormant spores in the presence of oxygen. The botulism toxin is produced only when the bacteria are in the vegetative state, after the spores germinate. As stated before, three outbreaks of avian botulism have been documented on Aimakapa Pond since 1995.

2. Although nutrients, primarily nitrogen levels, may not be unusual in perspective with other anchialine resources in Hawaii, any change in loading may affect aquatic resources in Aimakapa Pond because of its susceptibility to both environmental and human-influenced changes. As discussed previously in this report, existing vegetative and chemical data support the conclusion that eutrophication is currently experienced in the fishpond. In addition, high benthic algal standing crop and/or low water transparency (suggesting high phytoplankton activity) has been reported to already occur at many of the anchialine pools (Brock and Kam, 1997). The additional nutrients that would be added to the system by the discharge of septic system effluent can only increase the rate of eutrophication resulting in the enlargement of the physical zones of invasive vegetative species and increased and enlarged occurrences of algal blooms.

3. Perhaps the most serious threat to the water quality of the pools and fishpond is the predicted increase in ammonia concentrations. Baseline data indicate that existing concentrations of ammonia are below toxic concentrations. However, the addition of ammonia-laden groundwater to the pools and fishpond could elevate concentrations above the EPA criteria for this toxic compound. Long-term exposure to ammonia levels in excess of the recommended limits may harm aquatic life by altering metabolism or increasing body pH. Fish may suffer a loss of equilibrium, hyperexcitability, increased respiratory activity and oxygen uptake, and increased heart rate. At extreme ammonia levels, fish may experience convulsions, coma, and death.

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