

**DRAFT**

**ECOLOGICALLY SENSITIVE WETLANDS  
ON O‘AHU:**

**Groundwater Protection Strategy for Hawai‘i**

Jacquelin N. Miller  
Steven S. Armann  
Sonia S.C. Chan-Hui  
Roseanne Sakamoto  
Joanna Chiang

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Highly Vulnerable to Contamination, O‘ahu (Part 2)

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Principal Investigator: L. Stephen Lau

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ENVIRONMENTAL CENTER  
Water Resources Research Center  
University of Hawaii at Manoa  
Honolulu, Hawaii 96822

## AUTHORS:

Jacquelin N. Miller  
Associate Environmental Coordinator  
Environmental Center  
University of Hawaii at Manoa  
2550 Campus Road, Crawford Hall 317  
Honolulu, Hawaii 96822  
808/956-7361

Steven S. Armann  
Graduate Research Assistant, Project Manager  
Environmental Center  
University of Hawaii at Manoa  
2550 Campus Road, Crawford Hall 317  
Honolulu, Hawaii 96822  
808/956-7361

Sonia S.C. Chan-Hui  
Computer Specialist  
Environmental Center  
University of Hawaii at Manoa  
2550 Campus Road, Crawford Hall 317  
Honolulu, Hawaii 96822  
808/956-7361

Roseanne Sakamoto  
Research Assistant  
Environmental Center  
University of Hawaii at Manoa  
2550 Campus Road, Crawford Hall 317  
Honolulu, Hawaii 96822  
808/956-7361

Joanna Chiang  
Data Entry Clerk  
Environmental Center  
University of Hawaii at Manoa  
2550 Campus Road, Crawford Hall 317  
Honolulu, Hawaii 96822  
808/956-7361

## CONTENTS

ABSTRACT . . . . .	v
INTRODUCTION . . . . .	1
Groundwater Protection Strategy and Guidelines . . . . .	1
Groundwater Classification: Definitions and Uses . . . . .	2
Groundwater Protection in Hawaii: Rationale and Statutory Requirements . . . . .	3
Ecologically Sensitive Systems: Wetlands . . . . .	3
OBJECTIVES . . . . .	6
Identification and Assessment of Ecologically Sensitive Systems and the Determination of Ecologically Vital Habitats . . . . .	6
PROCEDURE . . . . .	7
Compilation and Processing of Information on Ecological Systems . . . . .	7
RESULTS . . . . .	8
Ecological Systems in Groundwater Discharge Areas . . . . .	8
DISCUSSION . . . . .	8
Assessment of Sensitivity of Ecological Systems . . . . .	8
Activities and Potential Pollutants to Ecological Systems . . . . .	13
RATING . . . . .	18
SUMMARY . . . . .	20
REFERENCES CITED . . . . .	21
APPENDIX CONTENTS . . . . .	23

### Figures

1. Wetland Sites, Aquifer Systems and Sectors, O'ahu, Hawai'i . . . . .	11
2. Potential Pollutant Sources . . . . .	12
3. Ecological Sensitivity Rating . . . . .	16

### Tables

1. Ecologically Sensitive Wetland Sites, Habitat Code, Sensitivity Rating, and Aquifer Sectors and Systems, O'ahu, Hawai'i . . . . .	9
2. Aquifer Classification Explanation . . . . .	15
3. Habitat Code . . . . .	17
4. Codes and Criteria for Sensitivity Ratings . . . . .	19



## ABSTRACT

The EPA Groundwater Protection Strategy has established differential protection levels based on the beneficial uses of groundwaters. Groundwater resources that are: (1) Irreplaceable sources of drinking water; and/or (2) Ecologically Vital are designated as of unusually high value. To determine those groundwaters that meet the EPA criteria for qualifying as “Ecologically Vital” we have examined 63 groundwater based (wetland) ecological systems on the island of O‘ahu. An inventory of the physical, biological and cultural characteristics of each area including certain “red flag” features has been developed and coded. Using this “habitat code” a rating system that reflects the sensitivity, i.e. “uniqueness” or “nonrenewable” attributes of each system was designed and 46 “ecologically vital” habitats were identified that meet the EPA criteria for Class 1 level of groundwater protection.



## INTRODUCTION

This report reflects the results of a study prepared in close accordance with the directives of the U.S. Environmental Protection Agency (EPA) Groundwater Protection Strategy (GPS) (EPA 1984; 1987) to identify special groundwater sources that are characterized as “ecologically vital”. That is to say that the aquifer provides the base flow for a particularly sensitive ecological system that, if polluted, would destroy a unique habitat.

### Groundwater Protection Strategy and Guidelines

In response to the recognized importance of the various uses of groundwater and its potential susceptibility to contamination the Environmental Protection Agency promulgated the “Groundwater Protection Strategy” (EPA 1984). Subsequently, the EPA technical draft document, “Guidelines for Groundwater Classification under the EPA Groundwater Protection Strategy”, was issued to provide policy direction for EPA programs with groundwater responsibility (EPA 1986). The “guidelines” document serves two purposes:

1. to further define the classes, concepts, and key terms related to the classification system outlined in the Groundwater Protection Strategy; and,
2. to describe the procedures and information needs for classifying groundwater.

The Environmental Protection Agency-Groundwater Protection Strategy (EPA-GPS) mandates that each state perform an inventory and analysis of available groundwater resources within their particular state. States are then required to, “set up management strategies, i.e. rules, regulations, laws, ordinances..., to protect these groundwater resources from contamination and misuse”. State agencies responsible for groundwater protection may be required to adopt the classification system for specific state programs that serve to carry out delegated or authorized EPA programs. To assure adequate protection of groundwaters and the compliance with special program requirements of the EPA, the Hawaii State Department of Health (DOH) has initiated a groundwater protection strategy consistent with the program established by the EPA (DOH 1988). Accordingly, the present study serves to address one aspect of this strategy: to identify and evaluate *ecologically sensitive systems* subject to groundwater inflows and to potential pollutants and to determine if those areas are *ecologically vital*. The methodology used for the identification and evaluation of the ecologically sensitive and ecologically vital areas follows that set forth

in the EPA draft guidelines. This report is an adjunct to the Mink and Lau (1987) aquifer classification report.

### **Groundwater Classification: Definitions and Uses**

The EPA Groundwater Protection Strategy is based on the recognition that “protection should consider the highest beneficial use to which groundwater having significant water resources value can presently or potentially be put” (EPA, 1986). Therefore, EPA has established three classes of groundwaters and has designated differential protection levels consistent with the beneficial uses for each class as follows:

Class I - Special Groundwaters. Class I groundwaters include those “resources of unusually high value” in that they are “highly vulnerable to contamination” and are:

- (1). Irreplaceable sources of drinking water; and/or,
- (2). Ecologically vital.

Groundwater is considered an “irreplaceable source of drinking water” if it serves a substantial population, and, if delivery of comparable quality and quantity of water from alternative sources in the area would be economically infeasible or precluded by institutional constraints. Groundwater is considered “ecologically vital” if it “supplies a sensitive ecological system that supports a unique habitat”. A *sensitive ecological system* is defined “as an aquatic or terrestrial ecosystem located in a groundwater discharge area”, (otherwise known as a wetland), and a *unique habitat* is “primarily defined as a habitat for a listed or proposed endangered or threatened species...”. However, “unique habitats” also include such special areas as National parks, wilderness areas, wildlife refuges, or natural areas (EPA 1986).

In simplified terms, *ecologically vital* groundwater supports a terrestrial or aquatic “wetland type” ecosystem which has exceptional functions including, but not limited to, habitat for endangered or threatened species.

Class II - Current and Potential Sources of Drinking Water and Water Having Other Beneficial Uses. Groundwaters may be classified under the Class II category if they do not meet the Class I criteria and if they include current or potential sources of drinking water and water having other beneficial uses.



Class III - Groundwater Not a Potential Source of Drinking Water and of Limited Beneficial Use. Class III groundwaters are saline or otherwise unsuitable for drinking or other beneficial purposes. Included in this class are groundwaters that are so contaminated by either naturally occurring conditions or by the effects of broad-scale human activity that they can not be cleaned up using reasonably standard or acceptable treatment methods.

### **Groundwater Protection in Hawaii: Rationale and Statutory Requirements**

In Hawaii, the ever increasing pressure of urban development has raised the potential for adverse impacts to essential groundwater sources. Urbanization of agricultural and undeveloped land in groundwater recharge areas can affect both the quality and quantity of groundwater through the improper use of chemicals and waste disposal practices, or through alterations in surface conditions that affect groundwater recharge. This avenue for potential contamination has been demonstrated over the past few years with the appearance of residues of volatile organic chemicals in groundwater wells on O‘ahu (Lau & Mink, 1987; Oki & Giambelluca, 1985). The need for additional potable water supplies to accommodate increased population and urban development has led to expanded development of groundwater sources and an increased draft on existing wells. Such increased developments if improperly managed can result in contamination of the aquifers. The importance of maintaining and protecting Class I and II groundwaters as sources for potable water is obvious. In this regard, Hawaii’s almost total reliance on groundwater for drinking water puts the State in a particularly sensitive position with respect to the need to wisely locate and balance urban development against maintaining both adequate and safe drinking water supplies. Furthermore, it must also be recognized that Class I groundwaters serve another use, second in importance only to their value for drinking water, and that is their contribution to *ecologically vital* areas. These areas are further defined by EPA as *sensitive ecological systems* that support a unique habitat and may include “springs, streams, caves, lakes, wetlands, estuaries, coastlines, embayments, and playas”.

### **Ecologically Sensitive Systems: Wetlands**

The commonly accepted terminology for groundwater influenced habitats that are ecologically sensitive is “wetland”. However, the term wetland has been specifically defined by various government agencies to suit their respective purposes. For example, the Soil Conservation Service (SCS) defines a wetland as:

“areas that have a predominance of hydric soils and that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under

normal circumstances do support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions, except lands in Alaska identified as having a high potential for agricultural development and a predominance of permafrost soils". (National Food Security Act Manual, 1988)

The EPA and United States Army Corps of Engineers (COE) define wetlands as:

"Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas". (EPA, 40 CFR 230.3, 33 CFR 328.3)

The United States Fish and Wildlife Service (USFWS) definition for wetlands states:

"Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year".

Each definition includes specific terminology to guide the particular agency in carrying out their mandated programs. For instance the EPA and COE oversee Section 404 of the Clean Water Act, thus their definition reflects their specific interest in regulating the filling and dredging of wetlands. In addition, the Soil Conservation Service is interested in agricultural practices which impact on "wetlands". Therefore, the SCS definition concentrates on soil types. These agency specific wetland definitions have resulted in confusion and inconsistencies when issuing appropriate permits from two or more agencies. The USFWS may identify a specific area as a wetland when, according to the criteria of the SCS, it is not a wetland. When an agency identifies an area as a wetland, other federal permitting agencies become affected due to the 1977 Federal Executive Order 11990, Protection of Wetlands which makes the protection of wetlands the official policy of all federal agencies. Under this Order wetlands are broadly defined as "those areas that are inundated by surface or groundwater with a frequency sufficient to support...vegetative or aquatic life that requires saturated or seasonally saturated soil

conditions for growth and reproduction”. Thus, confusion has reigned over which determination an agency should use when evaluating development proposals. To resolve this dilemma the Army Corps of Engineers, the Soil Conservation Service, the Environmental Protection Agency and the U.S. Fish and Wildlife Service have now developed a unified approach to identifying and delineating wetlands incorporating elements of each agencies specific definitions (1989). The common elements adopted from all definitions include specific criteria with regard to vegetation, soil and hydrology.

The importance of wetlands has been recognized in a wide variety of federal laws, policy statements, executive orders, and planning documents. To mention just the actions that have been initiated since the early 1970's, we might begin with the National Environmental Policy Act (NEPA) and the formation of the Council on Environmental Quality (CEQ) in 1970. Recognition of the need for preservation and protection of the environment, (including some specific citing of wetlands), was one of the primary purposes of NEPA. Subsequently, in 1971, the Federal Water Bank Program was created to prevent “the loss of wetlands and to preserve, restore, and improve wetlands” with special emphasis on conserving specific wetland areas for migratory waterfowl nesting and breeding. In 1973, the EPA issued a statement of “Policy on Protection of The Nations Wetlands” (38 CFR 10834, March 20, 1973). In this policy statement the “unique and major importance” of wetlands was recognized explicitly. It cited critical wetland functions, including provision of habitats for important wildlife including many species of fish and waterfowl, flood control, natural water purification through sediment trapping, nursery habitat for wildlife and plant species, recreational areas, and contributions to the maintenance and recharge of the groundwater resources. One of the most important provisions in this policy statement was the recognition and commitment of EPA to minimize alterations in quantity or quality of the natural flow of waters that nourish wetlands and to protect them against dredging and filling or other forms of potential pollutants. Following the EPA policy statement and to further strengthen the federal commitment to wetland protection, the Federal Executive Order (No. 11990) for the Protection of Wetlands was issued in 1977 by President Carter. The order directed each agency, in the course of carrying out its respective responsibilities, to “take action to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands”.

At the State level, Hawaii statutes and regulations pertinent to the protection of wetlands are under the regulatory responsibilities of the Department of Land and Natural

Resources or, in some cases, the Departments of Agriculture and Health. The State Water Commission may have related specific interests and responsibilities. Other documents dealing with wetland management or protection in Hawaii include the Master Plan for Hawaii Water Resources, developed by the Hawaii Water Resources Regional Study team in 1977 and the current Master Plan for the Hawaiian Wetland National Wildlife Refuge Complex now under review by both state and federal agencies. The rationale for these protective regulations, orders, policy statements, and master plans, has called attention to the importance of wetlands as wildlife sanctuaries for endangered and migratory species, breeding grounds, and nursery habitats for birds, fishes, and invertebrates; their importance to the food chain; their use as recreational areas, storm water retention ponds, silt settling basins, drainage and erosion control, water recharge areas; and their use by electric power generating stations for cooling water supplies or for potential wastewater discharge sites.

## OBJECTIVES

### **Identification and Assessment of Ecologically Sensitive Systems and the Determination of Ecologically Vital Habitats**

While all classes of groundwaters may provide base flows to *ecologically sensitive habitats*, the EPA groundwater protection strategy is a differential protection policy and assumes that different types of groundwaters require different levels of protection. Hence, in accordance with the priorities established by EPA, the present study had three objectives:

1. to identify ecological systems pursuant to the delineation of Class I groundwaters under the EPA Groundwater Protection Strategy program;
2. to assess the *ecological sensitivity* and “uniqueness” of these systems under the EPA groundwater classification system; and,
3. to determine which of these systems would qualify as *ecologically vital* habitats.

In the outset it must be emphasized that the wetlands listed do not represent an inclusive list of all ecologically sensitive groundwater systems in Hawaii. Hawaii’s vast groundwater resources preclude an all inclusive inventory of ecologically sensitive groundwater wetland habitats, given the time and budgetary constraints of this study. However, this report does reflect an inventory and analysis of the primary ecologically

sensitive groundwater habitats in Hawaii and provides a significant introductory baseline inventory from which more comprehensive reports can evolve as their need arises.

## PROCEDURE

To identify and assess *ecologically sensitive groundwater systems* and to determine *ecologically vital habitats* the following steps were undertaken:

1. The development of a statewide inventory of ecological systems that receive groundwater discharge and, therefore, are subject to potential groundwater contaminants. This inventory also includes a compilation of descriptive information pertinent to the selected areas in terms of their physical, chemical, biological, and cultural characteristics.
2. The identification of potential sources and generic types of groundwater pollutants to these selected areas.
3. The development of a computer aided search and retrieval system for interactive retrieval of special characteristics of each area.
4. The development of assessment methodologies for determining ecologically vital systems.

### Compilation and Processing of Information On Ecological Systems

To compile the inventory and description of *ecologically sensitive systems* that receive groundwater inflows, we first identified a number of documents directed specifically at wetland habitats in the state of Hawaii. The work on Wetlands and Wetland Vegetation of the Hawaiian Islands (Elliott, 1981), the Hawaii Water Resources Regional Study (1979), the Classification of Wetlands and Deepwater Habitats of the United States prepared by the U.S. Fish and Wildlife Service (1979) and An Ornithological Survey of Hawaii Wetlands (Shallenberger, 1977) were four of the major sources of information. Individuals knowledgeable in the field of wetland ecology were identified through the Environmental Center review network and with the help of staff of the Department of Health and the University of Hawaii Water Resources Research Center. Through correspondence and meetings, these individuals provided information and identified specific wetland areas on base maps provided by the Department of Health. Matthew Higashida (Environmental Health Specialist, Department of Health), L. Stephen Lau (Director, Water Resources Research Center), and John F. Mink

(Hydrologist/Consultant) were the major contributors to the initial ecologically sensitive habitat site selection/identification procedure.

The identification of potential sources and generic types of groundwater pollutants for each ecological system was synthesized from existing literature sources, verified whenever possible by field checks, and compiled and stored in a computer generated database (DBASE III +) to permit interactive retrieval of the information. Assessment of *ecological sensitivity* and determination of *ecologically vital* areas was developed by the authors based on certain criteria developed in accordance with the EPA-GPS, the "Wetland Function Value Index" of the Water Resources Council (1981), and the "Wetlands Research Program" of the U.S. Army Corps of Engineers (1987).

## RESULTS

### Ecological Systems in Groundwater Discharge Areas

A list of *ecologically sensitive systems* that receive groundwater flows and their respective habitat codes and sensitivity ratings are given in Table 1. The general location of each ecological system is indicated in Figure 1.

The physical, chemical, biological, and cultural characteristics of each ecological system have been entered into a data base information system designed to provide specialized access (sort) capabilities on individual habitat characteristics including but not limited to, ecological system, aquifer system, map quadrangle numbers (latitude and longitude), map quadrangle name, and endangered terrestrial species. In addition, for any requested area, a complete output of the descriptive characteristics can be retrieved (Appendices). It should be noted that the data base is "open-ended" and can be expanded as the need arises.

Potential sources and generic types of groundwater pollutants to each aquifer system have also been compiled and are included in the data base (Fig. 2 and Appendices).

## DISCUSSION

### Assessment of Sensitivity of Ecological Systems

As indicated, the objectives of this study were three fold: 1. to identify and describe certain groundwater based ecological systems; 2. to assess the *ecological sensitivity* of these

Table 1. Ecologically Sensitive Wetland Sites, Habitat Code, Sensitivity Rating, and Aquifer Sectors and Systems, O'ahu, Hawai'i

Ecological System	Sensitivity Rating	Habitat Code	Aquifer No. and Sector	Aquifer No. and System	App. Ref.	Quadrangle No.-Name
1. 'Ahuimanu Stream	@Aa2m	11c355421	6-Windward	3-Koolaupoko	E.3.8	12-Kane'ohe
2. Amorient	@Ab12m	12325413	6-Windward	1-Koolauloa	E.1.4	7-Kahuku
3. Apoka'a Pond	@Aa12t	11c321b412	2-Pearl Harbor	3-Waipahu	B.3.1	6-Ewa
4. Baskerville Spring	@Aa2m	11b245411	6-Windward	3-Koolaupoko	E.3.5	12-Kane'ohe
5. Bellows Air Force Station	@Aa12m	11c345424	6-Windward	4-Waimanalo	E.4.4	15-Koko Head
6. Coconut Grove	@Aa12m	11c355344	6-Windward	1-Koolauloa	E.1.5	7-Kahuku
7. Crowbar Ranch Pond	@Aa12m3f	11b31b5341	4-North	1-Mokuleia	D.1.3	1-Kaena
8. Dillingham Field Pond	@Aa12m3f	11c31b5341	4-North	1-Mokuleia	D.1.2	1-Kaena
9. Fort Kamehameha	Ba2m	21c255433	2-Pearl Harbor	1-Waimalu	B.1.2	10-Puuloa
10. Haiku Stream	@Aa1	11c155421	6-Windward	3-Kookaupoko	E.3.4	12-Kane'ohe
11. Hakipu'u Stream	@Aa1	11c11b5421	6-Windward	2-Kahana	E.2.4	11-Kahana
12. Hale'iwa Lotus Farms	@Aa12tm3f	11c31a1b311	4-North	2-Waiialua	D.3.5	4-Hale'iwa
13. He'eia	@Aa12m3fh	11c31b1b444	6-Windward	3-Koolaupoko	E.3.2	12-Kane'ohe
14. Honouliuli NWR	@Ab12wt3f	12323441	2-Pearl Harbor	3-Waipahu	B.3.6	10-Puuloa
15. Ho'omaluhia Park	@Aa12wm3f	11b344311	6-Windward	3-Koolaupoko	E.3.1	12-Kane'ohe
16. Ioleka'a Stream	@Aa12m	11c255421	6-Windward	3-Koolaupoko	E.3.3	12-Kane'ohe
17. Ka'a'awa Stream	@Aa13f	11c155321	6-Windward	2-Kahana	E.2.1	11-Kahana
18. Kaelepulu Pond	@Aa12m3f	11b355312	6-Windward	4-Waimanalo	E.4.2	14-Mokapu
19. Kahalu'u Stream	@Aa12tm3f	11c31b1b321	6-Windward	3-Koolaupoko	E.3.7	12-Kane'ohe
20. Kahana Stream	@Aa12wtm3fh	11c354321	6-Windward	2-Kahana	E.2.3	11-Kahana
21. Kahuku Prawn Farm	@Ab1	12125413	6-Windward	1-Koolauloa	E.1.8	7-Kahuku
22. Kalou Marsh	@Aa12m3h	11c31b1a411	4-North	3-Kawailoa	D.3.2	3-Waimea
23. Kaluanui Stream	@Aa13h	11c151b421	6-Windward	1-Koolauloa	E.1.7	8-Hauula
24. Kawainui Marsh	@Aa12m3fh	11c31b1b341	6-Windward	4-Waimanalo	E.4.1	14-Mokapu
25. Ke'ehi Lagoon	Ba12wm	21c342433	1-Honolulu	4-Moanalua	A.3.1	10-Puuloa
26. Ki'i NWR	@Ab12wm3f	12352342	6-Windward	1-Koolauloa	E.1.6	7-Kahuku
27. Kualoa Fish Pond	@Aa12wtm3fh	11b324312	6-Windward	2-Kahana	E.2.7	11-Kahana
28. Kuapa Pond	Ba1	21b145413	1-Honolulu	5-Waiialae	A.4.2	15-Koko Head
29. Kuilima Sewage Treatment Pond	Bb12m	22355414	6-Windward	1-Koolauloa	E.1.1	7-Kahuku
30. Laie Prawn Farm	@Ab12m	12325413	6-Windward	1-Koolauloa	E.1.9	7-Kahuku
31. Loko Ea	@Aa12m3f	11c355314	4-North	3-Kawailoa	D.3.4	3-Waimea

Table 1. (Continued)

Ecological System	Sensitivity Rating	Habitat Code	Aquifer No. and Sector	Aquifer No. and System	App. Ref.	Quadrangle No.-Name
32. Lualualei Reservoir	Ba12wm	21b352441	3-Waianae	2-Lualualei	C.1.1	2-Waianae
33. Mariculture Research Center UH	Bb12m	22325414	6-Windward	2-Kahana	E.2.5	11-Kahana
34. Mokuleia Quarry	@Aa12m	11b355411	4-North	1-Mokuleia	D.1.1	1-Kaena
35. Moli'i Pond	@Aa12wtm3fh	11b324312	6-Windward	2-Kahana	E.2.6	11-Kahana
36. Mount Ka'ala	@Aa1	11a155441	3-Waianae	4-Makaha	C.2.1	4-Hale'iwa
37. Niulij Reservoir	Bb12m	22352414	3-Waianae	2-Lualualei	C.1.2	2-Waianae
38. Nuuanu Reservoir 1	Bb12m	22355411	1-Honolulu	3-Kalihi	A.2.1	13-Honolulu
39. Nuuanu Reservoir 2	@Aa12m3f	11b355311	1-Honolulu	2-Nuuanu	A.1.1	13-Honolulu
40. Nuuanu Reservoir 3	@Aa12m3f	11b355311	1-Honolulu	2-Nuuanu	A.1.2	13-Honolulu
41. Nuuanu Reservoir 4	@Aa12m3f	11b355311	1-Honolulu	2-Nuuanu	A.1.3	13-Honolulu
42. Nuupia Pond Complex	Ba12wtm3f	21b354313	6-Windward	4-Waimanalo	E.4.3	14-Makapu
43. Paiko Lagoon	Ba12wm3f	21c352334	1-Honolulu	5-Waiialae	A.4.1	15-Koko Head
44. Pearl Harbor East Loch	Ba12wm	21c155433	2-Pearl Harbor	1-Waimalu	B.1.1	9-Waipahu
45. Pouhala	@Aa12m3f	11c355114	2-Pearl Harbor	3-Waipahu	B.3.4	9-Waipahu
46. Punahoolapa	@Aa12wm3f	11c352342	6-Windward	1-Koolauloa	E.1.2	7-Kahuku
47. Punalu'u Stream	@Aa12wt3f	11c155321	6-Windward	2-Kahana	E.2.2	11-Kahana
48. Punalu'u Prawn Farm	@Ab12m	12325413	6-Windward	1-Koolauloa	E.1.10	11-Kahana
49. Punamano NWR	@Aa12wm3f	11c352342	6-Windward	1-Koolauloa	E.1.3	7-Kahuku
50. Queen's Beach Marsh	Ba2m	21c245433	1-Honolulu	5-Waiialae	A.4.3	15-Koko Head
51. Reef Runway	Bb2m	22255433	1-Honolulu	4-Moanalua	A.3.3	10-Puuloa
52. Salt Lake	Ba12m3f	21b345313	1-Honolulu	4-Moanalua	A.3.2	10-Puuloa
53. 'Uko'a Pond	@Aa12m3f	11c31b5314	4-North	3-Kawailoa	D.3.3	4-Hale'iwa
54. Waiahole Stream	@Aa12m3fh	11c11a5421	6-Windward	3-Koolaupoko	E.3.9	12-Kane'ohe
55. Waiialua Sugar Settling Basins	Bb12m3f	2231a5114	4-North	2-Waiialua	D.2.1	4-Hale'iwa
56. Waiawa NWR	@Ab12wm3f	12352142	2-Pearl Harbor	2-Waiawa	B.2.1	9-Waipahu
57. Waihe'e Stream	@Aa12t3f	11c151b321	6-Windward	3-Koolaupoko	E.3.6	12-Kane'ohe
58. Waikane Stream	@Aa12m3f	11c355321	6-Windward	3-Koolaupoko	E.3.10	12-Kane'ohe
59. Waikele	@Aa12m3f	11c355144	2-Pearl Harbor	3-Waipahu	B.3.2	9-Waipahu
60. Waimea Falls Arboretum	@Aa12wm3fh	11c344321	4-North	3-Kawailoa	D.3.1	3-Waimea
61. Waipahu Landfill	@Ab12m	12355444	2-Pearl Harbor	3-Waipahu	B.3.3	9-Waipahu
62. Waipio Basins	Bb12tm3f	22355144	2-Pearl Harbor	3-Waipahu	B.3.5	9-Waipahu
63. Walker's Bay	Ba12m	21c355433	2-Pearl Harbor	3-Waipahu	B.3.7	10-Puuloa

@ Ecologically Vital



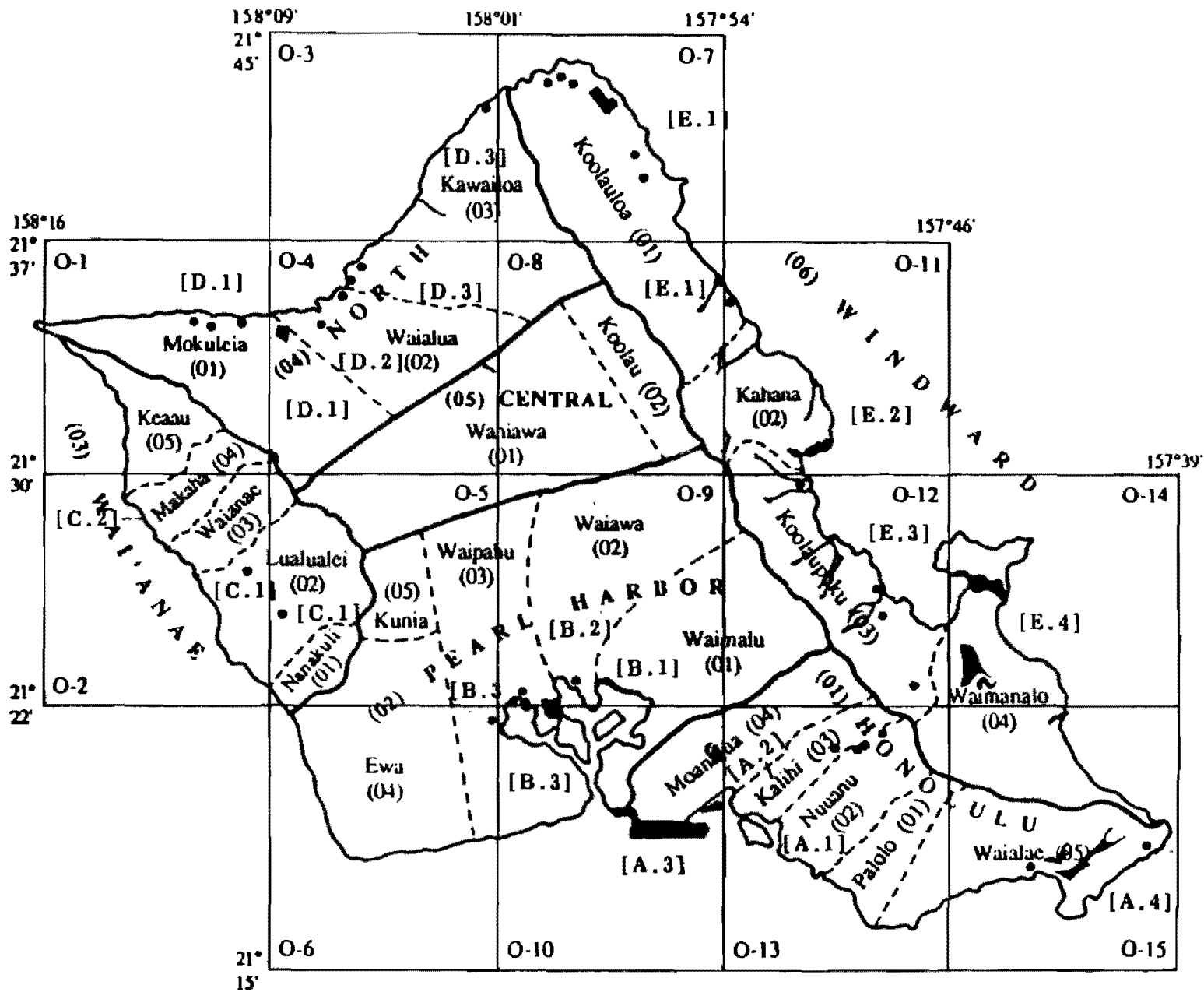


Figure 1. Wetland sites, aquifer systems and sectors, O'ahu, Hawai'i

POLLUTANT SOURCE	POTENTIAL POLLUTANTS																REMARKS	
	DISSOLVED INORGANIC NUTRIENTS	CHLORIDES	PESTICIDES	TOXIC METALS	BACTERIA	VIRUSES	GASOLINE	OIL	SILICA	TEMPERATURE	SOLVENTS	DETERGENTS	BORON	SODIUM	RADIOACTIVITY	ANTIBIOTICS		SEDIMENT
A. Sewage Effluent	x	x	x	x	x	x	x	x			x	x	x	x				
B. Cesspools	x	x	x	x	x	x		x			x	x	x	x				
C. Solid Waste (landfill)	x	x	x	x	x	x	x	x			x	x	x					
D. Animal Waste	x	x	x		x	x										x		
E. Aquaculture Waste	x	x	x	x	x	x					x	x				x		
F. Fuel Facility			x	x		x	x				x	x	x					
G. Agriculture (industrial)	x		x	x	x	x				x	x	x		x	x			
H. Manufacturing (industrial)	x			x				x		x	x	x	x	x	x			
I. Military (industrial)	x	x	x	x				x		x	x	x		x	x			
J. Sugarcane Culture	x		x								x	x						
K. Pineapple Culture	x	x	x								x	x						
L. Urban Runoff	x	x	x	x	x			x			x	x						x
M. Golf Course	x	x	x															
N. Desalting Plant	x	x		x	x				x	x	x	x		x				
O. Energy Generation		x		x					x	x	x	x						
P. Construction			x					x										x

Figure 2. Potential pollutant sources

systems; and, 3. to determine *ecologically vital* habitats in the context of the EPA Groundwater Protection Strategy program. The ultimate purpose of the study is to provide land use planners/managers with the information necessary to make informed decisions regarding groundwater protection. The inventory and description of ecological, hydrological and geological characteristics of various ecological systems and potential pollutants to those habitats is not sufficient without a mechanism whereby land use managers can readily estimate the significance or relative importance of the information available. Our tasks, therefore, were to compile the descriptive data and to derive a method whereby that descriptive and sometimes subjective ecological data could be objectively evaluated in concert with the hydrological and geological data. Presumably, such a method would allow for “better”, i.e. more objective, decision making as to the relative importance or *ecological sensitivity* of the habitats in accordance with EPA definitions for *ecologically vital* areas as set forth under the Groundwater Protection Strategy.

The U.S. Water Resources Council reviewed and assessed various methods for evaluating inland and coastal wetland functions (1981). In their analysis, critical elements are identified, and an assessment of functional value is determined. These elements include such items as: the function of the habitat with respect to wildlife needs; hydrologic functions; agriculture/silviculture functions; recreation and heritage functions; geographic features; personnel needs or administrative conditions; basic data requirements including monitoring; and so called “red flag” features of the wetlands. Their “sensitivity index” is based on the collective evaluation of each of the functional elements and the index derived varies with the site specific needs of the ecological communities as well as the uses or needs imposed by the evaluator.

We have modified the U.S. Water Resources Council evaluation procedure to suit the needs and environmental issues pertinent to Hawaii’s ecological systems. The various wetland function values for each ecological system have been identified and described in terms of the descriptive physical and biological elements. Key environmental attributes and uses of the systems by both the ecological community as well as man, and the potential pollutants to each system are noted.

### **Activities and Potential Pollutants to Ecological Systems**

In the aquifer classification scheme of Mink and Lau (1987), each island is divided into a number of Sectors and Systems based on hydrogeological similarities and groundwater

continuity, respectively. A series of aquifer and status codes is developed to describe the specific types of aquifers in each sector and system and the status of their current use. Where sedimentary caprock aquifers rest on primary basalt aquifers, two aquifer and status codes are indicated, an upper and a lower. The “Aquifer” and “Status Codes” for each habitat (see appendices) follow the Aquifer Classification Explanation of Mink and Lau (1987) that is reproduced here as Table 2. Pollutants entering any single aquifer system are assumed to have the potential for contaminating ecological systems receiving groundwater in that aquifer system. Activities occurring within a particular aquifer system that have the potential to contaminate groundwater sources are identified within the System-Wide-Characteristics section of the Appendices. Potential pollutants that may result from these activities are illustrated in Figure 2.

To evaluate *ecological sensitivity*, a two level procedure was developed: First, the characteristics of each ecological system were coded based on descriptive material from the inventory. Second, an ecological sensitivity rating was developed (Fig. 3).

**HABITAT CODE.** The habitat code (Table 3) is a description of the physical and cultural characteristics compiled for each ecological system and includes both the biological and physical (hydrological) environment of the system. The code reflects a compilation of “red flag” attributes as described by the Wetlands Research Program of the U.S. Army Corps of Engineers (1987), and U.S. Water Resources Council (1981).

**SENSITIVE ECOLOGICAL SYSTEMS RATING.** According to the EPA Groundwater Protection Strategy document, “*Sensitive Ecological Systems*”, are defined as all terrestrial or aquatic ecosystems that are located in a groundwater discharge area. However, the definition does not “rate” the relative sensitivity of each area to potential groundwater contamination. To determine the specific sensitivity it is necessary to evaluate the unique characteristics of each habitat. These characteristics may include not only the physical and biological attributes of that system, but also the cultural and even aesthetic values placed on the area by the community at large. Concomitantly, sensitivity to contamination varies with the individual system and is based on the magnitude of influence of groundwater, presence or absence of certain key ecological characteristics, and the types and quantity of potential pollutants.

Table 2. Aquifer Classification Explanation \*

AQUIFER AND STATUS CODES**			AQUIFER TYPE	HYDROLOGY†
Aquifer Code	=	Island + Sector	1 Basal	Fresh water in contact with seawater
	+	Aquifer System	2 High Level	Fresh water not in contact with seawater
	+	Aquifer Type	1 Unconfined	Where water table is upper surface of the saturated aquifer
Thus, 30104111	=	Aquifer Code	2 Confined	Aquifer bounded by impermeable or poorly permeable formations, and top of saturated aquifer is below groundwater surface
where	3	= O'ahu	3 Confined or Unconfined	Where actual condition is uncertain
	01	= Honolulu		
	04	= Moanalua		
	1	= Basal		
	1	= Unconfined		
	1	= Flank		
and	1111	= Status Code		
where	1	= Currently Used		
	1	= Drinking		
	1	= Fresh (< 250 mg/l Cl <sup>-</sup> )		
	1	= Irreplaceable		
	1	= High		
ISLAND	SECTOR	AQUIFER SYSTEM	GEOLOGY††	
3	01 Honolulu	01 Palolo	1 Flank	Horizontally extensive lavas
		02 Nuuanu	2 Dike	Aquifers in dike compartments
		03 Kalihi	3 Flank/Dike	Indistinguishable
		04 Moanalua	4 Perched	Aquifer on an impermeable layer
		05 Waialae	5 Dike/Perched	Indistinguishable
	02 Pearl Harbor	01 Waimalu	6 Sedimentary	Non-volcanic lithology
		02 Waiawa		
		03 Waipahu		
		04 Ewa		
		05 Kunia		
	03 Waianae	01 Nanakuli		
		02 Lualualei		
		03 Waianae		
		04 Makaha		
		05 Keaau		
04 North	01 Mokuleia			
	02 Waialua			
	03 Kawaioloa			
05 Central	01 Wahiawa			
	02 Koolau			
06 Windward	01 Koolauloa			
	02 Kahana			
	03 Koolaupoko			
	04 Waimanalo			
			†Hydrologic descriptors (1st two digits from pts. 1,2).	
			††Geologic descriptor (last digit).	
<b>STATUS CODE (GROUNDWATER)</b>				
Development Stage				
1 Currently Used				
2 Potential Use				
3 No Potential Use				
Utility				
1 Drinking				
2 Ecologically Important				
3 Neither				
Salinity (mg/l Cl <sup>-</sup> )				
1 Fresh (< 250)				
2 Low (250-1,000)				
3 Moderate (1,000-5,000)				
4 High (5,000-15,000)				
5 Seawater (> 15,000)				
Uniqueness				
1 Irreplaceable				
2 Replaceable				
Vulnerability to Contamination				
1 High				
2 Moderate				
3 Low				
4 None				

\*Taken from Mink and Lau (1987)

\*\*Where sedimentary caprock aquifers rest on primary basalt aquifers, two Aquifer and Status Codes separated by a slash indicate numerator code is upper aquifer and denominator is lower aquifer.

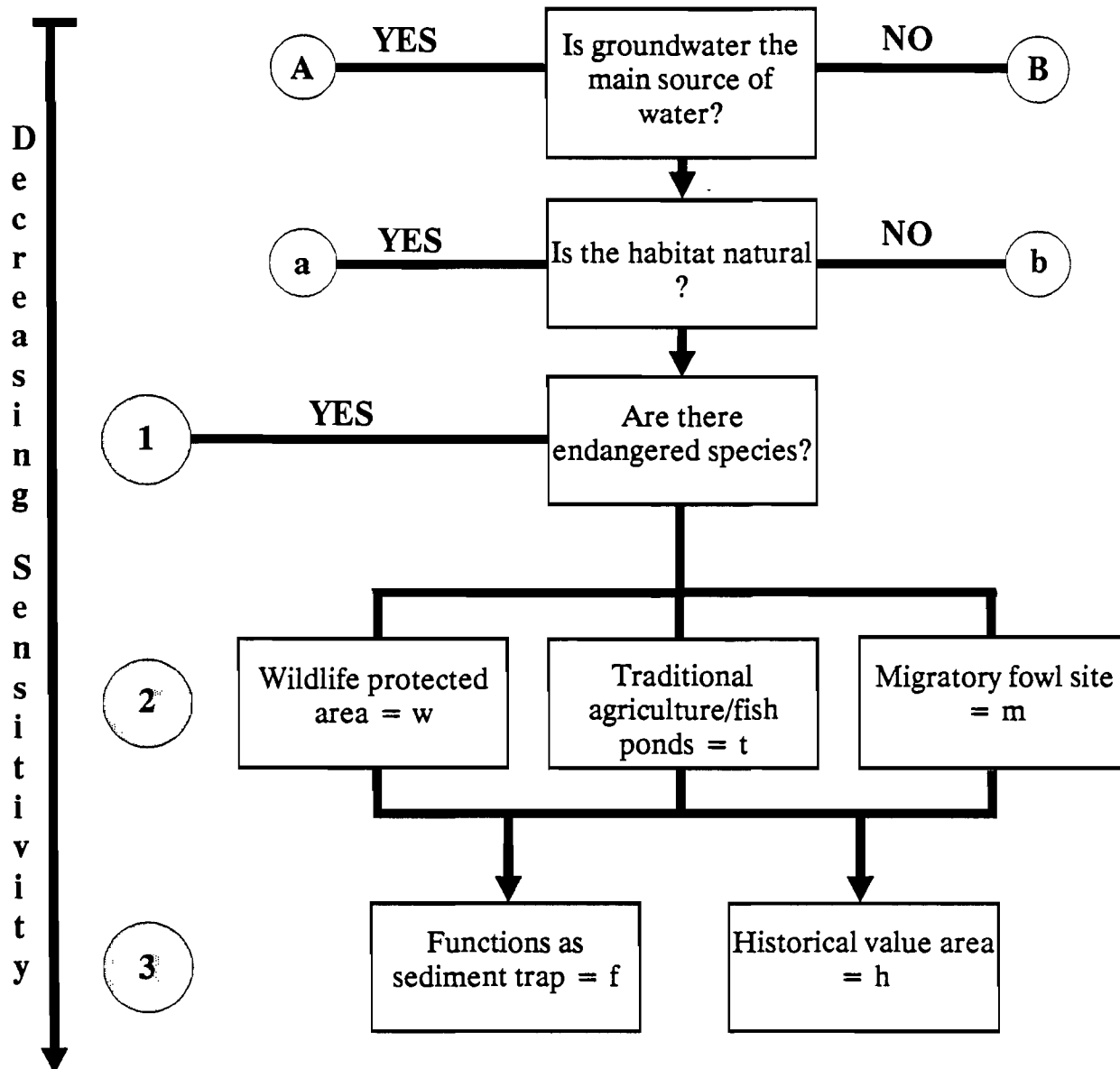


Figure 3. Ecological sensitivity rating. Ecological sensitivity ranked in decreasing level of sensitivity pursuant to EPA-GPS program. The presence of a 'w', 't' or 'm' [②] or 'f' or 'h' [③] reflects equal sensitivity within each respective level.

Table 3. Habitat Code

Code	Code
<b>Water Source</b>	<b>Social Significance</b>
1 Groundwater	1 Historic
2 Other	a Registered
	b Not Registered
<b>Habitat Origin/Development</b>	2 Wildlife Protected
1 Natural	3 1a + 2
a Pristine	4 1b + 2
b Altered	5 Neither
c a + b	
2 Artificial	<b>Physical Significance</b>
	1 Sediment Trap
<b>Ecological Character</b>	2 Flood Control
1 Endangered Species	3 1 + 2
2 Migratory Birds	4 Neither
3 1 + 2	
4 Neither	<b>Wetland Type</b>
<b>Present Activities</b>	1 Pond
1 Agriculture	2 Stream
a Crops	3 Coastal
b Livestock	4 Marsh
2 Aquaculture	<b>Water Quality (mg/l Cl<sup>-</sup>)</b>
3 1a + 2	1 Fresh (<250)
4 Recreation	2 Brackish (250-15,000)
5 Neither	3 Marine (>15,000)
	4 Combination

In our evaluation of the sensitivity of each of the ecological systems we have chosen to use a modified version of the “Wetland Function Value Index” as promulgated by the U.S. Water Resources Council (1981) as the primary “sensitivity rating” for the systems.

The *sensitive ecological system* rating (Fig. 3) reflects the “uniqueness” or “non-renewable” attributes of the particular system. Some of these evaluation attributes are amenable to measurement and quantification, i.e. presence or absence of endangered species or certain water quality characteristics that either exceed or meet specific values recognized by statute. Other attributes are less tangible, i.e. they may have seasonal periods of importance or varying degrees of value based on circumstances at the time, such as sediment trapping ability, use by migratory fowl, importance of archaeological remains, or the open space visual values subjectively assigned to an area. In general, we have found it to be inappropriate if not impossible to assign absolute numeric values to various attributes of ecological systems as a basis for determining relative ecological sensitivities. In this regard we note the recognition in the EPA Guidelines for Groundwater Protection Strategy of the use of both quantitative as well as qualitative assessments (EPA, 1986). The relative sensitivities of the various systems are coded and assessed in accordance with the criteria indicated in Table 4.

## RATING

Each of the *ecologically sensitive systems* identified for this project have been assigned an ecological sensitive system rating based on the criteria shown in Table 4. Sensitivity is determined by following a hierarchical flowchart (Fig. 3) which begins with a determination of the primary water source. For example, an ecological system which has groundwater, is natural, and has endangered species will be assigned a rating of “Aa1”. If the same ecological system also has historical value the rating will be “Aa13h”. The highest sensitivity rating is assigned to ecological systems which are supplied by groundwater (A); a natural ecological system (a); have endangered species (1); or are a designated wildlife protected area (2w), have migratory fowl (2m), or reflect ancient fishponds or other traditional agricultural practices (2t). A minimum rating of Aa1, Aa2, Ab1 or Ab2 represents a system that is *ecologically vital* according to the EPA-GPS guidelines and is entitled to protection as Class I-Special Groundwaters.



Table 4. Codes and Criteria for Sensitivity Ratings

Code	Criteria
A	Groundwater provides the main source of water to the ecological system.
B	Groundwater, although present, does not provide the main source of water to the ecological system.
a	A natural ecological system, i.e. one capable of sustaining itself without the interjection of “artificial” water sources. Note: Some systems are classified as natural even though they may have been artificially created or significantly altered by human intervention. For example the artificially constructed or enhanced water reservoirs of Nuuanu, island of O‘ahu, are classified as natural although their dimensions may have been mechanically modified. They now exist without substantive influence or intervention by man.
b	Artificial ecological systems. Artificially created systems that receive some groundwater flows but must be maintained by human influences. Examples are the Kuilima Sewage Treatment Pond, the Waialua Sugar Settling Basins on O‘ahu and most aquacultural facilities. These systems are dependent upon human intervention to supply continual inputs of water rather than natural processes.
1	The presence of endangered or threatened species described in the Federal register of endangered or threatened species or in the State register of endangered or threatened species.
2w	A wildlife protected area. Wildlife protected includes any Federal, State, County or privately managed wildlife area. Presence of this category implies that some organization has an interest in managing the wildlife resources of the area.
2t	Area is used for traditional agriculture/aquaculture. This ecological system has value as a cultural resource. Traditional crops such as taro or lotus are being cultivated. In addition traditional aquaculture such as mullet raising may be practiced.
2m	Area is used by migratory fowl.
3f	Area serves as a sediment trap or flood control.
3h	Area has historical/cultural value. Historic resources are known to be in the vicinity of the system. Many ancient fishponds are now used for waterbird habitat, but not for traditional agriculture, thus they are historic.

The Ab rating level reflects groundwater base flow, however these ecosystems are artificially created. Many, if not all, of the Ab ecosystems are also *ecologically vital* by the definition provided in the EPA-GPS program, therefore these artificial systems may be subject to the same statutory protection as a natural wetland ecosystem. However, when an aquaculture facility closes or the sugar industry stops production, the state would have to develop a management program to ensure the perpetuation of these artificial ecosystems. As a matter of fact, many of the National Wildlife Refuges are actually artificially maintained wetlands.

Ecological systems that are assigned a rating of “Ba” have reduced sensitivity to groundwater influx and are not *ecologically vital* by the EPA-GPS definition, however, they do receive some quantity of groundwater. Furthermore, they may exhibit natural qualities which are worthy of protection and therefore, they cannot be ignored in land use decision making for reason of the narrow objectives of this project. Many Hawaiian ecological systems have been recognized as having great historic significance and are listed on the Register of Historic Places. Many more have potential historic value but are not yet on the Register. Similarly, ecological systems which provide sediment trapping and flood control qualities may be essential to protection of coastal ecosystems and cannot and should not be overlooked when making land use decisions.

## SUMMARY

In summary, we have identified *ecologically sensitive systems* pursuant to the criteria set forth by the U.S. EPA Groundwater Protection Strategy and have codified certain ecological characteristics for subsequent use in rating the relative sensitivity of each habitat. The results provide the basis, along with certain geohydrological information, for determining if a particular groundwater should be considered *ecologically vital*. It is clear from the information compiled that those ecological systems receiving inflow of groundwater from densely urbanized areas, areas with significant groundwater withdrawal, or agricultural areas are most vulnerable to pollutant impacts. The wetland areas of the Kahuku region on the island of O‘ahu for example, are particularly sensitive and are designated a critical habitat due to their use by endangered water fowl and their role in sediment control to reduce pollutants to the nearby coastal waters. This study identifies needs for future studies for ecological characterization of many systems beyond extant available information. Furthermore, the attenuation and dilution of groundwater

contaminants by natural processes...advection, dispersion, sorption, biodegradation, or decay..., before the groundwater is discharged from the aquifer, can significantly affect the relative toxicity of the potential pollutants. However, a discussion of the specific toxicological effects of various potential pollutants on the ecologically sensitive systems is beyond the scope of this study.

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## APPENDIX CONTENTS

A.1	System-wide characteristics of ecologically sensitive habitats, aquifers of Honolulu Sector, Nuuanu System, O’ahu . . . . .	27
1.1	Habitat description of Nuuanu Reservoir 2 . . . . .	29
1.2	Habitat description of Nuuanu Reservoir 3 . . . . .	33
1.3	Habitat description of Nuuanu Reservoir 4 . . . . .	37
A.2	System-wide characteristics of ecologically sensitive habitats, aquifers of Honolulu Sector, Kalihi System, O’ahu . . . . .	41
2.1	Habitat description of Nuuanu Reservoir 1 . . . . .	43
A.3	System-wide characteristics of ecologically sensitive habitats, aquifers of Honolulu Sector, Moanalua System, O’ahu . . . . .	47
3.1	Habitat description of Ke’ehi Lagoon . . . . .	51
3.2	Habitat description of Salt Lake . . . . .	57
3.3	Habitat description of Reef Runway . . . . .	61
A.4	System-wide characteristics of ecologically sensitive habitats, aquifers of Honolulu Sector, Waialae System, O’ahu . . . . .	65
4.1	Habitat description of Paiko Lagoon . . . . .	67
4.2	Habitat description of Kuapa Pond . . . . .	71
4.3	Habitat description of Queen’s Beach Marsh . . . . .	75
B.1	System-wide characteristics of ecologically sensitive habitats, aquifers of Pearl Harbor Sector, Waimalu System, O’ahu . . . . .	81
1.1	Habitat description of Pearl Harbor East Loch . . . . .	83
1.2	Habitat description of Fort Kamehameha . . . . .	89
B.2	System-wide characteristics of ecologically sensitive habitats, aquifers of Pearl Harbor Sector, Waiawa System, O’ahu . . . . .	93
2.1	Habitat description of Waiawa National Wildlife Refuge . . . . .	97
B.3	System-wide characteristics of ecologically sensitive habitats, aquifers of Pearl Harbor Sector, Waipahu System, O’ahu . . . . .	103
3.1	Habitat description of Apoka’a Pond . . . . .	107
3.2	Habitat description of Waikele . . . . .	111
3.3	Habitat description of Waipahu Landfill . . . . .	117
3.4	Habitat description of Pouhala . . . . .	123
3.5	Habitat description of Waipio Basins . . . . .	129
3.6	Habitat description of Honouliuli National Wildlife Refuge . . . . .	135
3.7	Habitat description of Walker’s Bay . . . . .	141

C.1	System-wide characteristics of ecologically sensitive habitats, aquifers of Waianae Sector, Lualualei System, O'ahu . . . . .	145
1.1	Habitat description of Lualualei Reservoir . . . . .	147
1.2	Habitat description of Niulii Reservoir . . . . .	151
C.2	System-wide characteristics of ecologically sensitive habitats, aquifers of Waianae Sector, Makaha System, O'ahu . . . . .	155
2.1	Habitat description of Mount Ka'ala . . . . .	157
D.1	System-wide characteristics of ecologically sensitive habitats, aquifers of North Sector, Mokuleia System, O'ahu . . . . .	161
1.1	Habitat description of Mokuleia Quarry . . . . .	163
1.2	Habitat description of Dillingham Field Pond . . . . .	167
1.3	Habitat description of Crowbar Ranch Pond . . . . .	171
D.2	System-wide characteristics of ecologically sensitive habitats, aquifers of North Sector, Waialua System, O'ahu . . . . .	175
2.1	Habitat description of Waialua Sugar Settling Basins . . . . .	177
D.3	System-wide characteristics of ecologically sensitive habitats, aquifers of North Sector, Kawailoa System, O'ahu . . . . .	181
3.1	Habitat description of Waimea Falls Arboretum . . . . .	183
3.2	Habitat description of Kalou Marsh . . . . .	189
3.3	Habitat description of 'Uko'a Pond . . . . .	193
3.4	Habitat description of Loko Ea . . . . .	199
3.5	Habitat description of Hale'iwa Lotus Farms . . . . .	203
E.1	System-wide characteristics of ecologically sensitive habitats, aquifers of Windward Sector, Koolauloa System, O'ahu . . . . .	207
1.1	Habitat description of Kuilima Sewage Treatment Pond . . . . .	209
1.2	Habitat description of Punahoolapa . . . . .	215
1.3	Habitat description of Punamano National Wildlife Refuge . . . . .	221
1.4	Habitat description of Amorient . . . . .	227
1.5	Habitat description of Coconut Grove . . . . .	231
1.6	Habitat description of Ki'i National Wildlife Refuge . . . . .	235
1.7	Habitat description of Kaluanui Stream . . . . .	241
1.8	Habitat description of Kahuku Prawn Farm . . . . .	247
1.9	Habitat description of Laie Prawn Farm . . . . .	251
1.10	Habitat description of Punalu'u Prawn Farm . . . . .	255
E.2	System-wide characteristics of ecologically sensitive habitats, aquifers of Windward Sector, Kahana System, O'ahu . . . . .	259
2.1	Habitat description of Ka'a'awa Stream . . . . .	261
2.2	Habitat description of Punalu'u Stream . . . . .	265
2.3	Habitat description of Kahana Stream . . . . .	269
2.4	Habitat description of Hakipu'u Stream . . . . .	279

2.5	Habitat description of Mariculture Research Center UH . . . . .	283
2.6	Habitat description of Moli'i Pond . . . . .	287
2.7	Habitat description of Kualoa Fish Pond . . . . .	291
E.3	System-wide characteristics of ecologically sensitive habitats, aquifers of Windward Sector, Koolaupoko System, O'ahu . . . . .	295
3.1	Habitat description of Ho'omaluhia Park . . . . .	297
3.2	Habitat description of He'eia . . . . .	301
3.3	Habitat description of Ioleka'a Stream . . . . .	307
3.4	Habitat description of Haiku Stream . . . . .	311
3.5	Habitat description of Baskerville Spring . . . . .	315
3.6	Habitat description of Waihe'e Stream . . . . .	317
3.7	Habitat description of Kahalu'u Stream . . . . .	323
3.8	Habitat description of 'Ahuimanu Stream . . . . .	329
3.9	Habitat description of Waiahole Stream . . . . .	333
3.10	Habitat description of Waikane Stream . . . . .	339
E.4	System-wide characteristics of ecologically sensitive habitats, aquifers of Windward Sector, Waimanalo System, O'ahu . . . . .	345
4.1	Habitat description of Kawainui Marsh . . . . .	349
4.2	Habitat description of Kaelepulu Pond . . . . .	357
4.3	Habitat description of Nuupia Pond Complex . . . . .	361
4.4	Habitat description of Bellows Air Force Station . . . . .	367





**Appendix A.1 System-Wide Characteristics of Ecologically Sensitive Habitats,  
Aquifers of Honolulu Sector, Nuuanu System**

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Aquifer System: Nuuanu (02)

Aquifer Sector: Honolulu (01)

Island: O'ahu (3)

Water Wells in Aquifer System (Div. of Water and Land Development 1984):

Disposal	7	Domestic	5	Industrial	7
Irrigation	1	Lost	-	Municipal	16
Observation	8	Other	32	Recharge	-
Sealed	53	Unused	17	Unknown	1

(Department of Health 1987):

Drinking	-
Other	-

Total Number of Injection Wells: 8

Water Wells or Sampling Sites Once Contaminated with DBCP, EDB or TCP  
(Water Resources Research Center 1985):

None

Potential Pollutant Sources and Pollutants (see Fig. 2):

Source: Pali Highway  
Pollutants: Runoff  
Discharge: Non-point Source

Source: Iseri, Incorporated; dba Hal's City Chevron (UO 1349)  
Pollutants: Once-through carwash; wastewater treated by sand and grease traps  
Discharge: 1,300 gpd



### Appendix A.1.1 Habitat Description of Nuuanu Reservoir 2

---

Site:	Nuuanu Reservoir 2	Lat.:	21°21'05"
Island:	O'ahu	Long.:	157°49'27"
Sector:	Honolulu, 01	El.:	800-840 ft
System:	Nuuanu (02)	Approx. Area/Length:	1.8 acres

#### Site Description:

Nuuanu Reservoir 2 is a man-made reservoir bordered by dense vegetation on three sides and the Nuuanu Pali Road on the fourth side. On the mauka side of the reservoir is an approximately 20 ft diameter area of various monocotyledons. Overflow discharge is by way of a concrete culvert which passes under the Nuuanu Pali Road and into Nuuanu Stream.

Sensitivity Rating:	Aa12m3f
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Other Value:	3f Sediment Trap
Habitat Code:	1-1b-3-5-5-3-1-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1b Natural/Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	1 Pond
Water Quality:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:	30102212
Island:	3 O'ahu
Sector:	01 Honolulu
Aquifer System:	02 Nuuanu
Aquifer Type (Hydrology):	2 High Level
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	2 Dike
Status Code:	11111
Development Stage:	1 Currently Used
Utility:	1 Drinking
Salinity:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1 Irreplaceable
Vulnerability to Contamination:	1 High

**Nuuanu Reservoir 2--Continued**

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## U.S. Fish &amp; Wildlife Service Wetland Code:

Palustrine/Forested/Broad-Leaved Evergreen/Non-Tidal Seasonal (PFO3C)

Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent/Dike-Impounded (POWHh)

## Geology:

1. Nuuanu volcanics of Honolulu volcanic series
2. Late eruption rocks overlying valley fill sediments

## Soil Conservation Service, U.S. Dept. of Agriculture 1975:

LoB (Lolekaa silty clay, Humoxic Tropohumults)  
3-8% slopes

## Terrestrial Threatened or Endangered Plant(s):

No inventory available

## Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)

## Terrestrial Plant(s):

No inventory available

## Aquatic Plant(s):

No inventory available

## Terrestrial Animal(s):

No inventory available

## Aquatic Animal(s):

No inventory available

## Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)

## Freshwater Origin:

1. High level
2. Nuuanu volcanic rock consisting of cinders and lava
3. Runoff from Koolau formation; direct recharge into Nuuanu volcanics

## Comments:

**Nuuanu Reservoir 2--Continued**

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**References:**

- Timbol, A.S., and Maciolek, J.A. 1978. Stream channel modification in Hawaii. Part A: Statewide inventory of streams, habitat factors and associated biota. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 157 p.



### Appendix A.1.2 Habitat Description of Nuuanu Reservoir 3

---

Site:	Nuuanu Reservoir 3	Lat.:	21°21'14"
Island:	O'ahu	Long.:	157°49'20"
Sector:	Honolulu, 01	El.:	800-840 ft
System:	Nuuanu (02)	Approx. Area/Length:	2.3 acres

#### Site Description:

The Nuuanu Reservoir 3 is surrounded by ironwood trees. English papyrus is found in one corner of the site. The ducks seen during our field visit to the habitat were very tame and appeared to be of mixed "mallard type" ancestry. Drainage of the reservoir is by way of Nuuanu Stream.

Sensitivity Rating:	Aa12m3f
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Other Value:	3f Sediment Trap
Habitat Code:	1-1b-3-5-5-3-1-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1b Natural/Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	1 Pond
Water Quality:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:	30102212
Island:	3 O'ahu
Sector:	01 Honolulu
Aquifer System:	02 Nuuanu
Aquifer Type (Hydrology):	2 High Level
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	2 Dike
Status Code:	11111
Development Stage:	1 Currently Used
Utility:	1 Drinking
Salinity:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1 Irreplaceable
Vulnerability to Contamination:	1 High

**Nuuanu Reservoir 3--Continued**

---

## U.S. Fish &amp; Wildlife Service Wetland Code:

Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent/Dike-Impounded  
(POWHh)

## Geology:

1. Nuuanu volcanics of Honolulu volcanic series
2. Late eruption rocks overlying valley fill sediments

## Soil Conservation Service, U.S. Dept. of Agriculture 1975:

LoB (Lolekaa silty clay, Humoxic Trophumults)  
3-8% slopes

## Terrestrial Threatened or Endangered Plant(s):

No inventory available

## Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)

## Terrestrial Plant(s):

No inventory available

## Aquatic Plant(s):

No inventory available

## Terrestrial Animal(s):

No inventory available

## Aquatic Animal(s):

No inventory available

## Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
Mallard (*Anas platyrhynchos*)

## Freshwater Origin:

1. High level
2. Nuuanu volcanic rocks consisting of cinders and lava
3. Runoff from Koolau formation; direct recharge into Nuuanu volcanics

## Comments:



**Nuuanu Reservoir 3--Continued**

---

**References:**

- Timbol, A.S., and Maciolek, J.A. 1978. Stream channel modification in Hawaii. Part A: Statewide inventory of streams, habitat factors and associated biota. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 157 p.



### Appendix A.1.3 Habitat Description of Nuuanu Reservoir 4

---

Site:	Nuuanu Reservoir 4	Lat.:	21°21'30"
Island:	O'ahu	Long.:	157°48'35"
Sector:	Honolulu, 01	El.:	1000-1040 ft
System:	Nuuanu (02)	Approx. Area/Length:	60.4 acres

#### Site Description:

Nuuanu Reservoir 4 is a man-made reservoir with numerous Norfolk pines growing on the earthen dam. Removal of previous vegetation occurred in 1980 when the Board of Water Supply constructed monitoring wells on the dam. A large tower sits in the reservoir approximately 15 m (50 ft) from the dam and a catfish feeding device floats in the reservoir.

Sensitivity Rating:	Aa12m3f
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Other Value:	3f Sediment Trap
Habitat Code:	1-1b-3-5-5-3-1-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1b Natural/Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	1 Pond
Water Quality:	1 Fresh (<250 mg/l Cl <sup>-</sup> )
Aquifer Code:	30102212
Island:	3 O'ahu
Sector:	01 Honolulu
Aquifer System:	02 Nuuanu
Aquifer Type (Hydrology):	2 High Level
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	2 Dike
Status Code:	11111
Development Stage:	1 Currently Used
Utility:	1 Drinking
Salinity:	1 Fresh (<250 mg/l Cl <sup>-</sup> )
Uniqueness:	1 Irreplaceable
Vulnerability to Contamination:	1 High

**Nuuanu Reservoir 4--Continued**

---

## U.S. Fish &amp; Wildlife Service Wetland Code:

Lacustrine/Limnetic/Open Water-Unknown Bottom/Non-Tidal  
Permanent/Dike-Impounded (L1OWHh)

Lacustrine/Littoral/Unconsolidated Bottom/Mud/Non-Tidal  
Seasonal/Dike-Impounded (L2UB3Ch)

## Geology:

1. Nuuanu volcanics of Honolulu volcanic series
2. Late eruption rocks overlying valley fill sediments

## Soil Conservation Service, U.S. Dept. of Agriculture 1975:

LoB (Lolekaa silty clay, Humoxic Tropohumults)  
3-8% slopes

## Terrestrial Threatened or Endangered Plant(s):

No inventory available

## Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)

## Terrestrial Plant(s):

No inventory available

## Aquatic Plant(s):

No inventory available

## Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
Brown Noddy (*Anous stolidus pileatus*)

## Aquatic Animal(s):

No inventory available

## Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)

## Freshwater Origin:

1. High level
2. Nuuanu volcanic rocks consisting of cinders and lava
3. Runoff from Koolau formation; direct recharge into Nuuanu volcanics

## Comments:

**Nuuanu Reservoir 4--Continued**

---

**References:**

- Timbol, A.S., and Maciolek, J.A. 1978. Stream channel modification in Hawaii. Part A: Statewide inventory of streams, habitat factors and associated biota. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 157 p.



## Appendix A.2 System-Wide Characteristics of Ecologically Sensitive Habitats, Aquifers of Honolulu Sector, Kalihi System

---

Aquifer System: Kalihi (03)

Aquifer Sector: Honolulu (01)

Island: O'ahu (3)

Water Wells in Aquifer System (Div. of Water and Land Development 1984):

Disposal	2	Domestic	2	Industrial	11
Irrigation	-	Lost	3	Municipal	12
Observation	2	Other	2	Recharge	-
Sealed	14	Unused	6	Unknown	2

(Department of Health 1987):

Drinking	1
Other	-

Total Number of Injection Wells: 8

Water Wells or Sampling Sites Once Contaminated with DBCP, EDB or TCP  
(Water Resources Research Center 1985):

None

Potential Pollutant Sources and Pollutants (see Fig. 2):

Source: McKinley Motor Service, Inc.; McKinley Car Wash (UO 1214)  
Pollutants: Primary treated car wash effluent  
Discharge: 3,352 gpd

Source: Honolulu Fueling Facilities Corporation Lot #3 (UO 1239)  
Pollutants: Oil/water separator effluent  
Discharge: 100,800 gpd

Source: Pacific Resources, Incorporated Co.; Gasco, Inc. (UO 1323)  
Pollutants: Gas holder condensate, storm water runoff  
Discharge: 8,000 gpd

Source: Pacific Resources, Incorporated Co.; Gasco, Inc. (UO 1322)  
Pollutants: Boiler blowdown  
Discharge: 15,000 gpd

Source: Unocal Corporation dba Surf Union Service (UO 1268)  
Pollutants: Untreated car wash effluent  
Discharge: 3,000 gpd





### Appendix A.2.1 Habitat Description of Nuuanu Reservoir 1

---

Site:	Nuuanu Reservoir 1	Lat.:	21°20'35"
Island:	O'ahu	Long.:	157°50'23"
Sector:	Honolulu, 01	El.:	360-400 ft
System:	Kalihi (03)	Approx. Area/Length:	2.2 acres

#### Site Description:

According to personnel of the Honolulu Board of Water Supply, this reservoir is a man-made, concrete lined basin. It is presently not maintained or used for any Board of Water Supply activities.

Sensitivity Rating:	Bb12m
Main Water Source:	B Not Groundwater
Habitat:	b Artificial
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Habitat Code:	2-2-3-5-5-4-1-1
Water Source:	2 Other
Habitat Origin/Development:	2 Artificial
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	1 Pond
Water Quality:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:	30103116
Island:	3 O'ahu
Sector:	01 Honolulu
Aquifer System:	03 Kalihi
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	6 Sedimentary
Status Code:	13321
Development Stage:	1 Currently Used
Utility:	3 Neither Drinking nor Ecologically Important
Salinity:	3 Moderate (1,000-5,000 mg/l Cl <sup>-</sup> )
Uniqueness:	2 Replaceable
Vulnerability to Contamination:	1 High

**Nuuanu Reservoir 1--Continued**

---

Aquifer Code:		30103121
Island:	3	O'ahu
Sector:	01	Honolulu
Aquifer System:	03	Kalihi
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank
Status Code:		11113
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	3	Low

U.S. Fish & Wildlife Service Wetland Code:  
Palustrine/Emergent/Persistent/Non-Tidal Seasonal (PEM1C)

Geology:  
1. Nuuanu volcanic of Honolulu volcanic series  
2. Late eruption rocks overlying vally fill sediments

Soil Conservation Service, U.S. Dept. of Agriculture 1975:  
LoD (Lolekaa silty clay, Humoxic Tropohumults)  
15-25% slopes

Terrestrial Threatened or Endangered Plant(s):  
No inventory available

Terrestrial Threatened or Endangered Animal(s):  
Hawaiian Coot (*Fulica americana alai*)  
'I'iwi (*Vestiaria coccinea*)  
Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)

Terrestrial Plant(s):  
Tree lobelia (*Rollandia crispa* Gaud.)  
Wimmer lobelia (*Neowimmeria hypoleuca* Hbd. (Deg. & Deg.))  
Water fern (*Marsilea villosa* Kaulf.)  
Hawaiian gardenia (*Gardenia* sp.)  
Kauai night shade (*Solanum kauaiense* Hbd.)

Aquatic Plant(s):  
No inventory available

**Nuuanu Reservoir 1--Continued**

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## Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)

## Aquatic Animal(s):

No inventory available

## Migratory Animal(s):

Mallard (*Anas platyrhynchos*)

## Freshwater Origin:

1. High level
2. Nuuanu volcanic rock consisting of cinders and lava
3. Runoff from Koolau formation; direct recharge into Nuuanu volcanics

## Comments:

## References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.
- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.



### Appendix A.3 System-Wide Characteristics of Ecologically Sensitive Habitats, Aquifers of Honolulu Sector, Moanalua System

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Aquifer System: Moanalua (04)

Aquifer Sector: Honolulu (01)

Island: O'ahu (3)

Water Wells in Aquifer System (Div. of Water and Land Development 1984):

Disposal	-	Domestic	3	Industrial	3
Irrigation	-	Lost	-	Municipal	7
Observation	3	Other	2	Recharge	-
Sealed	16	Unused	2	Unknown	-

(Department of Health 1987):

Drinking	-
Other	-

Total Number of Injection Wells: 6

Water Wells or Sampling Sites Once Contaminated with DBCP, EDB or TCP  
(Water Resources Research Center 1985):

None

Potential Pollutant Sources and Pollutants (see Fig. 2):

Source: Honolulu Fueling Factory Corporation (NPDES 20354)

Pollutants: Industrial wastes

Discharge: Emergency (0)

Source: Ameron HC&D (NPDES 132)

Pollutants: Industrial wastes including suspended solids, settleable solids and  
chemical oxygen demand

Discharge: 10,000 gpd into Kalihi Stream

Source: Honolulu Fueling Fac. Corp. Satellite Plant #1 (UO 1238)

Pollutants: Oil/water separator effluent

Discharge: 432,000 gpd

Source: Honolulu Fueling Facilities Corporation Plant #2 (UO 1430)

Pollutants: Salt tower (fuel dehydrator) brine

Discharge: 8.4 gpd

Source: Carwash for Tropical Rent-A-Car (UO 1383)

Pollutants: Once-through carwash wastewater treated by sand and grease separators

Discharge: 1,000 gpd

**Moanalua--Continued**

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Source: Hickam Air Force Base Golf Course (UO 1353)  
Pollutants: Secondary treated sewage and untreated sewage  
Discharge: 2,000 and 1,000 gpd respectively

Source: Budget Rent-A-Car Systems Inc. Kalewa St. Facility (UO 1341)  
Pollutants: Untreated carwash effluent  
Discharge: 500 gpd

Source: Enivel Inc. dba Young Laundry and Dry Cleaning (UO 1339)  
Pollutants: Primary treated laundry wastewater  
Discharge: 200,000 gpd

Source: Hickam Air Field and Military Base  
Pollutants: Wastewater and petroleum products

Source: Ameron HC&D, Limited (NPDES 21075)  
Pollutants: Industrial wastes  
Discharge: 2,900 gpd

Source: Castle and Cooke, Inc., Dole Cannery (NPDES 43)  
Pollutants: Industrial wastes including suspended solids, oil and grease, settleable solids.  
Discharge: 5.5 mgd

Source: Chevron U.S.A., Inc. (NPDES 20940)  
Pollutants: Industrial wastes from Kapalama Terminal  
Discharge: Emergency (0)

Source: Chevron U.S.A., Inc. (NPDES 20923)  
Pollutants: Industrial wastes from Honolulu main plant  
Discharge: Emergency (0)

Source: Chevron U.S.A., Inc. (NPDES 20931)  
Pollutants: Industrial wastes from Honolulu Harbor  
Discharge: Emergency (0)

Source: Gasco, Inc. (NPDES 35)  
Pollutants: Industrial wastes including suspended solids, settleable solids, oil, grease  
Discharge: Emergency (0)

Source: Honolulu Shipyard (NPDES 20753)  
Pollutants: Industrial wastes including suspended solids, settleable solids, lead, chromium, arsenic, copper, zinc, mercury, tin, cadmium  
Discharge: Emergency (0)

**Moanalua--Continued**

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Source: Ke'ehi Marine Center (NPDES 20664)

Pollutants: Industrial wastes

Discharge: Emergency (0)

Source: Pacific Resources Terminal, Inc. (NPDES 663)

Pollutants: Industrial wastes including suspended solids, settleable solids, lead, oil, grease

Discharge: Emergency (0)

Source: Shell Oil Company (NPDES 582)

Pollutants: Industrial wastes including settleable solids, suspended solids, lead, oil, grease

Discharge: Emergency (0)

Source: Hickam Golf Course

Pollutants: Fertilizer and pesticide residue and runoff

Discharge: Non-point Source

Source: Nonpoint Urban Runoff

Pollutants: Stormwater runoff may contain elevated levels of petroleum products, heavy metals, fine sediments

Discharge: Non-point Source





### Appendix A.3.1 Habitat Description of Ke'ehi Lagoon

---

Site:	Ke'ehi Lagoon	Lat.:	21°19'10"
Island:	O'ahu	Long.:	157°54'30"
Sector:	Honolulu, 01	El.:	20-40 ft
System:	Moanalua (04)	Approx. Area/Length:	340.7 acres

#### Site Description:

Ke'ehi Lagoon is located on the southern shore of the island of O'ahu, Hawaii. The lagoon is a product of planned alterations during WWII of a fringing coral reef lagoon. The lagoon today is approximately triangular in shape with the entrance to the lagoon extending east-west from Sand Island to Ahua Point (Bogost 1976).

This lagoon consists of tidal flats, shallow water, and small islands with a total area of about 450 acres on the leeward coast near the Honolulu International Airport. The area is presently used by stilts for feeding and resting. Management of the area as a sanctuary could enhance its value to stilts by preventing disturbance by people and dogs.

Ke'ehi Lagoon is a biologically very poor area in terms of species diversity and abundance of specimens. Animals characteristic of this region are, in addition to the micromolluscs, worms of various kinds living in the mud of the channels, and tubeworms living on dead coral (Harvey 1970).

Ke'ehi Lagoon is located on O'ahu's southern coastal plain, leeward of the Koolau mountain range. These leeward lowlands are characterized by abundant sunshine, the persistence of trade winds, equable day-to-day temperatures, and few severe storms.

#### Sensitivity Rating:

	Ba12wm
Main Water Source:	B Not Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Status:	2w Wildlife Protected
Wetland Avifauna:	m Migratory Fowl

#### Habitat Code:

	2-1c-3-4-2-4-3-3
Water Source:	2 Other
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	4 Recreation
Social Significance:	2 Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	3 Coastal
Water Quality:	3 Marine (> 15,000 mg/l Cl <sup>-</sup> )

#### Aquifer Code:

	30104116
Island:	3 O'ahu
Sector:	01 Honolulu
Aquifer System:	04 Moanalua
Aquifer Type (Hydrology):	1 Basal

**Ke'ehi Lagoon--Continued**

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Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		23321
Development Stage:	2	Potential Use
Utility:	3	Neither Drinking nor Ecologically Important
Salinity:	3	Moderate (1,000-5,000 mg/l Cl <sup>-</sup> )
Uniqueness:	2	Replaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30104121
Island:	3	O'ahu
Sector:	01	Honolulu
Aquifer System:	04	Moanalua
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank
Status Code:		11113
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	3	Low
U.S. Fish & Wildlife Service Wetland Code:		Marine/Intertidal/Unknown/Temporary Tidal/Euhaline/Tidal Irregularly Exposed (M2US2M)
		Upland [Non-Wetland] (U)
Geology:		1. Alluvial sediments over limestone and coastal plain sediments
Soil Conservation Service, U.S. Dept. of Agriculture 1975:		
Terrestrial Threatened or Endangered Plant(s):		No inventory available
Terrestrial Threatened or Endangered Animal(s):		Hawaiian Owl ( <i>Asio flammeus sandwichensis</i> ) Hawaiian Stilt ( <i>Himantopus mexicanus knudseni</i> )

## Ke'ehi Lagoon--Continued

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### Terrestrial Plant(s):

- Sandbur (*Cenchrus echinatus* L.)
- Bermuda grass (*Cynodon dactylon* (L.) Pers.)
- Pluchea (*Pluchea x fosbergii* Coop. and Gal.)
- Mesquite (*Prosopis pallida* (Humb. and Bonpl. ex Willd.) HBK.)
- Portia tree (*Thespesia populnea* (L.) Sol.)

### Aquatic Plant(s):

- Pickle-weed (*Batis maritima* L.)
- Oriental mangrove (*Bruguiera gymnorrhiza* Lam.)
- Seashore paspalum (*Paspalum vaginatum* Sw.)
- Hairy fleabane (*Pluchea odorata* (L.) Cass.)
- Red mangrove (*Rhizophora mangle* L.)
- Sea purslane (*Sesuvium portulacastrum* L.)

### Terrestrial Animal(s):

- Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)
- Brown Booby (*Sula leucogaster plotus*)
- Cattle Egret (*Bubulcus ibis*)
- Common Myna (*Acridotheres tristis*)
- House Finch (*Carpodacus mexicanus*)
- House Sparrow (*Passer domesticus*)
- Japanese White-eye (*Zosterops japonicus*)
- Northern Mockingbird (*Mimus polyglottos*)
- Pomarine Jaeger (*Stercorarius pomarinus*)
- Red-crested Cardinal (*Paroaria coronata*)
- Rock Dove (*Columba livia*)
- Spotted Dove (*Streptopelia chinensis*)
- Zebra Dove (*Geopelia striata*)

### Aquatic Animal(s):

- Saddle Wrasse (*Thalassoma duperrey*)
- Belted Wrasse (*Stethojulis balteata*)
- Makimaki (*Arothron hispidus*)
- 'O'opu (*Vitraria clarescens* Jordan and Evermann)
- 'O'opu 'alamo'o (*Lentipes concolor*)
- 'O'opu nakea (*Awaous stamineus*)
- 'O'opu naniha (*Awaous genivittatus*)
- 'O'opu nopili (*Sicydium stimsonii*)
- Striped Mullet (*Mugil cephalus* L.)
- Bluespine Unicornfish (*Naso unicornis*)
- White Branded Surgeon (*Acanthurus leucopareius*)
- Surgeonfish (*Acanthurus sandvicensis*)

## Ke'ehi Lagoon--Continued

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Hawaiian Surgeon (*Acanthurus dussumieri*)  
 Lemon Butterfly (*Chaetodon miliaris*)  
 Bluestripe Butterfly (*Chaetodon fremblii*)  
 Rectangular Triggerfish (*Rhinecanthus rectangulus*)  
 Painted Triggerfish (*Rhinecanthus aculeatus*)  
 Hammerhead Shark (*Sphyrna lewini*)  
 Eagle Ray (*Aetobatus narinari*)  
 Brown Sting Ray (*Dasyatis hawaiiensis*)

### Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
 Ruddy Turnstone (*Arenaria interpres*)  
 Sanderling (*Calidris alba*)  
 Wandering Tattler (*Heteroscelus incanus*)

### Freshwater Origin:

1. Surface runoff, combined flood flow and base flow springs of basal water
2. Sediments

### Comments:

27% of Kalihi Stream channel is altered and is diverted in one area. Moanalua Stream channel is altered for 35% of its length.

### References:

- Bogost, M.S. 1976. Revised Environmental Impact Statement for the proposed disposal of solid waste bales in Ke'ehi Lagoon and the coastal waters of O'ahu. Prepared for Department of Public Works, City and County of Honolulu. 53 p. plus app.
- Harvey, G.W. 1970. Ke'ehi Lagoon ecological survey. Oceanic Institute, Makapu'u Ocean Center. 197 p.
- Hall, D.H. 1970. Use of agricultural chemicals and factors contributing to their transport to estuaries in Hawaii. Technical report no. 30, Water Resources Research Center, University of Hawaii, Honolulu. 44 p.
- State of Hawaii, Office of Environmental Quality Control. 1971. Report on Ke'ehi Lagoon and Waikiki Beach water quality. 30 p. plus app.
- Bathen, K.H. 1970. The circulation in Ke'ehi Lagoon, O'ahu, Hawaii, during July and August, 1968. Technical report no. 17, Hawaii Institute of Marine Biology, University of Hawaii, Honolulu. 26 p. plus maps.

**Ke'ehi Lagoon--Continued**

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- U.S. Fish and Wildlife Service. 1985. Recovery plan for the Hawaiian Waterbirds. Prepared for U.S. Fish and Wildlife Service, Portland, Oregon. 99 p.
- Timbol, A.S., and Maciolek, J.A. 1978. Stream channel modification in Hawaii. Part A: Statewide inventory of streams, habitat factors and associated biota. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 157 p.
- Berger, A.J. 1971. Ke'ehi Lagoon bird survey. Department of Zoology, University of Hawaii, Honolulu, Hawaii. 32 p.



### Appendix A.3.2 Habitat Description of Salt Lake

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Site:	Salt Lake	Lat.:	21°21'15"
Island:	O'ahu	Long.:	157°54'35"
Sector:	Honolulu, 01	El.:	0-20 ft
System:	Moanalua (04)	Approx. Area/Length:	212.4 acres

#### Site Description:

A remnant pond and marsh exist within a developed area between Pearl City and downtown Honolulu. Salt Lake has been highly modified but still supports coots and some stilts.

Abundant sunshine and equable temperatures characterize this area. Northeasterly trade winds predominate about 80% of the time with monthly mean velocities ranging from 10 to 20 mph. The persistence of the northeasterly trade winds results in moderate humidity.

Sensitivity Rating:		Ba12m3f
Main Water Source:	B	Not Groundwater
Habitat:	a	Natural
Endangered Species:	1	Observed
Wetland Avifauna:	2m	Migratory Fowl
Other Value:	3f	Sediment Trap
Habitat Code:		2-1b-3-4-5-3-1-3
Water Source:	2	Other
Habitat Origin/Development:	1b	Natural/Altered
Ecological Character:	3	Endangered Species + Migratory Birds
Present Activities:	4	Recreation
Social Significance:	5	Neither Historic nor Wildlife Protected
Physical Significance:	3	Sediment Trap + Flood Control
Wetland Type:	1	Pond
Water Quality:	3	Marine (> 15,000 mg/l Cl <sup>-</sup> )
Aquifer Code:		30104116
Island:	3	O'ahu
Sector:	01	Honolulu
Aquifer System:	04	Moanalua
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		23321
Development Stage:	2	Potential Use
Utility:	3	Neither Drinking nor Ecologically Important
Salinity:	3	Moderate (1,000-5,000 mg/l Cl <sup>-</sup> )
Uniqueness:	2	Replaceable

**Salt Lake--Continued**

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Vulnerability to Contamination: 1 High

Aquifer Code: 30104121  
 Island: 3 O'ahu  
 Sector: 01 Honolulu  
 Aquifer System: 04 Moanalua  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 1 Flank

Status Code: 11113  
 Development Stage: 1 Currently Used  
 Utility: 1 Drinking  
 Salinity: 1 Fresh (< 250 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 3 Low

**U.S. Fish & Wildlife Service Wetland Code:**

Lacustrine/Limnetic/Open Water-Unknown Bottom/Non-Tidal  
 Permanent/Excavated (L1OWHx)

Palustrine/Emergent/Persistent/Non-Tidal Seasonal (PEM1C)

Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent/ Excavated  
 (POWHx)

**Geology:**

1. Salt Lake crater tuff of the Honolulu volcanic series
2. Tuff is poorly permeable

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

FL (Fill land mixed)

MdB (Makalapa clay, Typic Chromusterts)  
 2-6% slopes

MdC (Makalapa clay, Typic Chromusterts)  
 6-12% slopes

MdD (Makalapa clay, Typic Chromusterts)  
 12-20% slopes

rRK (Rock land)



## Salt Lake--Continued

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### Terrestrial Threatened or Endangered Plant(s):

No inventory available

### Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)  
 Hawaiian Duck (*Anas wyvilliana*)  
 Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
 Hawaiian Stilt (*Himantopus mexicanus knudseni*)

### Terrestrial Plant(s):

Mesquite (*Prosopis pallida* (Humb. and Bonpl. ex Willd.) HBK.)  
 Portia tree (*Thespesia populnea* (L.) Sol.)  
 Morning-glory (*Ipomoea congesta* R. Br.)  
 Indian marsh fleabane (*Pluchea indica* (L.) Less.)

### Aquatic Plant(s):

Pickle-weed (*Batis maritima* L.)  
 California grass (*Brachiaria mutica* (Forsk.) Stapf)  
 Day flower (*Commelina diffusa* Burm. f.)  
 Water purslane (*Ludwigia palustris* (L.) Ell.)  
 Cattail (*Typha angustata* Bory & Chau.)

### Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
 Cattle Egret (*Bubulcus ibis*)

### Aquatic Animal(s):

No inventory available

### Migratory Animal(s):

American Wigeon (*Anas americana*)  
 Bonaparte's Gull (*Larus philadelphia*)  
 Bufflehead (*Bucephala albeola*)  
 Glaucous Gull (*Larus hyperboreus*)  
 Lesser Golden-Plover (*Pluvialis dominica fulva*)  
 Lesser Scaup (*Aythya affinis*)  
 Mallard (*Anas platyrhynchos*)  
 Northern Pintail (*Anas acuta*)  
 Ring-billed Gull (*Larus delawarensis*)  
 Ruddy Turnstone (*Arenaria interpres*)  
 Sanderling (*Calidris alba*)  
 Wandering Tattler (*Heteroscelus incanus*)

**Salt Lake--Continued**

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**Freshwater Origin:**

1. Surface runoff from drainage area
2. Closed basin of nearly impermeable tuff; poor subsurface drainage

**Comments:****References:**

Wilson Okamoto & Associates, Inc. 1979. Environmental Impact Statement for the Salt Lake District Park. Prepared for the Department of Parks and Recreation, City and County of Honolulu. 136 p. plus app.

U.S. Fish and Wildlife Service. 1985. Recovery plan for the Hawaiian Waterbirds. Prepared for U.S. Fish and Wildlife Service, Portland, Oregon. 99 p.

### Appendix A.3.3 Habitat Description of Reef Runway

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Site:	Reef Runway	Lat.:	21°18'40"
Island:	O'ahu	Long.:	157°56'00"
Sector:	Honolulu, 01	El.:	20-40 ft
System:	Moanalua (04)	Approx. Area/Length:	792.0 acres

#### Site Description:

This is a coastal wetland which surrounds the fringe area of the reef runway.

Sensitivity Rating:	Bb2m
Main Water Source:	B Not Groundwater
Habitat:	b Artificial
Wetland Avifauna:	2m Migratory Fowl
Habitat Code:	2-2-2-5-5-4-3-3
Water Source:	2 Other
Habitat Origin/Development:	2 Artificial
Ecological Character:	2 Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	3 Coastal
Water Quality:	3 Marine (> 15,000 mg/l Cl <sup>-</sup> )
Aquifer Code:	30104116
Island:	3 O'ahu
Sector:	01 Honolulu
Aquifer System:	04 Moanalua
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	6 Sedimentary
Status Code:	23321
Development Stage:	2 Potential Use
Utility:	3 Neither Drinking nor Ecologically Important
Salinity:	3 Moderate (1,000-5,000 mg/l Cl <sup>-</sup> )
Uniqueness:	2 Replaceable
Vulnerability to Contamination:	1 High
Aquifer Code:	30104121
Island:	3 O'ahu
Sector:	01 Honolulu
Aquifer System:	04 Moanalua
Aquifer Type (Hydrology):	1 Basal

**Reef Runway--Continued**

---

Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank
Status Code:		11113
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	3	Low

U.S. Fish & Wildlife Service Wetland Code:  
Upland [Non-Wetland] (U)

Geology:

Soil Conservation Service, U.S. Dept. of Agriculture 1975:  
FL (Fill land mixed)

Terrestrial Threatened or Endangered Plant(s):  
No inventory available

Terrestrial Threatened or Endangered Animal(s):  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)

Terrestrial Plant(s):  
No inventory available

Aquatic Plant(s):  
No inventory available

Terrestrial Animal(s):  
No inventory available

Aquatic Animal(s):  
No inventory available

Migratory Animal(s):  
Lesser Golden-Plover (*Pluvialis dominica (fulva)*)

Freshwater Origin:

Comments:

**Reef Runway--Continued**

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## References:

U.S. Fish and Wildlife Service. 1985. Recovery plan for the Hawaiian Waterbirds. Prepared for U.S. Fish and Wildlife Service, Portland, Oregon. 99 p.



**Appendix A.4 System-Wide Characteristics of Ecologically Sensitive Habitats,  
Aquifers of Honolulu Sector, Waialae System**

---

Aquifer System: Waialae (05)

Aquifer Sector: Honolulu (01)

Island: O'ahu (3)

Water Wells in Aquifer System (Div. of Water and Land Development 1984):

Disposal	-	Domestic	-	Industrial	-
Irrigation	3	Lost	2	Municipal	3
Observation	4	Other	12	Recharge	-
Sealed	3	Unused	12	Unknown	-

(Department of Health 1987):

Drinking	-
Other	-

Total Number of Injection Wells: -

Water Wells or Sampling Sites Once Contaminated with DBCP, EDB or TCP  
(Water Resources Research Center 1985):

None

Potential Pollutant Sources and Pollutants (see Fig. 2):

Source: Nonpoint

Pollutants: Stormwater runoff may contain elevated levels of petroleum products,  
heavy metals, and fine sediments

Discharge: Non-point Source

Source: Agricultural Farms

Pollutants: Insecticide Cygon and herbicide VegeDex

Discharge: Non-point Source





### Appendix A.4.1 Habitat Description of Paiko Lagoon

---

Site:	Paiko Lagoon	Lat.:	21°17'09"
Island:	O'ahu	Long.:	157°43'38"
Sector:	Honolulu, 01	El.:	0-20 ft
System:	Waialae (05)	Approx. Area/Length:	29.8 acres

#### Site Description:

Paiko Lagoon was formerly managed as a coastal fishpond. A freshwater spring feeds a small private pond near the lagoon and Kuliouou Stream drains into the mouth of the lagoon through a channelized outlet. Water level in the lagoon fluctuates with the tides, periodically exposing extensive saline mudflats. A flat, sand-covered reef outside the peninsula is also exposed by low tides. The maximum depth of water over the mudflat in the lagoon is 0.5 m to 0.7 m.

The peninsula supports a variety of native and exotic plants including pickle-weed, koa haole, pluchea, kiawe, ilima, and milo. Mangrove has encroached on the inland shore of the peninsula and threatens to spread if not adequately controlled. Much of the inland border of the pond is surrounded by homes.

The area is characterized by a relatively arid climate. Annual precipitation is generally less than 30 in. Temperatures are comparable to neighboring coastal areas typically ranging from 70-90 °F throughout the day. Northeasterly trade winds predominate throughout the year.

Sensitivity Rating:	Ba12wm3f
Main Water Source:	B Not Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Status:	2w Wildlife Protected
Wetland Avifauna:	m Migratory Fowl
Other Value:	3f Sediment Trap
Habitat Code:	2-1c-3-5-2-3-3-4
Water Source:	2 Other
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	2 Wildlife Protected
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	3 Coastal
Water Quality:	4 Combination
Aquifer Code:	30105116
Island:	3 O'ahu
Sector:	01 Honolulu
Aquifer System:	05 Waialae

**Paiko Lagoon--Continued**

---

Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 1 Unconfined  
 Aquifer Type (Geology): 6 Sedimentary

Status Code: 23421  
 Development Stage: 2 Potential Use  
 Utility: 3 Neither Drinking nor Ecologically Important  
 Salinity: 4 High (5,000-15,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 2 Replaceable  
 Vulnerability to Contamination: 1 High

Aquifer Code: 30105121  
 Island: 3 O'ahu  
 Sector: 01 Honolulu  
 Aquifer System: 05 Waialae  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 1 Flank

Status Code: 21113  
 Development Stage: 2 Potential Use  
 Utility: 1 Drinking  
 Salinity: 1 Fresh (< 250 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 3 Low

U.S. Fish & Wildlife Service Wetland Code:  
 Marine/Subtidal/Reef/Coral/Tidal Subtidal (M1RF1L)

Geology:

Soil Conservation Service, U.S. Dept. of Agriculture 1975:  
 JaC (Jaucas sand, Typic Ustipsamments)  
 0-15% slopes

Terrestrial Threatened or Endangered Plant(s):  
 No inventory available

Terrestrial Threatened or Endangered Animal(s):  
 Hawaiian Stilt (*Himantopus mexicanus knudseni*)

Terrestrial Plant(s):  
 Koa haole (*Leucaena leucocephala* (Lam.) deWit)  
 Pluchea (*Pluchea x fosbergii* Coop. and Gal.)

## Paiko Lagoon--Continued

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Mesquite (*Prosopis pallida* (Humb. and Bonpl. ex Willd.) HBK.)  
 Sida (*Sida acuta* var. *carpinifolia* Brum. f.)  
 'Ilima (*Sida fallax* Walp.)  
 Portia tree (*Thespesia populnea* (L.) Sol.)

### Aquatic Plant(s):

Pickle-weed (*Batis maritima* L.)  
 Oriental mangrove (*Bruguiera gymnorrhiza* Lam.)  
 Hairy fleabane (*Pluchea odorata* (L.) Cass.)

### Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
 Common Myna (*Acridotheres tristis*)  
 House Finch (*Carpodacus mexicanus*)  
 House Sparrow (*Passer domesticus*)  
 Japanese White-eye (*Zosterops japonicus*)  
 Red-crested Cardinal (*Paroaria coronata*)  
 Rock Dove (*Columba livia*)  
 Spotted Dove (*Streptopelia chinensis*)  
 Zebra Dove (*Geopelia striata*)  
 Mongoose (*Herpestes auropunctatus*)

### Aquatic Animal(s):

Bonefish (*Albula vulpes*)  
 Barracuda (*Sphyrnaena barracuda* (Walbaum))  
 Milkfish (*Chanos chanos* (Forsk))  
 Tilapia (*Tilapia mossambica*)  
 'O'opu (*Vitraria clarescens* Jordan and Evermann)  
 'O'opu 'alamo'o (*Lentipes concolor*)  
 'O'opu nakea (*Awaous stamineus*)  
 'O'opu naniha (*Awaous genivittatus*)  
 'O'opu nopili (*Sicydium stimsonii*)  
 Sailfin Molly (*Poecilia latipinna* (Lesueur))  
 Slender Lizard Fish (*Saurida gracilis* (Quoy and Gaimard))  
 Striped Mullet (*Mugil cephalus* L.)  
 Surgeonfish (*Acanthurus sandvicensis*)

### Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
 Mallard (*Anas platyrhynchos*)  
 Ruddy Turnstone (*Arenaria interpres*)  
 Sanderling (*Calidris alba*)  
 Wandering Tattler (*Heteroscelus incanus*)

**Paiko Lagoon--Continued**

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**Freshwater Origin:**

1. Local surface runoff; small amount of basal groundwater
2. Shallow alluvium

**Comments:****References:**

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.
- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
- Thomas, K. 1973. A contribution to the ecology and distribution of annelids in Paiko Lagoon, O'ahu. Master thesis (Zoology), University of Hawaii, Honolulu. 109 p.

## Appendix A.4.2 Habitat Description of Kuapa Pond

---

Site:	Kuapa Pond	Lat.:	21°17'30"
Island:	O'ahu	Long.:	157°42'20"
Sector:	Honolulu, 01	El.:	0-20 ft
System:	Waialae (05)	Approx. Area/Length:	262.2 acres

### Site Description:

Kuapa Pond in southeastern O'ahu was a large mullet pond in what had once been a bay lying between southeasterly ridges of the Koolau Range and Koko Head, a youthful tuff cone. Until the 1930s the pond was separated from the ocean by only a narrow beach ridge. The beach strip was then widened when a highway was built along it. The pond has now been reduced by dredging a series of channels separated by points and islands, which are rapidly being developed as a residential district, and the entrance has been enlarged for small boat navigation and drainage. Both the natural lands and the filled lands bordering the pond, as well as lands extending up four short valleys in the Koolau Range tributary to the pond, are rapidly filling with residences. The piggeries in the two westernmost tributary valleys and the truck farms are now displaced.

The freshwater supply of the pond area is derived from rainfall in the area, freshet flows of the short intermittent tributary streams, and basal spring flow.

The area is characterized by a relatively arid climate, with annual precipitation generally less than 30 in. Temperatures are comparable to neighboring coastal areas typically ranging from 70-90 °F throughout the day. Northeasterly trade winds predominate throughout the year.

Sensitivity Rating:		Ba1
Main Water Source:	B	Not Groundwater
Habitat:	a	Natural
Endangered Species:	1	Observed
Habitat Code:		2-1b-1-4-5-4-1-3
Water Source:	2	Other
Habitat Origin/Development:	1b	Natural/Altered
Ecological Character:	1	Endangered Species
Present Activities:	4	Recreation
Social Significance:	5	Neither Historic nor Wildlife Protected
Physical Significance:	4	Neither Sediment Trap nor Flood Control
Wetland Type:	1	Pond
Water Quality:	3	Marine (> 15,000 mg/l Cl <sup>-</sup> )
Aquifer Code:		30105116
Island:	3	O'ahu
Sector:	01	Honolulu
Aquifer System:	05	Waialae
Aquifer Type (Hydrology):	1	Basal

**Kuapa Pond--Continued**

---

Aquifer Type (Hydrology): 1 Unconfined  
 Aquifer Type (Geology): 6 Sedimentary

Status Code: 23421  
 Development Stage: 2 Potential Use  
 Utility: 3 Neither Drinking nor Ecologically Important  
 Salinity: 4 High (5,000-15,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 2 Replaceable  
 Vulnerability to Contamination: 1 High

Aquifer Code: 30105121  
 Island: 3 O'ahu  
 Sector: 01 Honolulu  
 Aquifer System: 05 Waialae  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 1 Flank

Status Code: 21113  
 Development Stage: 2 Potential Use  
 Utility: 1 Drinking  
 Salinity: 1 Fresh (< 250 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 3 Low

**U.S. Fish & Wildlife Service Wetland Code:**

Estuarine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal (E1OWL)

Estuarine/Intertidal/Scrub-Shrub/Broad-Leaved Evergreen Tidal Regular (E2SS3N)

Marine/Intertidal/Tidal Unknown/Tidal Temporary Tidal/ Euhaline/Tidal Regular (M2US2N)

Upland [Non-Wetland] (U)

**Geology:**

1. Sediments overlying pyroclastics of Honolulu volcanic series
2. Pyroclastics poorly permeable

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

FL (Fill land mixed)

Kfb (Kaloko clay, noncalcareous variant, Typic Calciaquolls)

## Kuapa Pond--Continued

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KsB (Koko silt loam, Ustollic Eutrandepts)  
2-6% slopes

LuA (Lualualei stony clay, Typic Chromusterts)  
0-2% slopes

Terrestrial Threatened or Endangered Plant(s):  
No inventory available

Terrestrial Threatened or Endangered Animal(s):  
Hawaiian Owl (*Asio flammeus sandwichensis*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)

Terrestrial Plant(s):  
No inventory available

Aquatic Plant(s):  
Pickle-weed (*Batis maritima* L.)  
Red mangrove (*Rhizophora mangle* L.)

Terrestrial Animal(s):  
No inventory available

Aquatic Animal(s):  
No inventory available

Migratory Animal(s):  
No inventory available

Freshwater Origin:  
1. Local surface runoff; small amount of basal groundwater  
2. Shallow alluvium

Comments:

### References:

- Hall, D.H. 1970. Use of agricultural chemicals and factors contributing to their transport to estuaries in Hawaii. Technical report no. 30, Water Resources Research Center, University of Hawaii, Honolulu. 44 p.
- Cox, D.C., and Gordon, L.C. Jr. 1970. Estuarine pollution in the State of Hawaii. Technical report no. 31, Water Resources Research Center, University of Hawaii, Honolulu. 151 p.

**Kuapa Pond--Continued**

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Takemoto, A.H., Joeger, P.K., Mitchell, M.E.F., and Bareng, C.E. 1975. Historical/cultural essay report on the Kuapa Pond area. Prepared for the U.S. Army Corps of Engineers, Honolulu. 79 p.

De Ausen, T.T. 1966. Coastline ecosystem in O'ahu, Hawaii. Master thesis (Botany), University of Hawaii, Honolulu. 114 p. plus app.



### **Appendix A.4.3 Habitat Description of Queen's Beach Marsh**

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Site:	Queen's Beach Marsh	Lat.:	21°17'50"
Island:	O'ahu	Long.:	157°39'43"
Sector:	Honolulu, 01	El.:	0-20 ft
System:	Waialae (05)	Approx. Area/Length:	6.3 acres

#### **Site Description:**

Queen's Beach Marsh is a coastal inlet of two small estuaries, east of the Hawaii Kai Golf Course and south of Makapu'u Head. Mangroves line the eastern estuary and grow only in patches in the western estuary. The adjacent terrain is very rugged with large boulders dumped in the area from the Hawaii Kai development.

#### **Sensitivity Rating:**

	Ba2m
Main Water Source:	B Not Groundwater
Habitat:	a Natural
Wetland Avifauna:	2m Migratory Fowl

#### **Habitat Code:**

	2-1c-2-4-5-4-3-3
Water Source:	2 Other
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	2 Migratory Birds
Present Activities:	4 Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	3 Coastal
Water Quality:	3 Marine (> 15,000 mg/l Cl <sup>-</sup> )

#### **Aquifer Code:**

	30105116
Island:	3 O'ahu
Sector:	01 Honolulu
Aquifer System:	05 Waialae
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	6 Sedimentary

#### **Status Code:**

	23421
Development Stage:	2 Potential Use
Utility:	3 Neither Drinking nor Ecologically Important
Salinity:	4 High (5,000-15,000 mg/l Cl <sup>-</sup> )
Uniqueness:	2 Replaceable
Vulnerability to Contamination:	1 High

#### **Aquifer Code:**

	30105121
Island:	3 O'ahu
Sector:	01 Honolulu

**Queen's Beach Marsh--Continued**

---

Aquifer System:	05	Waialae
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank

Status Code:	21113
Development Stage:	2 Potential Use
Utility:	1 Drinking
Salinity:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1 Irreplaceable
Vulnerability to Contamination:	3 Low

U.S. Fish & Wildlife Service Wetland Code:  
Marine/Intertidal/Rocky Shore/Bedrock/Tidal Regular (M2RS1N)

Geology:

Soil Conservation Service, U.S. Dept. of Agriculture 1975:  
KsB (Koko silt loam, Ustollic Eutrandspts)  
2-6% slopes

rRK (Rock land)

Terrestrial Threatened or Endangered Plant(s):  
No inventory available

Terrestrial Threatened or Endangered Animal(s):  
No inventory available

Terrestrial Plant(s):  
Hairy abutilon (*Abutilon molle* Sweet)  
Perfume plant (*Acacia farnesiana* (L.) Willd.)  
Australian blackwood (*Acacia melanoxylon* R. Br.)  
Century plant (*Agave americana* L.)  
Sisal (*Agave sisalana* (Engelm.) Perrine)  
Ageratum (*Ageratum conyzoides* L.)  
Tree 'aloe (*Aloe arborescens* Mill.)  
'Aloe (*Aloe vera* L.)  
Khaki weed (*Alternanthera repens* (L.) O. Ktze.)  
Spiny amaranth (*Amaranthus spinosus* L.)  
Wilder grass (*Andropogon aristatus* Poir.)  
Mexican creeper (*Antigonon leptopus* H. and A.)  
Chinese violet (*Asystasia gangetica* (L.) T. Anders.)  
Australian salt bush (*Atriplex semibaccata* R. Br.)

## Queen's Beach Marsh--Continued

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- Philippine violet (*Barleria cristata* L.)  
 Hairy horseweed (*Bidens pilosa* L.)  
 Spiderling (*Boerhavia diffusa* Heimerl.)  
 Partridge pea (*Cassia leschenaultiana* DC.)  
 Common ironwood (*Casuarina equisetifolia* L.)  
 Sandbur (*Cenchrus echinatus* L.)  
 Keeled goosefoot (*Chenopodium carinatum* R. Br.)  
 Swollen finger grass (*Chloris inflata* Link.)  
 Butterfly pea (*Clitoria ternatea* L.)  
 Coconut tree (*Cocos nucifera* L.)  
 Bindweed (*Convolvulus arvensis* L.)  
 Rattle box (*Crotalaria incana* L.)  
 Sunn hemp (*Crotalaria juncea* L.)  
 Wild cucumber (*Cucumis dipsaceus* Ehrenb.)  
 Dodder (*Cuscuta sandwichiana* Choisy)  
 Taro patch fern (*Cyclosorus interruptus* (Wild.) H. Ito)  
 Bermuda grass (*Cynodon dactylon* (L.) Pers.)  
 Beach wiregrass (*Dactyloctenium aegyptium* (L.) Willd.)  
 Slender mimosa (*Desmanthus virgatus* (L.) Willd.)  
 Henry's crabgrass (*Digitaria henryi* Rendle)  
 Wiregrass (*Eleusine indica* (L.) Gaertn.)  
 Red pualele (*Emilia javanica* (Burm. f.) C. B. Robins)  
 Flora's paint brush (*Emilia sonchifolia* (L.) DC.)  
 Common coral tree (*Erythrina crista-galli* L.)  
 Beach spurge (*Euphorbia degeneri* var. *degeneri* Sherff)  
 Graceful spurge (*Euphorbia glomerifera* (Millsp.) L. C. Wheeler)  
 Mottled candlestick (*Euphorbia lactea* Haw.)  
 Prostrate spurge (*Euphorbia prostrata* Ait.)  
 Pencil tree (*Euphorbia tirucalli* L.)  
 Hawaiian cotton (*Gossypium sandvicense* Parl.)  
 Cotton (*Gossypium* sp.)  
 Nena (*Heliotropium anomalum* var. *argenteum* Gray)  
 Seaside heliotrope (*Heliotropium curassavicum* L.)  
 Pili (*Heteropogon contortus* (L.) Beauv.)  
 Night-blooming cereus (*Hylocereus undatus* (Haw.) Britt. and Rose)  
 Comb hyptis (*Hyptis pectinata* (L.) Poit)  
 Indigo (*Indigofera anil* L.)  
 Indigo (*Indigofera suffruticosa* Mill.)  
 Indigo (*Indigofera tinctoria* L.)  
 Hawaiian jacquemontia (*Jacquemontia sandwicensis* Gray)  
 Bryophyllum (*Kalanchoe crenata* Haw.)  
 Air plant (*Kalanchoe pinnatum* (Lam.) Pers.)  
 Lantana (*Lantana camara* L.)  
 Lion's tail (*Leonotis leonurus* (L.) R. Br.)

## Queen's Beach Marsh--Continued

- Pepper-grass (*Lepidium owaihiense* Cham. and Schlecht.)  
 Koa haole (*Leucaena leucocephala* (Lam.) deWit)  
 Nehe (*Lipochaeta integrifolia* Gray)  
 Nehe (*Lipochaeta lobata* (Gaud.) DC.)  
 Hawaiian wolfberry (*Lycium sandwicense* Gray)  
 False mallow (*Malvastrum coromandelianum* (L.) Garcke)  
 Hairy morning-glory (*Merremia aegyptia* (L.) Urban)  
 Tree heliotrope (*Messerschmidia argentea* (L. f.) Johnston)  
 Bastard sandalwood (*Myoporum sandwicense* (DC.) Gray)  
 Hawaiian nama (*Nama sandwicensis* A. Gray)  
 Wild tobacco (*Nicotiana glauca* Grah.)  
 Cochineal cactus (*Nopalea cochenillifer* (L.) Salm-Dyck)  
 Basil (*Ocimum basilicum* L.)  
 White-fruited panini (*Opuntia megacantha* Salm-Dyck)  
 Yellow wood-sorrel (*Oxalis corniculata* L.)  
 Guinea grass (*Panicum maximum* Jacq.)  
 Scarlet fruited passion flower (*Passiflora foetida* L.)  
 Wild bean (*Phaseolus lathyroides* L.)  
 Spurflower (*Plectranthus parviflorus* Willd.)  
 Pluchea (*Pluchea x fosbergii* Coop. and Gal.)  
 Native yellow purslane (*Portulaca lutea* Soland. ex Forst. f.)  
 Purslane (*Portulaca oleracea* L.)  
 Portulaca (*Portulaca pilosa* L.)  
 Mesquite (*Prosopis pallida* (Humb. and Bonpl. ex Willd.) HBK.)  
 Picridium (*Reichardia picroides* (L.) Roth)  
 Natal grass (*Rhynchelytrum repens* (Willd.) C. E. Hubb.)  
 Castor bean (*Ricinus communis* L.)  
 Bowstring hemp (*Sansevieria trifasciata* Prain)  
 Mountain naupaka (*Scaevola gaudichaudiana* Cham.)  
 Beach naupaka (*Scaevola taccada* (Gaertn.) Roxb.)  
 Ma'oli'oli (*Schiedea globosa* Mann)  
 Ma'oli'oli (*Schiedea pubescens* var. *purpurascens* Sherff)  
 Bristly foxtail (*Setaria verticillata* (L.) Beauv.)  
 Sida (*Sida acuta* var. *carpinifolia* Brum. f.)  
 'Ilima (*Sida fallax* Walp.)  
 Prickly sida (*Sida spinosa* L.)  
 Sow thistle (*Sonchus oleraceus* L.)  
 Johnson grass (*Sorghum halepense* (L.) Pers.)  
 Jamaica vervain (*Stachytarpheta jamaicensis* (L.) Vahl)  
 Carrion flower (*Stapelia nobilis* N.E. Br.)  
 Portia tree (*Thespesia populnea* (L.) Sol.)  
 Yellow oleander (*Thevetia peruviana* (Pers.) K. Schum.)  
 Large flowered caltrop (*Tribulus cistoides* L.)  
 Sourgrass (*Trichachne insularis* (L.) Nees)

## Queen's Beach Marsh--Continued

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Golden crown-beard (*Verbesina encelioides* (Cav.) Benth. and Hook.)  
 Ironweed (*Vernonia cinerea* (L.) Less.)  
 Vetch (*Vicia* sp.)  
 Beach pea (*Vigna marina* (Burm.) Merr.)  
 Hi'aloa (*Waltheria americana* L.)  
 Wedelia (*Wedelia trilobata* (L.) Hitchc.)  
 Cocklebur (*Xanthium saccharatum* Wallr.)  
 Beach morning-glory (*Ipomoea brasiliensis* (L.) Sweet)  
 Morning-glory (*Ipomoea congesta* R. Br.)  
 Koali (*Ipomoea obscura* (L.) Ker-Gawl.)  
 Sedge (*Fimbristylis cymosa* Sensu. Hbd.)  
 Hairy abutilon (*Abutilon molle* Sweet)

### Aquatic Plant(s):

Pickle-weed (*Batis maritima* L.)  
 California grass (*Brachiaria mutica* (Forsk.) Stapf)  
 Oriental mangrove (*Bruguiera gymnorhiza* Lam.)  
 Day flower (*Commelina diffusa* Burm. f.)  
 Primrose willow (*Ludwigia octovalvis* (Jacq.) Raven)  
 Indian pluchea (*Pluchea indica* (L.) Less.)  
 Hairy fleabane (*Pluchea odorata* (L.) Cass.)  
 Red mangrove (*Rhizophora mangle* L.)  
 Beach dropseed (*Sporobolus virginicus* (L.) Kunth)

### Terrestrial Animal(s):

No inventory available

### Aquatic Animal(s):

No inventory available

### Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)

### Freshwater Origin:

### Comments:

### References:

Funk, E. 1984. Queen's Beach Park feasibility study/botanical survey. Department of Parks and Recreation, City and County of Honolulu. 29 p.



**Appendix B.1 System-Wide Characteristics of Ecologically Sensitive Habitats,  
Aquifers of Pearl Harbor Sector, Waimalu System**

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**Aquifer System:** Waimalu (01)

**Aquifer Sector:** Pearl Harbor (02)

**Island:** O'ahu (3)

**Water Wells in Aquifer System (Div. of Water and Land Development 1984):**

Disposal	-	Domestic	7	Industrial	7
Irrigation	7	Lost	7	Municipal	40
Observation	14	Other	-	Recharge	-
Sealed	76	Unused	12	Unknown	37

**(Department of Health 1987):**

Drinking	-
Other	-

**Total Number of Injection Wells:** -

**Water Wells or Sampling Sites Once Contaminated with DBCP, EDB or TCP  
(Water Resources Research Center 1985):**

None

**Potential Pollutant Sources and Pollutants (see Fig. 2):**

**Source:** O'ahu Sugar Company, Inc. (NPDES 20699)

**Pollutants:** Agricultural runoff

**Discharge:** Emergency (0)

**Source:** U.S. Navy, Public Works Center (NPDES 110230)

**Pollutants:** Industrial wastes from shipyard drydocks 1, 2, 3, & 4

**Discharge:** 6.1 mgd

**Source:** U.S. Navy, Public Works Center (NPDES 1121016)

**Pollutants:** Industrial wastes from Air Compressor Plant, Bldg. 841

**Discharge:** Emergency (0)

**Source:** U.S. Navy, Public Works Center (NPDES 1120907)

**Pollutants:** Industrial wastes from Air Compressor Plant, Bldg. 826

**Discharge:** 160,000 gpd

**Source:** C & H Sugar Company (NPDES 281)

**Pollutants:** Industrial wastes

**Discharge:** 2.9 mgd

**Source:** Lone Star Industries, Inc. (NPDES 558)

**Pollutants:** Industrial wastes from Halawa Batch Plant #151

**Discharge:** Emergency (0)

**Waimalu--Continued**

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**Source:** Prestressed Concrete (NPDES 20320)  
**Pollutants:** Industrial wastes  
**Discharge:** Emergency (0)

**Source:** U.S. Navy, Public Works Center (NPDES 1121105)  
**Pollutants:** Industrial wastes including suspended solids, oil and grease into Pearl Harbor  
**Discharge:** 400,000 gpd

**Source:** Naval Supply Center, Pearl City Fuel Annex (NPDES 647)  
**Pollutants:** Industrial wastes including oil and grease into Kaiapo Canal  
**Discharge:** Emergency (0)

**Source:** Naval Submarine Base (NPDES 1121032)  
**Pollutants:** Industrial wastes including suspended solids, settleable solids, lead, chromium, arsenic, copper, zinc, mercury, tin and cadmium  
**Discharge:** Emergency (0)

**Source:** Agricultural Runoff  
**Pollutants:** Chlorinated hydrocarbons, Dalapon, Hyvar X, nitrates, and phosphates  
**Discharge:** Non-point Source

**Source:** Hawaiian Electric Company, Inc. (NPDES 604)  
**Pollutants:** Energy generating wastes from Waiiau Power Station  
**Discharge:** 545,152 mgd

**Source:** Stormwater Runoff  
**Pollutants:** Petroleum products, heavy metals, and fine sediments  
**Discharge:** Non-point Source

**Source:** Hickam Air Field and Military Base  
**Pollutants:** Wastewater and petroleum products  
**Discharge:** Non-point Source



### Appendix B.1.1 Habitat Description of Pearl Harbor East Loch

Site:	Pearl Harbor East Loch	Lat.:	21°23'15"
Island:	O'ahu	Long.:	157°57'30"
Sector:	Pearl Harbor, 02	El.:	0-40 ft
System:	Waimalu (01)	Approx. Area/Length:	2.5 miles

#### Site Description:

Pearl Harbor in southern O'ahu is a nearly level coastal plain formed by the submergence of ancient river valleys. Soils are poorly drained deltaic sediments and lie on layers of muck or peat and on reef deposits.

The habitat associated with wetland areas of Pearl Harbor supports an unusual variety of waterbirds and exotic birds including game species, cage birds, and long-established varieties widely distributed throughout the islands. Pearl Harbor has been the location of more sightings of rare stragglers and unusual migrants than any other wetland on O'ahu. These sightings include little blue heron, black tern, least tern, ring-billed gull, Franklin's gull, Bonaparte's gull, osprey, and peregrine falcon.

Most of the site is covered by dense growths of American mangrove which reaches 40 ft in height. Inland, small agricultural wetlands occur in spring-fed patches of land. These are characterized by California grass, great bulrush, kamole, cultivated taro, watercress, and ong-choi (Elliott 1981).

The climate of the Pearl Harbor area is semi-tropical with average temperatures in the 70s. The prevailing winds vary from 10 to 20 mph and originate from the northeast. The annual precipitation for this area is about 30 in.

Sensitivity Rating:	Ba12wm
Main Water Source:	B Not Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Status:	2w Wildlife Protected
Wetland Avifauna:	m Migratory Fowl
Habitat Code:	2-1c-1-5-5-4-3-3
Water Source:	2 Other
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	1 Endangered Species
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	3 Coastal
Water Quality:	3 Marine (> 15,000 mg/l Cl <sup>-</sup> )
Aquifer Code:	30201116
Island:	3 O'ahu
Sector:	02 Pearl Harbor

**Pearl Harbor East Loch--Continued**

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Aquifer System:	01	Waimalu
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary

Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High

Aquifer Code:		30201121
Island:	3	O'ahu
Sector:	02	Pearl Harbor
Aquifer System:	01	Waimalu
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank

Status Code:		12212
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	2	Moderate

**U.S. Fish & Wildlife Service Wetland Code:**

Estuarine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal (E1OWL)

Estuarine/Intertidal/Forested/Broad-Leaved Evergreen/Tidal Regular (E2FO3N)

Estuarine/Intertidal/Scrub-Shrub/Broad-Leaved Evergreen/ Tidal Regular (E2SS3N)

**Geology:**

1. Alluvial sediments over limestone and coastal plain sediments

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

FL (Fill land mixed)

HxA (Honouliuli clay, Typic Chromusterts)

0-2% slopes

## Pearl Harbor East Loch--Continued

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KmbA (Keaau clay, Typic Tropaquepts; saline)  
0-2% slopes

Ph (Pearl Harbor clay, Typic Tropaquepts)

WIB (Waialua stony silty clay, Vertic Haplustolls)  
3-8% slopes

WzC (Waipahu silty clay, Vertic Ustropepts)  
6-12% slopes

rRK (Rock land)

Terrestrial Threatened or Endangered Plant(s):  
No inventory available

Terrestrial Threatened or Endangered Animal(s):  
Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Duck (*Anas wyvilliana*)  
Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)

Terrestrial Plant(s):  
No inventory available

Aquatic Plant(s):  
Water fern (*Azolla filiculoides* Lam.)  
California grass (*Brachiaria mutica* (Forsk.) Stapf)  
Red mangrove (*Rhizophora mangle* L.)  
California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)  
Great bulrush (*Scirpus validus* Vahl)

Terrestrial Animal(s):  
Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
Cattle Egret (*Bubulcus ibis*)  
Common Myna (*Acridotheres tristis*)  
Japanese White-eye (*Zosterops japonicus*)  
Nutmeg Mannikin (*Lonchura punctulata*)  
Spotted Dove (*Streptopelia chinensis*)  
Zebra Dove (*Geopelia striata*)

Aquatic Animal(s):  
Ladyfish (*Elops hawaiiensis* Regan)  
Barracuda (*Sphyraena barracuda* (Walbaum))

## Pearl Harbor East Loch--Continued

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Electrid (*Eleotris sandwicensis* *Vaillant and Sauvage*)  
 Whitespot Goatfish (*Parupeneus porphyreus*)  
 Green Swordtail (*Xiphophorus helleri* (*Heckel*))  
 Silver Perch (*Kuhlia sandwicensis*)  
 Milkfish (*Chanos chanos* (*Forskal*))  
 Mosquitofish (*Gambusia affinis* (*Baird and Girard*))  
 Tilapia (*Tilapia mossambica*)  
 'O'opu (*Vitraria clarescens* *Jordan and Evermann*)  
 'O'opu 'alamo'o (*Lentipes concolor*)  
 'O'opu nakea (*Awaous stamineus*)  
 'O'opu naniha (*Awaous genivittatus*)  
 'O'opu nopili (*Sicydium stimsonii*)  
 Striped Mullet (*Mugil cephalus* *L.*)  
 Hammerhead Shark (*Sphyrna lewini*)

### Migratory Animal(s):

Sanderling (*Calidris alba*)  
 Wandering Tattler (*Heteroscelus incanus*)

### Freshwater Origin:

1. Surface runoff, combined flood flow and base flow springs of basal water
2. Sediments

### Comments:

Aiea, Halawa, Kalauao, and Waimalu streams are moderately degraded; between 1 and 25% of total channel length is altered.

### References:

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- Elliott, M.E., and Hall, E.M. 1977. Wetlands and wetland vegetation of Hawaii. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 344 p.

**Pearl Harbor East Loch--Continued**

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## **Appendix B.1.2 Habitat Description of Fort Kamehameha**

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Site:	Fort Kamehameha	Lat.:	21°19'12"
Island:	O'ahu	Long.:	157°57'00"
Sector:	Honolulu, 01; Pearl Harbor, 02	El.:	0-40 ft
System:	Moanalua (04); Waimalu (01)	Approx. Area/Length:	67.4 acres

### **Site Description:**

This area is a coastal wetland, subject to high intensity noise from the adjacent Honolulu International Airport. The Reef Runway adjoins the northern boundary of Fort Kamehameha and Hickam Golf Course is at its southern edge.

The area enjoys a dry equable climate throughout the spring, summer, and fall months. In the winter, it sometimes experiences regional storms. Fort Kamehameha receives only the most persistent tradewind showers generated in the Koolau mountains by orographic cooling.

The area north of the shoreline has been developed as a golf course. The topography is relatively flat. The golf course may contribute fertilizer and pesticide residues to the coastal waters. The southernmost portion of the wetland habitat runs parallel to the Reef Runway.

### **Sensitivity Rating:**

	Ba2m
Main Water Source:	B Not Groundwater
Habitat:	a Natural
Wetland Avifauna:	2m Migratory Fowl

### **Habitat Code:**

	2-1c-2-5-5-4-3-3
Water Source:	2 Other
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	2 Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	3 Coastal
Water Quality:	3 Marine (> 15,000 mg/l Cl <sup>-</sup> )

### **Aquifer Code:**

	30201116
Island:	3 O'ahu
Sector:	02 Pearl Harbor
Aquifer System:	01 Waimalu
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	6 Sedimentary

**Fort Kamehameha--Continued**

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Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30201121
Island:	3	O'ahu
Sector:	02	Pearl Harbor
Aquifer System:	01	Waimalu
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank
Status Code:		12212
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	2	Moderate
Aquifer Code:		30104116
Island:	3	O'ahu
Sector:	01	Honolulu
Aquifer System:	04	Moanalua
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		23321
Development Stage:	2	Potential Use
Utility:	3	Neither Drinking nor Ecologically Important
Salinity:	3	Moderate (1,000-5,000 mg/l Cl <sup>-</sup> )
Uniqueness:	2	Replaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30104121
Island:	3	O'ahu
Sector:	01	Honolulu
Aquifer System:	04	Moanalua
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank



## Fort Kamehameha--Continued

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Status Code: 11113  
 Development Stage: 1 Currently Used  
 Utility: 1 Drinking  
 Salinity: 1 Fresh (< 250 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 3 Low

U.S. Fish & Wildlife Service Wetland Code:  
 Estuarine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal (E1OWL)

Geology:

Soil Conservation Service, U.S. Dept. of Agriculture 1975:  
 FL (Fill land mixed)

MnC (Malama stony silty clay loam, Typic Tropofolists)  
 0-12% slopes

Terrestrial Threatened or Endangered Plant(s):  
 No inventory available

Terrestrial Threatened or Endangered Animal(s):  
 No inventory available

Terrestrial Plant(s):  
 No inventory available

Aquatic Plant(s):  
 Red mangrove (*Rhizophora mangle* L.)

Terrestrial Animal(s):  
 No inventory available

Aquatic Animal(s):  
 No inventory available

Migratory Animal(s):  
 Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
 Ruddy Turnstone (*Arenaria interpres*)  
 Wandering Tattler (*Heteroscelus incanus*)

Freshwater Origin:

**Fort Kamehameha--Continued**

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**Comments:**

A former landfill, (site 1) is located near Taxiway V and Kamakahi Street. The site was in operation from approximately 1942-1946 as the major on-base landfill. Site 1 contains heavy metal sludges from plating operations, small amounts of POL, solvents, paint wastes, and various other industrial wastes. It is assumed that the site contains only relatively moderate amounts of hazardous wastes, due to its being operational during WWII when a high premium was put on recycling of waste materials. Based on current waste generation, it is estimated that 1,200 gal of waste material were disposed into the landfill per year. This is equivalent to a total of 84 drums over the four-year life of the site.

**References:**

Dames & Moore. 1986. Installation restoration program phase II--confirmation/quantification stage 1. Prepared for Hickam Air Force Base, O'ahu, Hawaii. 28 p. plus app.

## Appendix B.2 System-Wide Characteristics of Ecologically Sensitive Habitats, Aquifers of Pearl Harbor Sector, Waiawa System

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Aquifer System: Waiawa (02)

Aquifer Sector: Pearl Harbor (02)

Island: O'ahu (3)

Water Wells in Aquifer System (Div. of Water and Land Development 1984):

Disposal	-	Domestic	22	Industrial	-
Irrigation	42	Lost	2	Municipal	10
Observation	3	Other	1	Recharge	-
Sealed	28	Unused	9	Unknown	13

(Department of Health 1987):

Drinking	-
Other	3

Total Number of Injection Wells: 2

Water Wells or Sampling Sites Once Contaminated with DBCP, EDB or TCP  
(Water Resources Research Center 1985):

2558-10	DBCP	TCP	
2800-01	DBCP	EDB	TCP
2800-02	DBCP	EDB	TCP
2800-03	DBCP	EDB	TCP
2800-04	DBCP	EDB	TCP
2859	DBCP		
2859-01	DBCP	EDB	TCP
2859-02	DBCP		

Potential Pollutant Sources and Pollutants (see Fig. 2):

Source: Agricultural Runoff  
 Pollutants: Chlorinated hydrocarbons, Dalapon, Hyvar X, nitrates, phosphates  
 Discharge: Non-point Source

Source: Abandoned Military Landfill Next To USFWS Refuge  
 Pollutants: PCBs and various heavy metals found in paints and photographic chemicals  
 Discharge: Non-point Source

Source: Stormwater Runoff  
 Pollutants: Petroleum products, heavy metals, and fine sediments  
 Discharge: Non-point Source

Source: O'ahu Sugar Company, Inc. (NPDES 20699)  
 Pollutants: Agricultural wastes  
 Discharge: Emergency (0)

**Waiawa--Continued**

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- Source: U.S. Navy, Public Works Center (NPDES 110086)  
Pollutants: Domestic wastes from Fort Kamehameha STP  
Discharge: 6.0 mgd
- Source: U.S. Navy, Public Works Center (NPDES 110230)  
Pollutants: Industrial wastes from Shipyard Drydocks 1, 2, 3, & 4  
Discharge: 6.1 mgd
- Source: U.S. Navy, Public Works Center (NPDES 1121016)  
Pollutants: Industrial wastes from Air Compressor Plant, Bldg. 841  
Discharge: Emergency (0)
- Source: U.S. Navy, Public Works Center (NPDES 1120907)  
Pollutants: Industrial wastes from Air Compressor Plant, Bldg. 826  
Discharge: 160,000 gpd
- Source: C & H Sugar Company (NPDES 281)  
Pollutants: Industrial wastes  
Discharge: 2.9 mgd
- Source: Lone Star Industries, Inc. (NPDES 558)  
Pollutants: Industrial wastes from Halawa Batch Plant #151  
Discharge: Emergency (0)
- Source: Prestressed Concrete (NPDES 20320)  
Pollutants: Industrial wastes  
Discharge: Emergency (0)
- Source: Marsh Drainage; Intermittent Flow  
Pollutants: Fecal coliform  
Discharge: Non-point Source
- Source: Kaipō Canal  
Pollutants: Fecal coliform  
Discharge: Non-point Source
- Source: Waiawa Stream  
Pollutants: Fecal coliform  
Discharge: Non-point Source
- Source: Naval Supply Center, Pearl City Fuel Annex (NPDES 647)  
Pollutants: Industrial wastes including oil and grease into Kaiapo Canal  
Discharge: Emergency (0)

**Waiawa--Continued**

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**Source:** U.S. Navy, Public Works Center (NPDES 1121105)  
**Pollutants:** Industrial wastes including suspended solids, oil and grease into Pearl Harbor  
**Discharge:** 400,000 gpd

**Source:** Naval Submarine Base (NPDES 1121032)  
**Pollutants:** Industrial wastes including suspended solids, settleable solids, lead, chromium, arsenic, copper, zinc, mercury, tin and cadmium  
**Discharge:** Emergency (0)



### **Appendix B.2.1 Habitat Description of Waiawa National Wildlife Refuge**

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Site:	Waiawa National Wildlife Refuge	Lat.:	21°23'30"
Island:	O'ahu	Long.:	157°59'07"
Sector:	Pearl Harbor, 02	El.:	20-40 ft
System:	Waiawa (02)	Approx. Area/Length:	54.1 acres

#### **Site Description:**

The Waiawa National Wildlife Refuge (WNWR) consists of a large pond, built in a low-lying area adjacent to a U.S. Navy landfill and the Middle Loch of Pearl Harbor. A 3.05 m (10 ft) high berm surrounds most of this wetland area. The single impoundment was divided into two sections by a 4.6 m (15 ft) wide dike which was used as a road. In early 1980, the eastern half of this central dike was subdivided into nesting islands, making the wetland a single pond. The southern half of this pond is shallow water, 0.03 to 0.15 m (1-6 in.) while the northern half is 6 to 1.2 m (2-4 ft) deep. The pond bottom in the northern section is below sea level. Water is pumped into the pond from nearby Waiawa Stream. The salinity of the water pumped into the refuge ranges from 5 ppt to 20 ppt depending on the stream flow and tidal influences. The potential for water pollution is great because Waiawa Stream drainage includes a heavily populated area, sugar cane fields and pineapple fields (U.S. Fish and Wildlife Service 1985).

The WNWR is composed almost entirely of exotic plants and animals. Along Waiawa Stream, mangrove and hau form dense thickets that harbor introduced mongooses, rats, and feral dogs and cats. On drier sites, between the impoundment and the stream, kiawe is the major tree. The salt tolerant plant pickle-weed is predominant as ground cover in open areas on moist sites and in the water (U.S. Fish and Wildlife Service 1985).

The most commonly seen birds in the exotic terrestrial habitats are common mynas, barred and spotted doves, common munia and house finches. Black-crowned night-herons, migratory ducks and shorebirds, and the four species of endangered waterbirds also frequent the area. The Pearl Harbor wetlands are used each winter by several hundred ducks, primarily pintails and Northern shovelers (U.S. Fish and Wildlife Service 1985).

Sensitivity Rating:	Ab12wm3f
Main Water Source:	A Groundwater
Habitat:	b Artificial
Endangered Species:	1 Observed
Wetland Status:	2w Wildlife Protected
Wetland Avifauna:	m Migratory Fowl
Other Value:	3f Sediment Trap

Habitat Code:	1-2-3-5-2-1-4-2
Water Source:	1 Groundwater
Habitat Origin/Development:	2 Artificial
Ecological Character:	3 Endangered Species + Migratory Birds

**Waiawa National Wildlife Refuge--Continued**

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Present Activities:	5	Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	2	Wildlife Protected
Physical Significance:	1	Sediment Trap
Wetland Type:	4	Marsh
Water Quality:	2	Brackish (250-15,000 mg/l Cl <sup>-</sup> )
Aquifer Code:		30202116
Island:	3	O'ahu
Sector:	02	Pearl Harbor
Aquifer System:	02	Waiawa
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30202121
Island:	3	O'ahu
Sector:	02	Pearl Harbor
Aquifer System:	02	Waiawa
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank
Status Code:		12212
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	2	Moderate
U.S. Fish & Wildlife Service Wetland Code:		
		Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent/ Excavated [Upland Non-Wetland] (POWHx/U)
Geology:		
		1. Coastal plain sediments
		2. Alluvium with limestone seaward



## Waiawa National Wildlife Refuge--Continued

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Soil Conservation Service, U.S. Dept. of Agriculture 1975:  
Ph (Pearl Harbor clay, Typic Trophaepts)

WzC (Waipahu silty clay, Vertic Ustrophepts)  
6-12% slopes

Terrestrial Threatened or Endangered Plant(s):  
No inventory available

Terrestrial Threatened or Endangered Animal(s):  
Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Duck (*Anas wyvilliana*)  
Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)

Terrestrial Plant(s):  
Water hyssop (*Bacopa monnieri* (L.) Pennell)  
Mesquite (*Prosopis pallida* (Humb. and Bonpl. ex Willd.) HBK.)  
Duckweed (*Spirodela punctata* (G. F. W. Meyer))

Aquatic Plant(s):  
Water fern (*Azolla filiculoides* Lam.)  
Pickle-weed (*Batis maritima* L.)  
California grass (*Brachiaria mutica* (Forsk.) Stapf)  
Hau (*Hibiscus tiliaceus* L.)  
Lesser duckweed (*Lemna minor* L.)  
Watercress (*Nasturtium microphyllum* Boenn.)  
California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)  
Great bulrush (*Scirpus validus* Vahl)  
Cattail (*Typha angustata* Bory & Chau.)

Terrestrial Animal(s):  
Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
Cattle Egret (*Bubulcus ibis*)  
Common Myna (*Acridotheres tristis*)  
House Finch (*Carpodacus mexicanus*)  
Japanese White-eye (*Zosterops japonicus*)  
Nutmeg Mannikin (*Lonchura punctulata*)  
Spotted Dove (*Streptopelia chinensis*)  
Zebra Dove (*Geopelia striata*)  
Hawaiian Bat (*Lasiurus cinereus semotus*)  
Hawaiian Rat (*Rattus exulans hawaiiensis*)  
House Mouse (*Mus musculus domesticus*)  
Mongoose (*Herpestes auropunctatus*)

## Waiawa National Wildlife Refuge--Continued

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### Pig (*Sus scrofa*)

#### Aquatic Animal(s):

American Bullfrog (*Rana catesbeiana*)  
 Ladyfish (*Elops hawaiiensis* Regan)  
 Barracuda (*Sphyrna barracuda* (Walbaum))  
 Saddle Wrasse (*Thalassoma duperrey*)  
 Belted Wrasse (*Stethojulis balteata*)  
 Green Swordtail (*Xiphophorus helleri* (Heckel))  
 Guppy (*Poecilia reticulata* Peters)  
 Silver Perch (*Kuhlia sandvicensis*)  
 Lai (*Scomberoides Lyson* (Cuvier))  
 Makimaki (*Arothron hispidus*)  
 Milkfish (*Chanos chanos* (Forsk.)  
 Mosquitofish (*Gambusia affinis* (Baird and Girard))  
 Tilapia (*Tilapia mossambica*)  
 'O'opu (*Vitraria clarescens* Jordan and Evermann)  
 'O'opu 'alamo'o (*Lentipes concolor*)  
 'O'opu nakea (*Awaous stamineus*)  
 'O'opu naniha (*Awaous genivittatus*)  
 'O'opu nopili (*Sicydium stimsonii*)  
 Sailfin Molly (*Poecilia latipinna* (Lesueur))  
 Shortfin Molly (*Poecilia mexicana*)  
 Striped Mullet (*Mugil cephalus* L.)  
 White Branded Surgeon (*Acanthurus leucopareius*)  
 Hammerhead Shark (*Sphyrna lewini*)

#### Migratory Animal(s):

Northern Pintail (*Anas acuta*)  
 Northern Shoveler (*Anas clypeata*)  
 Osprey (*Pandion haliaetus*)  
 Sanderling (*Calidris alba*)  
 Wandering Tattler (*Heteroscelus incanus*)

#### Freshwater Origin:

1. Basal
2. Alluvial sediments
3. Artesian seepage by way of springs from confined Koolau aquifer

#### Comments:

Primary objectives of the refuge include: to protect and provide a habitat for endangered species, to expand understanding and appreciation of the environment, and to provide refuge-oriented research opportunities. Waiawa Stream channel is moderately degraded; between 1 and 25% of total channel length is altered.

**Waiawa National Wildlife Refuge--Continued**

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Evans, E.C. 1974. Pearl Harbor biological survey : final report. Prepared for the Naval Undersea Center, San Diego, California. 800 p.

### Appendix B.3 System-Wide Characteristics of Ecologically Sensitive Habitats, Aquifers of Pearl Harbor Sector, Waipahu System

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Aquifer System: Waipahu (03)

Aquifer Sector: Pearl Harbor (02)

Island: O'ahu (3)

Water Wells in Aquifer System (Div. of Water and Land Development 1984):

Disposal	-	Domestic	17	Industrial	3
Irrigation	86	Lost	1	Municipal	22
Observation	18	Other	3	Recharge	-
Sealed	32	Unused	37	Unknown	3

(Department of Health 1987):

Drinking	-
Other	-

Total Number of Injection Wells: 10

Water Wells or Sampling Sites Once Contaminated with DBCP, EDB or TCP  
(Water Resources Research Center 1985):

2703-01	DBCP	EDB	
2701	DBCP	TCP	
2603-01	DBCP		
2600-03	DBCP		
2501	DBCP	TCP	
2500-01	TCP		
2500-02	TCP		
2402-01	DBCP	TCP	
2402-02	DBCP	TCP	
2400-01	EDB	TCP	
2400-02	EDB	TCP	
2400-03	DBCP	EDB	TCP
2400-04	EDB	TCP	
2400-05	EDB	TCP	
2400-06	EDB	TCP	
2302-01	TCP		
2302-02	DBCP	TCP	
2302-03	TCP		
2302-04	TCP		
2301-34	TCP		
2301-35	TCP		
2301-36	TCP		
2301-37	TCP		
2301-38	TCP		
2301-39	TCP		
2703	DBCP	EDB	

**Waipahu--Continued**

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2700	DBCP		
2402	DBCP		
2302	DBCP		
2601	DBCP		
2600	DBCP		
2859	DBCP		
2859-01	DBCP	EDB	TCP
2859-02	DBCP		
2800-01	DBCP	EDB	TCP
2800-02	DBCP	EDB	TCP
2800-03	DBCP	EDB	TCP
2800-04	DBCP	EDB	TCP
2558-10	DBCP	TCP	

**Potential Pollutant Sources and Pollutants (see Fig. 2):**

**Source:** O'ahu Sugar Company, Inc. (NPDES 20699)

**Pollutants:** Agricultural wastes

**Discharge:** Emergency (0)

**Source:** Hawaiian Electric Company, Inc. (NPDES 604)

**Pollutants:** Industrial wastes from Waiau Power Generating Station

**Discharge:** 545,152 mgd

**Source:** C & H Sugar Company (NPDES 281)

**Pollutants:** Industrial wastes

**Discharge:** 2.9 mgd

**Source:** Prestressed Concrete (NPDES 20320)

**Pollutants:** Industrial wastes

**Discharge:** Emergency (0)

**Source:** U.S. Navy, Public Works Center (NPDES 1121105)

**Pollutants:** Industrial wastes including suspended solids, oil and grease into Pearl Harbor

**Discharge:** 400,000 gpd

**Source:** Naval Submarine Base (NPDES 1121032)

**Pollutants:** Industrial wastes including suspended solids, settleable solids, lead, chromium, arsenic, copper, zinc, mercury, tin and cadmium

**Discharge:** Emergency (0)

**Source:** Barbers Point Naval Air Station (UO 1343)

**Pollutants:** Untreated sewage

**Discharge:** 1,800 gpd

**Waipahu--Continued**

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Source: Kahua Ranch Slaughter House and Sludge Pond  
Pollutants: Slaughter house washdown and seepage from sludge pond  
Discharge: Non-point Source

Source: (Unknown)  
Pollutants: High fecal coliform counts have been detected in Waikele Stream  
(1983/5,650, 1984/5,500 and 1985/7,900 counts per 100 ml)  
Discharge: Non-point Source

Source: Agricultural Runoff  
Pollutants: Chlorinated hydrocarbons, Dalapon, Hyvar X, nitrates, and phosphates  
Discharge: Non-point Source

Source: Stormwater Runoff  
Pollutants: Petroleum products, heavy metals, fine sediments  
Discharge: Non-point Source

Source: Waipahu Landfill  
Pollutants: Leachate  
Discharge: Non-point Source





### Appendix B.3.1 Habitat Description of Apoka'a Pond

---

Site:	Apoka'a Pond	Lat.:	21°21'59"
Island:	O'ahu	Long.:	158°01'30"
Sector:	Pearl Harbor, 02	El.:	0-30 ft
System:	Waipahu (03)	Approx. Area/Length:	19.3 acres

#### Site Description:

Five small aquaculture ponds at Apoka'a contain emergent vegetation providing habitat for stilts, coots and gallinules.

The climate is constant and relatively dry, with prevailing trade winds blowing from the northeast about 80% of the time at speeds of 10-20 mph.

#### Sensitivity Rating:

	Aa12t
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Use:	2t Traditional

#### Habitat Code:

	1-1c-3-2-1b-4-1-2
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	2 Aquaculture
Social Significance:	1b Historic Not Registered
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	1 Pond
Water Quality:	2 Brackish (250-15,000 mg/l Cl <sup>-</sup> )

#### Aquifer Code:

	30203116
Island:	3 O'ahu
Sector:	02 Pearl Harbor
Aquifer System:	03 Waipahu
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	6 Sedimentary

#### Status Code:

	12211
Development Stage:	1 Currently Used
Utility:	2 Ecologically Important
Salinity:	2 Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1 Irreplaceable
Vulnerability to Contamination:	1 High

**Apoka'a Pond--Continued**

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Aquifer Code: 30203121  
 Island: 3 O'ahu  
 Sector: 02 Pearl Harbor  
 Aquifer System: 03 Waipahu  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 1 Flank  
  
 Status Code: 12212  
 Development Stage: 1 Currently Used  
 Utility: 2 Ecologically Important  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 2 Moderate

**U.S. Fish & Wildlife Service Wetland Code:**

Estuarine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal (E1OWL)

Estuarine/Intertidal/Scrub-Shrub/Broad-Leaved Evergreen/ Tidal Regular (E2SS3N)

Palustrine/Emergent/Persistent/Non-Tidal Semipermanent/ Dike-Impounded  
(PEM1Fh)

Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent/ Dike-Impounded  
(POWHh)

**Geology:**

1. Coastal plain sediments overlying Koolau aquifer
2. Sediments partially confine Koolau aquifer

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

FL (Fill land mixed)

KmbA (Keaau clay, saline, Typic Tropaquepts)  
0-2% slopes

Ph (Pearl Harbor clay, Typic Tropaquepts)

**Terrestrial Threatened or Endangered Plant(s):**

No inventory available

**Terrestrial Threatened or Endangered Animal(s):**

Hawaiian Coot (*Fulica americana alai*)

Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)

**Apoka'a Pond--Continued**

---

Hawaiian Stilt (*Himantopus mexicanus knudseni*)

**Terrestrial Plant(s):**

No inventory available

**Aquatic Plant(s):**

No inventory available

**Terrestrial Animal(s):**

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)

**Aquatic Animal(s):**

No inventory available

**Migratory Animal(s):**

No inventory available

**Freshwater Origin:**

1. Basal
2. Shallow sediments
3. Artesian seepage from Koolau aquifer

**Comments:**

The City and County of Honolulu is building a housing subdivision and golf course around Apoka'a Pond (West Loch Estates and Golf Course).

**References:**

U.S. Fish and Wildlife Service. 1985. Recovery plan for the Hawaiian Waterbirds. Prepared for U.S. Fish and Wildlife Service, Portland, Oregon. 99 p.



### Appendix B.3.2 Habitat Description of Waikele

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Site:	Waikele	Lat.:	21°22'45"
Island:	O'ahu	Long.:	158°01'15"
Sector:	Pearl Harbor, 02	El.:	0-40 ft
System:	Waipahu (03)	Approx. Area/Length:	54.4 acres

#### Site Description:

The site occupies the northwestern corner of Waipio Peninsula. It is an estuarine swamp with associated marsh and flat areas. Dense stands of mangrove grow along shore with pickle-weed, salt, and mud flats characterizing inland features. Farther west along West Loch is a small fishpond also surrounded by an American mangrove swamp (Elliott 1981).

Mangrove mudflats throughout the Pearl Harbor area are periodically exposed with fluctuations in tides and provide an ephemeral feeding habitat for waterbirds and an unusual variety of exotic birds, including game species, cage birds, and long established varieties widely distributed throughout the islands. Pearl Harbor has been the location of more sightings of rare stragglers and unusual migrants than any other wetland on O'ahu. These sightings include little blue heron, black tern, least tern, ring-billed gull, Franklin's laughing gull, Bonaparte's gull, osprey, and peregrine falcon.

The climate is constant and relatively dry, with prevailing trade winds blowing from the northeast about 80% of the time at speeds of 10-20 mph.

Sensitivity Rating:	Aa12m3f
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Other Value:	3f Sediment Trap
Habitat Code:	1-1c-3-5-5-1-4-4
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	1 Sediment Trap
Wetland Type:	4 Marsh
Water Quality:	4 Combination
Aquifer Code:	30203116
Island:	3 O'ahu
Sector:	02 Pearl Harbor
Aquifer System:	03 Waipahu
Aquifer Type (Hydrology):	1 Basal

**Waikele--Continued**

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Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High

Aquifer Code:		30203121
Island:	3	O'ahu
Sector:	02	Pearl Harbor
Aquifer System:	03	Waipahu
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank

Status Code:		12212
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	2	Moderate

**U.S. Fish & Wildlife Service Wetland Code:**

Estuarine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal (E1OWL)

Estuarine/Intertidal/Forested/Broad-Leaved Evergreen/Tidal Regular (E2FO3N)

**Geology:**

1. Valley fill alluvial sediments in lower reach of stream
2. Sediments act as caprock, confining Koolau aquifer

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

HLMG (Helemano silty clay, Tropeptic Haplustox)  
30-90% slopes

HxA (Honouliuli clay, Typic Chromusterts)  
0-2% slopes

Ph (Pearl Harbor clay, Typic Tropaquepts)

## Waikele--Continued

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### Terrestrial Threatened or Endangered Plant(s):

No inventory available

### Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)  
 Hawaiian Duck (*Anas wyvilliana*)  
 Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
 Hawaiian Stilt (*Himantopus mexicanus knudseni*)

### Terrestrial Plant(s):

No inventory available

### Aquatic Plant(s):

Pickle-weed (*Batis maritima* L.)  
 Oriental mangrove (*Bruguiera gymnorrhiza* Lam.)  
 Red mangrove (*Rhizophora mangle* L.)  
 California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)  
 Great bulrush (*Scirpus validus* Vahl)

### Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
 Cattle Egret (*Bubulcus ibis*)  
 Common Myna (*Acridotheres tristis*)  
 Japanese White-eye (*Zosterops japonicus*)  
 Nutmeg Mannikin (*Lonchura punctulata*)  
 Spotted Dove (*Streptopelia chinensis*)  
 Zebra Dove (*Geopelia striata*)

### Aquatic Animal(s):

Barracuda (*Sphyraena barracuda* (Walbaum))  
 Chinese Catfish (*Clarias fuscus*)  
 Green Swordtail (*Xiphophorus helleri* (Heckel))  
 Guppy (*Poecilia reticulata* Peters)  
 Silver Perch (*Kuhlia sandvicensis*)  
 Milkfish (*Chanos chanos* (Forsk.)  
 Mosquitofish (*Gambusia affinis* (Baird and Girard))  
 Tilapia (*Tilapia mossambica*)  
 Shortfin Molly (*Poecilia mexicana*)  
 Southern Platyfish (*Xiphophorus maculatus* (Gunther))  
 Striped Mullet (*Mugil cephalus* L.)  
 Top Minnow (*Poecilia vittata*)

**Waikele--Continued**

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**Migratory Animal(s):**

Sanderling (*Calidris alba*)

Wandering Tattler (*Heteroscelus incanus*)

**Freshwater Origin:**

1. Basal

2. Shallow alluvial sediments of coastal plain

3. Artesian seepage from confined Koolau aquifer

**Comments:**

Waikele Stream channel is moderately degraded; between 1 and 25% of the total channel length is altered.

**References:**

Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.

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- Evans, E.C. 1974. Pearl Harbor biological survey : final report. Prepared for the Naval Undersea Center, San Diego, California. 800 p.



### **Appendix B.3.3 Habitat Description of Waipahu Landfill**

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Site:	Waipahu Landfill	Lat.:	21°22'30"
Island:	O'ahu	Long.:	158°00'30"
Sector:	Pearl Harbor, 02	El.:	0-40 ft
System:	Waipahu (03)	Approx. Area/Length:	17.6 acres

#### **Site Description:**

Waipahu Landfill is situated on the western coast of Waipio Peninsula just south of the Waikele wetland. Coastal mangroves dominate the coastal area with other saltwater tolerant vegetation in the interior.

Mangrove mudflats throughout the Pearl Harbor area are periodically exposed with fluctuations in tides and provide ephemeral feeding habitats for waterbirds and an unusual variety of exotic birds, including game species, cage birds, and long-established varieties widely distributed throughout the islands. Pearl Harbor has been the location of more sightings of rare stragglers and unusual migrants than any other wetland on O'ahu. These sightings include little blue heron, black tern, least tern, ring-billed gull, Franklin's laughing gull, Bonaparte's gull, osprey, and peregrine falcon. Most fishes characteristic of estuarine waters in Hawaii are found in waters over the mangrove mudflats in Pearl Harbor.

The climate is constant and relatively dry, with prevailing trade winds blowing from the northeast about 80% of the time at speeds of 10-20 mph.

Sensitivity Rating:	Ab12m
Main Water Source:	A Groundwater
Habitat:	b Artificial
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Habitat Code:	1-2-3-5-5-4-4-4
Water Source:	1 Groundwater
Habitat Origin/Development:	2 Artificial
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	4 Marsh
Water Quality:	4 Combination
Aquifer Code:	30203116
Island:	3 O'ahu
Sector:	02 Pearl Harbor
Aquifer System:	03 Waipahu
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined

**Waipahu Landfill--Continued**

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<b>Aquifer Type (Geology):</b>	6	Sedimentary
<b>Status Code:</b>		12211
<b>Development Stage:</b>	1	Currently Used
<b>Utility:</b>	2	Ecologically Important
<b>Salinity:</b>	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
<b>Uniqueness:</b>	1	Irreplaceable
<b>Vulnerability to Contamination:</b>	1	High

<b>Aquifer Code:</b>		30203121
<b>Island:</b>	3	O'ahu
<b>Sector:</b>	02	Pearl Harbor
<b>Aquifer System:</b>	03	Waipahu
<b>Aquifer Type (Hydrology):</b>	1	Basal
<b>Aquifer Type (Hydrology):</b>	2	Confined
<b>Aquifer Type (Geology):</b>	1	Flank

<b>Status Code:</b>		12212
<b>Development Stage:</b>	1	Currently Used
<b>Utility:</b>	2	Ecologically Important
<b>Salinity:</b>	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
<b>Uniqueness:</b>	1	Irreplaceable
<b>Vulnerability to Contamination:</b>	2	Moderate

**U.S. Fish & Wildlife Service Wetland Code:**

Estuarine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal (E1OWL)

Estuarine/Intertidal/Forested/Broad-Leaved Evergreen/Tidal Regular (E2FO3N)

Estuarine/Intertidal/Scrub-Shrub/Broad-Leaved Evergreen/ Tidal Regular (E2SS3N)

**Geology:**

1. Coastal plain sediments
2. Limestone at top of sediment

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

CR (Coral outcrop)

FL (Fill land mixed)

**Terrestrial Threatened or Endangered Plant(s):**

No inventory available

## Waipahu Landfill--Continued

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### Terrestrial Threatened or Endangered Animal(s):

- Hawaiian Coot (*Fulica americana alai*)
- Hawaiian Duck (*Anas wyvilliana*)
- Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)
- Hawaiian Stilt (*Himantopus mexicanus knudseni*)

### Terrestrial Plant(s):

No inventory available

### Aquatic Plant(s):

- Oriental mangrove (*Bruguiera gymnorhiza Lam.*)
- Red mangrove (*Rhizophora mangle L.*)

### Terrestrial Animal(s):

- Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)
- Cattle Egret (*Bubulcus ibis*)
- Common Myna (*Acridotheres tristis*)
- Japanese White-eye (*Zosterops japonicus*)
- Nutmeg Mannikin (*Lonchura punctulata*)
- Red Avadavat (*Amandava amandava*)
- Spotted Dove (*Streptopelia chinensis*)
- Zebra Dove (*Geopelia striata*)

### Aquatic Animal(s):

- Barracuda (*Sphyraena barracuda Walbaum*)
- Chinese Catfish (*Clarias fuscus*)
- Green Swordtail (*Xiphophorus helleri Heckel*)
- Guppy (*Poecilia reticulata Peters*)
- Silver Perch (*Kuhlia sandvicensis*)
- Milkfish (*Chanos chanos Forskal*)
- Mosquitofish (*Gambusia affinis Baird and Girard*)
- Tilapia (*Tilapia mossambica*)
- Shortfin Molly (*Poecilia mexicana*)
- Southern Platyfish (*Xiphophorus maculatus Gunther*)
- Striped Mullet (*Mugil cephalus L.*)
- Top Minnow (*Poecilia vittata*)

### Migratory Animal(s):

- Lesser Golden-Plover (*Pluvialis dominica fulva*)
- Sanderling (*Calidris alba*)
- Wandering Tattler (*Heteroscelus incanus*)

**Waipahu Landfill--Continued**

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**Freshwater Origin:**

1. Basal
2. Alluvium and limestone
3. Seepage from confined Koolau aquifer

**Comments:**

Waikele Stream channel is moderately degraded; between 1 and 25% of total channel length is altered.

**References:**

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
- Norton, S.E., Timbol, A.S., and Parrish, J.D. 1978. Stream channel modification in Hawaii. Part B: Effect of channelization on the distribution and abundance of fauna in selected streams. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 47 p.
- Chinn, S.S., Tateishi, G.A., and Yee, J.J.S. 1985. Water resources data/Hawaii and other Pacific areas/water year 1985/volume 1. U.S. Geological Survey Water-Data Report HI-85-1, prepared in cooperation with Division of Water and Land Development, Dept. of Land and Natural Resources, State of Hawaii, Honolulu. 302 p.
- Hall, D.H. 1970. Use of agricultural chemicals and factors contributing to their transport to estuaries in Hawaii. Technical report no. 30, Water Resources Research Center, University of Hawaii, Honolulu. 44 p.
- U.S. Department of the Interior. 1969. Report on pollution of the navigable waters of Pearl Harbor. Federal Water Pollution Control Administration, Pacific Southwest Region. 55 p. plus app.
- Green, R.E., Goswami, K.P., Mukhtar, M., and Young, H.Y. 1977. Herbicides from cropped watersheds in stream and estuarine sediments in Hawaii. J. Environ. Qual. 6:(2):145-154.
- Stearns, H.T. 1985. Geology of the state of Hawaii, 2d ed. Pacific Books. Palo Alto, California. 335 p.
- U.S. Fish and Wildlife Service. 1985. Recovery plan for the Hawaiian Waterbirds. Prepared for U.S. Fish and Wildlife Service, Portland, Oregon. 99 p.

**Waipahu Landfill--Continued**

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- Timbol, A.S., and Maciolek, J.A. 1978. Stream channel modification in Hawaii. Part A: Statewide inventory of streams, habitat factors and associated biota. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 157 p.
- Evans, E.C. 1974. Pearl Harbor biological survey : final report. Prepared for the Naval Undersea Center, San Diego, California. 800 p.





### Appendix B.3.4 Habitat Description of Pouhala

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Site:	Pouhala	Lat.:	21°22'55"
Island:	O'ahu	Long.:	158°00'35"
Sector:	Pearl Harbor, 02	El.:	0-40 ft
System:	Waipahu (03)	Approx. Area/Length:	33.1 acres

#### Site Description:

Pouhala is an estuarine swamp with associated marsh and mudflat areas. Dense stands of mangrove grow along the harbor with pickle-weed, salt, and mud flats characterizing inland features (Elliott 1981).

Mangrove mudflats throughout the Pearl Harbor area are periodically exposed with fluctuations in tides and provide ephemeral feeding habitats for waterbirds and an unusual variety of exotic birds, including game species, cage birds, and long-established varieties widely distributed throughout the other wetlands on O'ahu. These sightings include little blue heron, black tern, least tern, ring-billed gull, Franklin's laughing gull, Bonaparte's gull, osprey, and peregrine falcon.

The climate is constant and relatively dry, with prevailing trade winds blowing from the northeast about 80% of the time at speeds of 10-20 mph.

Sensitivity Rating:	Aa12m3f
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Other Value:	3f Sediment Trap
Habitat Code:	1-1c-3-5-5-1-1-4
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	1 Sediment Trap
Wetland Type:	1 Pond
Water Quality:	4 Combination
Aquifer Code:	30203116
Island:	3 O'ahu
Sector:	02 Pearl Harbor
Aquifer System:	03 Waipahu
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	6 Sedimentary

**Pouhala--Continued**

---

Status Code: 12211  
 Development Stage: 1 Currently Used  
 Utility: 2 Ecologically Important  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 1 High

Aquifer Code: 30203121  
 Island: 3 O'ahu  
 Sector: 02 Pearl Harbor  
 Aquifer System: 03 Waipahu  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 1 Flank

Status Code: 12212  
 Development Stage: 1 Currently Used  
 Utility: 2 Ecologically Important  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 2 Moderate

**U.S. Fish & Wildlife Service Wetland Code:**

Estuarine/Intertidal/Emergent/Persistent/Tidal Irregular (E2EM1P)

Estuarine/Intertidal/Forested/Broad-Leaved Evergreen/Tidal Regular (E2FO3N)

Palustrine/Emergent/Persistent/Non-Tidal Semipermanent (PEM1F)

**Geology:**

1. Alluvial sediments over limestone and coastal plain sediment

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

FL (Fill land mixed)

**Terrestrial Threatened or Endangered Plant(s):**

No inventory available

**Terrestrial Threatened or Endangered Animal(s):**

Hawaiian Coot (*Fulica americana alai*)

Hawaiian Duck (*Anas wyvilliana*)

Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)

Hawaiian Stilt (*Himantopus mexicanus knudseni*)

## Pouhala--Continued

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### Terrestrial Plant(s):

No inventory available

### Aquatic Plant(s):

Pickle-weed (*Batis maritima* L.)  
 Oriental mangrove (*Bruguiera gymnorrhiza* Lam.)  
 Red mangrove (*Rhizophora mangle* L.)  
 California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)  
 Great bulrush (*Scirpus validus* Vahl)

### Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
 Cattle Egret (*Bubulcus ibis*)  
 Common Myna (*Acridotheres tristis*)  
 Japanese White-eye (*Zosterops japonicus*)  
 Nutmeg Mannikin (*Lonchura punctulata*)  
 Spotted Dove (*Streptopelia chinensis*)  
 Zebra Dove (*Geopelia striata*)

### Aquatic Animal(s):

Barracuda (*Sphyraena barracuda* (Walbaum))  
 Chinese Catfish (*Clarias fuscus*)  
 Green Swordtail (*Xiphophorus helleri* (Heckel))  
 Guppy (*Poecilia reticulata* Peters)  
 Silver Perch (*Kuhlia sandvicensis*)  
 Milkfish (*Chanos chanos* (Forsk))  
 Mosquitofish (*Gambusia affinis* (Baird and Girard))  
 Tilapia (*Tilapia mossambica*)  
 Shortfin Molly (*Poecilia mexicana*)  
 Southern Platyfish (*Xiphophorus maculatus* (Gunther))  
 Striped Mullet (*Mugil cephalus* L.)  
 Top Minnow (*Poecilia vittata*)

### Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica fulva*)  
 Mallard (*Anas platyrhynchos*)  
 Sanderling (*Calidris alba*)  
 Wandering Tattler (*Heteroscelus incanus*)

### Freshwater Origin:

1. Surface runoff, combined flood flow and base flow springs of basal water
2. Sediments

**Pouhala--Continued**

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**Comments:**

Waikele Stream channel is moderately degraded; between 1 and 25% of total channel length is altered.

**References:**

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.
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**Pouhala--Continued**

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Timbol, A.S., and Maciolek, J.A. 1978. Stream channel modification in Hawaii, Part A: Statewide inventory of streams, habitat factors and associated biota. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 157 p.

Evans, E.C. 1974. Pearl Harbor biological survey : final report. Prepared for the Naval Undersea Center, San Diego, California. 800 p.



### **Appendix B.3.5 Habitat Description of Waipio Basins**

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Site: Waipio Basins	Lat.: 21°22'30"
Island: O'ahu	Long.: 157°59'45"
Sector: Pearl Harbor, 02	El.: 0-40 ft
System: Waipahu (03)	Approx. Area/Length: 453.6 acres

#### **Site Description:**

There are several large and small wetlands on the Waipio Peninsula at Pearl Harbor that provide important waterbird habitat. Much of the land in this area is in sugar cane production and the settling basins for the irrigation system provide habitat. There are also some old fishponds, sewage oxidation ponds, and mangrove tidal flats which provide habitat for waterbirds. Mangrove now occupies much of the Waipio Peninsula shoreline; as a result, extensive tidal mudflats have developed in formerly open bays.

Mangrove mudflats throughout the Pearl Harbor area are periodically exposed with fluctuations in tides and provide ephemeral feeding habitats for waterbirds and an unusual variety of exotic birds, including game species, cage birds, and long-established varieties widely distributed throughout the islands. Pearl Harbor has been the location of more sightings of rare stragglers and unusual migrants than any other wetland on O'ahu. These sightings include little blue heron, black tern, least tern, ring-billed gull, Franklin's laughing gull, Bonaparte's gull, osprey, and peregrine falcon. Most fishes characteristic of estuarine waters in Hawaii are found in the mangrove mudflat waters of Pearl Harbor.

The climate is constant and relatively dry, with prevailing trade winds blowing from the northeast about 80% of the time at speeds of 10-20 mph.

<b>Sensitivity Rating:</b>	Bb12tm3f
Main Water Source:	B Not Groundwater
Habitat:	b Artificial
Endangered Species:	1 Observed
Wetland Use:	2t Traditional
Wetland Avifauna:	m Migratory Fowl
Other Value:	3f Sediment Trap
<b>Habitat Code:</b>	2-2-3-5-5-1-4-4
Water Source:	2 Other
Habitat Origin/Development:	2 Artificial
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	1 Sediment Trap
Wetland Type:	4 Marsh
Water Quality:	4 Combination

**Waipio Basins--Continued**

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Aquifer Code:		30203116
Island:	3	O'ahu
Sector:	02	Pearl Harbor
Aquifer System:	03	Waipahu
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30203121
Island:	3	O'ahu
Sector:	02	Pearl Harbor
Aquifer System:	03	Waipahu
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank
Status Code:		12212
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	2	Moderate

**U.S. Fish & Wildlife Service Wetland Code:**

Estuarine/Intertidal/Scrub-Shrub/Broad-Leaved Evergreen/ Tidal Regular (E2SS3N)

Palustrine/Emergent/Persistent/Non-Tidal Semipermanent [Open Water-Unknown Bottom/Non-Tidal Semipermanent] (PEM1/OWF)

Palustrine/Emergent/Persistent/Non-Tidal Semipermanent (PEM1F)

Palustrine/Open Water-Unknown Bottom/Non-Tidal Semipermanent (POWF)

Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent/Dike-Impounded (POWHh)



## Waipio Basins--Continued

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Palustrine/Scrub-Shrub/Broad-Leaved Deciduous/Non-Tidal Seasonal  
[Emergent/Persistent/Non-Tidal Seasonal] (PSS/EM1C)

Palustrine/Scrub-Shrub/Broad-Leaved Deciduous/Non-Tidal Seasonal (PSS1C)

Riverine/Lower Perennial/Open Water-Unknown Bottom/Non-Tidal  
Permanent/Excavated (R2OWHx)

Upland [Non-Wetland] (U)

### Geology:

1. Alluvial sediments over limestone and coastal plain sediment

### Soil Conservation Service, U.S. Dept. of Agriculture 1975:

EmA (Ewa silty clay loam, moderately shallow, Torroxic Haplustolls)  
0-2% slopes

Fd (Fill land)

HxA (Honouliuli clay, Typic Chromusterts)  
0-2% slopes

KmA (Keeau clay, Typic Trophaquepts)  
0-2% slopes

MnC (Malama stony silty clay loam, Typic Tropofolists)  
2-6% slopes

### Terrestrial Threatened or Endangered Plant(s):

No inventory available

### Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Duck (*Anas wyvilliana*)  
Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)

### Terrestrial Plant(s):

No inventory available

### Aquatic Plant(s):

Oriental mangrove (*Bruguiera gymnorhiza Lam.*)  
Red mangrove (*Rhizophora mangle L.*)

## Waipio Basins--Continued

---

### Terrestrial Animal(s):

- Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)
- Cattle Egret (*Bubulcus ibis*)
- Common Myna (*Acridotheres tristis*)
- Japanese White-eye (*Zosterops japonicus*)
- Nutmeg Mannikin (*Lonchura punctulata*)
- Red Avadavat (*Amandava amandava*)
- Spotted Dove (*Streptopelia chinensis*)
- Zebra Dove (*Geopelia striata*)

### Aquatic Animal(s):

- Barracuda (*Sphyraena barracuda* (Walbaum))
- Saddle Wrasse (*Thalassoma duperrey*)
- Belted Wrasse (*Stethojulis balteata*)
- Chinese Catfish (*Clarias fuscus*)
- Green Swordtail (*Xiphophorus helleri* (Heckel))
- Guppy (*Poecilia reticulata* Peters)
- Silver Perch (*Kuhlia sandvicensis*)
- Lai (*Scomberoides Lyson* (Cuvier))
- Milkfish (*Chanos chanos* (Forsk.)
- Mosquitofish (*Gambusia affinis* (Baird and Girard))
- Tilapia (*Tilapia mossambica*)
- Shortfin Molly (*Poecilia mexicana*)
- Southern Platyfish (*Xiphophorus maculatus* (Gunther))
- Striped Mullet (*Mugil cephalus* L.)
- White Branded Surgeon (*Acanthurus leucopareius*)

### Migratory Animal(s):

- Baird's Sandpiper (*Calidris bairdii*)
- Bar-tailed Godwit (*Limosa lapponica*)
- Black-bellied Plover (*Pluvialis squatarola*)
- Bristle-thighed Curlew (*Numenius tahitiensis*)
- Buff-breasted Sandpiper (*Tryngites subruficollis*)
- Common Sandpiper (*Actitis macularia*)
- Common Snipe (*Gallinago gallinago*)
- Dunlin (*Calidris alpina*)
- Greater Yellowlegs (*Tringa melanoleuca*)
- Killdeer (*Charadrius vociferus*)
- Least Sandpiper (*Calidris minutilla*)
- Lesser Golden-Plover (*Pluvialis dominica* (fulva))
- Lesser Yellowlegs (*Tringa flavipes*)
- Long-billed Dowitcher (*Limnodromus scolopaceus*)
- Pectoral Sandpiper (*Calidris melanotos*)

## Waipio Basins--Continued

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Red Knot (*Calidris canutus*)  
 Ruddy Turnstone (*Arenaria interpres*)  
 Sanderling (*Calidris alba*)  
 Semipalmated Plover (*Charadrius semipalmatus*)  
 Sharp-tailed Sandpiper (*Calidris acuminata*)  
 Wandering Tattler (*Heteroscelus incanus*)  
 Western Sandpiper (*Calidris mauri*)  
 White-faced Ibis (*Plegadis chihi*)

### Freshwater Origin:

1. Surface runoff, combined flood flow and base flow springs of basal water
2. Sediments

### Comments:

Waikele Stream channels are moderately degraded; between 1 and 25% of total channel length is altered.

### References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
- Norton, S.E., Timbol, A.S., and Parrish, J.D. 1978. Stream channel modification in Hawaii. Part B: Effect of channelization on the distribution and abundance of fauna in selected streams. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 47 p.
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**Waipio Basins--Continued**

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- U.S. Fish and Wildlife Service. 1985. Recovery plan for the Hawaiian Waterbirds. Prepared for U.S. Fish and Wildlife Service, Portland, Oregon. 99 p.
- Timbol, A.S., and Maciolek, J.A. 1978. Stream channel modification in Hawaii. Part A: Statewide inventory of streams, habitat factors and associated biota. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 157 p.
- Evans, E.C. 1974. Pearl Harbor biological survey : final report. Prepared for the Naval Undersea Center, San Diego, California. 800 p.

### Appendix B.3.6 Habitat Description of Honouliuli National Wildlife Refuge

Site:	Honouliuli National Wildlife Refuge	Lat.:	21°21'37"
Island:	O'ahu	Long.:	158°01'20"
Sector:	Pearl Harbor, 02	El.:	0-40 ft
System:	Waipahu (03)	Approx. Area/Length:	31.2 acres

#### Site Description:

Honouliuli National Wildlife Refuge has four impoundments with nesting islands and its water comes from a well. The Refuge is surrounded by a narrow, but dense, kiawe forest; mangrove has taken over a large portion of the West Loch shoreline area. Most of the land west of the site is in sugar cane production.

Immediately north of the Refuge is a series of four 1-2 acre fishponds, now in production of Malaysian prawns. This wetland was formerly a single pond, but extensive diking in recent years has allowed independent use of the four different water impoundments. The two southernmost ponds are not presently in active use for aquaculture. As a result, cattails and pluchea have encroached into these two impoundments. All of the ponds are between 0.15 to 0.9 m (6-36 in.) in depth, with a relatively hard-packed mud bottom.

Of the three fishponds towards the north, the largest pond is now encircled with mangrove and marshland associated vegetation. It is still maintained for aquaculture and limited grazing.

The artificial aquatic ecosystem at Honouliuli is currently one of the best freshwater marshes in the Pearl Harbor wetland complex. The primary robust emergent is Scirpus maritimus. A floating and emergent mat of azolla and algae occurs in some ponds; both are habitat for aquatic invertebrates. Lemna, a known food for waterfowl, also occurs. The Pearl Harbor wetlands are used each winter by shovelers. There is considerable movement between the Waipio Peninsula and the Refuge units. The Pearl Harbor wetlands tend to draw unusual stragglers. White-faced ibis, little blue heron and several species of black-crowned night-herons are recorded in the wetlands complex (U.S. Fish and Wildlife Service 1985).

The climate is constant and relatively dry, with prevailing trade winds blowing from the northeast about 80% of the time at speeds of 10-20 mph.

Sensitivity Rating:	Ab12wt3f
Main Water Source:	A Groundwater
Habitat:	b Artificial
Endangered Species:	1 Observed
Wetland Status:	2w Wildlife Protected
Wetland Use:	t Traditional
Other Value:	3f Sediment Trap

Habitat Code:	1-2-3-2-3-4-4-1
Water Source:	1 Groundwater
Habitat Origin/Development:	2 Artificial
Ecological Character:	3 Endangered Species + Migratory Birds

**Honouliuli National Wildlife Refuge--Continued**

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Present Activities: 2 Aquaculture  
 Social Significance: 3 Historic Registered + Wildlife Protected  
 Physical Significance: 4 Neither Sediment Trap nor Flood Control  
 Wetland Type: 4 Marsh  
 Water Quality: 1 Fresh (< 250 mg/l Cl<sup>-</sup>)

Aquifer Code: 30203116  
 Island: 3 O'ahu  
 Sector: 02 Pearl Harbor  
 Aquifer System: 03 Waipahu  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 1 Unconfined  
 Aquifer Type (Geology): 6 Sedimentary

Status Code: 12211  
 Development Stage: 1 Currently Used  
 Utility: 2 Ecologically Important  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 1 High

Aquifer Code: 30203121  
 Island: 3 O'ahu  
 Sector: 02 Pearl Harbor  
 Aquifer System: 03 Waipahu  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 1 Flank

Status Code: 12212  
 Development Stage: 1 Currently Used  
 Utility: 2 Ecologically Important  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 2 Moderate

**U.S. Fish & Wildlife Service Wetland Code:**

Estuarine/Intertidal/Forested/Broad-Leaved Evergreen/Tidal Irregular (E2FO3P)

Estuarine/Intertidal/Scrub-Shrub/Broad-Leaved Evergreen/ Tidal Regular (E2SS3N)

Palustrine/Emergent/Persistent/Tidal Artificial/Non-Tidal  
Semipermanent/Dike-Impounded (PEM1KFh)

## Honouliuli National Wildlife Refuge--Continued

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Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent/ Excavated  
(POWHx)

Upland [Non-Wetland] (U)

### Geology:

1. Alluvium of coastal plain sediments
2. Sediments saturated with spring water

Soil Conservation Service, U.S. Dept. of Agriculture 1975:

FL (Fill land mixed)

### Terrestrial Threatened or Endangered Plant(s):

No inventory available

### Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)  
 Hawaiian Duck (*Anas wyvilliana*)  
 Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
 Hawaiian Stilt (*Himantopus mexicanus knudseni*)

### Terrestrial Plant(s):

Pluchea (*Pluchea x fosbergii* Coop. and Gal.)  
 Mesquite (*Prosopis pallida* (Humb. and Bonpl. ex Willd.) HBK.)  
 Cattail (*Typha latifolia* L.)

### Aquatic Plant(s):

Water fern (*Azolla filiculoides* Lam.)  
 Pickle-weed (*Batis maritima* L.)  
 California grass (*Brachiaria mutica* (Forsk.) Stapf)  
 Oriental mangrove (*Bruguiera gymnorrhiza* Lam.)  
 Hairy fleabane (*Pluchea odorata* (L.) Cass.)  
 Red mangrove (*Rhizophora mangle* L.)  
 Great bulrush (*Scirpus validus* Vahl)  
 Cattail (*Typha angustata* Bory & Chau.)

### Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
 Cattle Egret (*Bubulcus ibis*)  
 Common Myna (*Acridotheres tristis*)  
 Japanese White-eye (*Zosterops japonicus*)  
 Nutmeg Mannikin (*Lonchura punctulata*)  
 Spotted Dove (*Streptopelia chinensis*)  
 Zebra Dove (*Geopelia striata*)

**Honouliuli National Wildlife Refuge--Continued**

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Mongoose (*Herpestes auropunctatus*)

**Aquatic Animal(s):**

Barracuda (*Sphyraena barracuda* (Walbaum))  
Chinese Catfish (*Clarias fuscus*)  
Green Swordtail (*Xiphophorus helleri* (Heckel))  
Guppy (*Poecilia reticulata* Peters)  
Silver Perch (*Kuhlia sandvicensis*)  
Milkfish (*Chanos chanos* (Forsk.)  
Mosquitofish (*Gambusia affinis* (Baird and Girard))  
Tilapia (*Tilapia mossambica*)  
Shortfin Molly (*Poecilia mexicana*)  
Southern Platyfish (*Xiphophorus maculatus* (Gunther))  
Striped Mullet (*Mugil cephalus* L.)  
Top Minnow (*Poecilia vittata*)

**Migratory Animal(s):**

Lesser Golden-Plover (*Pluvialis dominica* (fulva))  
Mallard (*Anas platyrhynchos*)  
Northern Pintail (*Anas acuta*)  
Northern Shoveler (*Anas clypeata*)  
Ruddy Turnstone (*Arenaria interpres*)  
Sanderling (*Calidris alba*)  
Wandering Tattler (*Heteroscelus incanus*)

**Freshwater Origin:**

1. Basal
2. Shallow alluvial sediments
3. Artesian seepage or springs from confined Koolau aquifer

**Comments:**

Primary objectives of the refuge include: to protect and provide habitat for endangered species, to expand understanding and appreciation of the environment, and to provide refuge-oriented research opportunities. Waikele Stream channel is moderately degraded; between 1 and 25% of total channel length is altered.

**References:**

Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.



**Honouliuli National Wildlife Refuge--Continued**

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- Chinn, S.S., Tateishi, G.A., and Yee, J.J.S. 1985. Water resources data/Hawaii and other Pacific areas/water year 1985/volume 1. U.S. Geological Survey Water-Data Report HI-85-1, prepared in cooperation with Division of Water and Land Development, Dept. of Land and Natural Resources, State of Hawaii, Honolulu. 302 p.
- Hall, D.H. 1970. Use of agricultural chemicals and factors contributing to their transport to estuaries in Hawaii. Technical report no. 30, Water Resources Research Center, University of Hawaii, Honolulu. 44 p.
- U.S. Department of the Interior. 1969. Report on pollution of the navigable waters of Pearl Harbor. Federal Water Pollution Control Administration, Pacific Southwest Region. 55 p. plus app.
- Stearns, H.T. 1985. Geology of the state of Hawaii, 2d ed. Pacific Books. Palo Alto, California. 335 p.
- U.S. Fish and Wildlife Service. 1985. Master plan for the Hawaiian Wetlands National Wildlife Refuge Complex. U.S. Fish and Wildlife Service, Honolulu, Hawaii. 77 p.
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- Evans, E.C. 1974. Pearl Harbor biological survey : final report. Prepared for the Naval Undersea Center, San Diego, California. 800 p.
- Environmental Impact Study Corporation. 1981. Environmental Impact Statement for Honouliuli Wells. Prepared for the Board of Water Supply, City and County of Honolulu, Hawaii. 189 p. plus app.



### Appendix B.3.7 Habitat Description of Walker's Bay

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Site:	Walker's Bay	Lat.:	21°21'47"
Island:	O'ahu	Long.:	157°59'30"
Sector:	Pearl Harbor, 02	El.:	0-40 ft
System:	Waipahu (03)	Approx. Area/Length:	26.6 acres

#### Site Description:

This area is within the Pearl Harbor basin and is an inlet in Waipio Peninsula. The climate is constant and relatively dry, with prevailing trade winds blowing from the northeast about 80% of the time at speeds of 10-20 mph.

Sensitivity Rating:		Ba12m
Main Water Source:	B	Not Groundwater
Habitat:	a	Natural
Endangered Species:	1	Observed
Wetland Avifauna:	2m	Migratory Fowl
Habitat Code:		2-1c-3-5-5-4-3-3
Water Source:	2	Other
Habitat Origin/Development:	1c	Natural/Pristine + Altered
Ecological Character:	3	Endangered Species + Migratory Birds
Present Activities:	5	Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5	Neither Historic nor Wildlife Protected
Physical Significance:	4	Neither Sediment Trap nor Flood Control
Wetland Type:	3	Coastal
Water Quality:	3	Marine (> 15,000 mg/l Cl <sup>-</sup> )
Aquifer Code:		30203116
Island:	3	O'ahu
Sector:	02	Pearl Harbor
Aquifer System:	03	Waipahu
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High

**Walker's Bay--Continued**

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Aquifer Code:		30203121
Island:	3	O'ahu
Sector:	02	Pearl Harbor
Aquifer System:	03	Waipahu
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank
Status Code:		12212
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	2	Moderate

**U.S. Fish & Wildlife Service Wetland Code:**

Estuarine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal (E1OWL)

Estuarine/Intertidal/Forested/Broad-Leaved Evergreen/Tidal Regular (E2FO3N)

Estuarine/Intertidal/Scrub-Shrub/Broad-Leaved Evergreen/ Tidal Regular (E2SS3N)

**Geology:**

Soil Conservation Service, U.S. Dept. of Agriculture 1975:  
FL (Fill land mixed)

**Terrestrial Threatened or Endangered Plant(s):**  
No inventory available

**Terrestrial Threatened or Endangered Animal(s):**  
Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Duck (*Anas wyvilliana*)  
Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
Hawaiian Owl (*Asio flammeus sandwichensis*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)

**Terrestrial Plant(s):**  
No inventory available

**Aquatic Plant(s):**  
No inventory available

## Walker's Bay--Continued

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### Terrestrial Animal(s):

- Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)
- Cattle Egret (*Bubulcus ibis*)
- Common Myna (*Acridotheres tristis*)
- Japanese White-eye (*Zosterops japonicus*)
- Nutmeg Mannikin (*Lonchura punctulata*)
- Red Avadavat (*Amandava amandava*)
- Spotted Dove (*Streptopelia chinensis*)
- Zebra Dove (*Geopelia striata*)

### Aquatic Animal(s):

- Barracuda (*Sphyraena barracuda* (Walbaum))
- Silver Perch (*Kuhlia sandvicensis*)
- Milkfish (*Chanos chanos* (Forsk))
- Mosquitofish (*Gambusia affinis* (Baird and Girard))
- Tilapia (*Tilapia mossambica*)
- Striped Mullet (*Mugil cephalus* L.)

### Migratory Animal(s):

- Lesser Golden-Plover (*Pluvialis dominica* (fulva))
- Ruddy Turnstone (*Arenaria interpres*)
- Sanderling (*Calidris alba*)
- Wandering Tattler (*Heteroscelus incanus*)

### Freshwater Origin:

#### Comments:

Waikele Stream channel is moderately degraded; between 1 and 25% of total channel length is altered.

#### References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.
- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
- Norton, S.E., Timbol, A.S., and Parrish, J.D. 1978. Stream channel modification in Hawaii. Part B: Effect of channelization on the distribution and abundance of fauna in selected streams. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 47 p.

**Walker's Bay--Continued**

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Hall, D.H. 1970. Use of agricultural chemicals and factors contributing to their transport to estuaries in Hawaii. Technical report no. 30, Water Resources Research Center, University of Hawaii, Honolulu. 44 p.

U.S. Department of the Interior. 1969. Report on pollution of the navigable waters of Pearl Harbor. Federal Water Pollution Control Administration, Pacific Southwest Region. 55 p. plus app.

Green, R.E., Goswami, K.P., Mukhtar, M., and Young, H.Y. 1977. Herbicides from cropped watersheds in stream and estuarine sediments in Hawaii. J. Environ. Qual. 6:(2):145-154.

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**Appendix C.1 System-Wide Characteristics of Ecologically Sensitive Habitats,  
Aquifers of Waianae Sector, Lualualei System**

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**Aquifer System:** Lualualei (02)

**Aquifer Sector:** Waianae (03)

**Island:** O'ahu (3)

**Water Wells in Aquifer System (Div. of Water and Land Development 1984):**

Disposal	-	Domestic	3	Industrial	2
Irrigation	30	Lost	2	Municipal	-
Observation	-	Other	7	Recharge	-
Sealed	2	Unused	48	Unknown	11

**(Department of Health 1987):**

Drinking	-
Other	-

**Total Number of Injection Wells:** 8

**Water Wells or Sampling Sites Once Contaminated with DBCP, EDB or TCP  
(Water Resources Research Center 1985):**

None

**Potential Pollutant Sources and Pollutants (see Fig. 2):**

**Source:** C & C of Honolulu, Waianae WWTP Cesspool Sump (UO 1377)  
**Pollutants:** Untreated sewage  
**Discharge:** 8,000 gpd

**Source:** Toledo Twin Pine Dairy (NPDES 20672)  
**Pollutants:** Agricultural wastes, run-off into Dairy #2 Pond  
**Discharge:** Emergency (0)

**Source:** U.S. Navy PACNAVENGCOM (NPDES 110221)  
**Pollutants:** Domestic wastes from Lualualei Naval Magazine  
**Discharge:** 200,000 gpd





### **Appendix C.1.1 Habitat Description of Lualualei Reservoir**

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Site:	Lualualei Reservoir	Lat.:	21°26'28"
Land:	O'ahu	Long.:	158°09'53"
Sector:	Waianae, 03	El.:	20-40 ft
System:	Lualualei (02)	Approx. Area/Length:	34.0 acres

#### **Site Description:**

This depressed floodplain was formerly a large reservoir, that has been completely choked by encroaching California grass. The site is fed primarily by storm runoff that supports the green grassland throughout the year. The site originally was diked around the entire periphery, and damned at the downstream end to provide water storage capability. It has since been opened, and is now drained after heavy rains by a large channelized stream.

Seashore Paspalum covers 76 to 100% of the estuary area. California grass, Christmas-berry tree, and Hau cover 5 to 25% of the area while families of Gramineae, Compositae, and Leguminosae represent less than 5% cover.

Cattle, mongoose, and dogs are present in the area. There is no permanent standing water to support diverse aquatic fauna, but tilapia and mosquitofish can be expected at the site during periods when it becomes flooded. Non-wetland birds observed at the site included northern cardinals, common mynas, barred and spotted doves, and house finch. Cattle egrets are common in the prime grazing areas. Migratory ducks occasionally visit the reservoir when water ponds temporarily form after storms.

Sensitivity Rating:	Ba12wm
Main Water Source:	B Not Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Status:	2w Wildlife Protected
Wetland Avifauna:	m Migratory Fowl
Habitat Code:	2-1b-3-5-2-4-4-1
Water Source:	2 Other
Habitat Origin/Development:	1b Natural/Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	2 Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	4 Marsh
Water Quality:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:	30302116
Island:	3 O'ahu
Sector:	03 Waianae
Aquifer System:	02 Lualualei

**Lualualei Reservoir--Continued**

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Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 1 Unconfined  
 Aquifer Type (Geology): 6 Sedimentary

Status Code: 13311  
 Development Stage: 1 Currently Used  
 Utility: 3 Neither Drinking nor Ecologically Important  
 Salinity: 3 Moderate (1,000-5,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 1 High

Aquifer Code: 30302122  
 Island: 3 O'ahu  
 Sector: 03 Waianae  
 Aquifer System: 02 Lualualei  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 2 Dike

Status Code: 23323  
 Development Stage: 2 Potential Use  
 Utility: 3 Neither Drinking nor Ecologically Important  
 Salinity: 3 Moderate (1,000-5,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 2 Replaceable  
 Vulnerability to Contamination: 3 Low

**U.S. Fish & Wildlife Service Wetland Code:**

Palustrine/Emergent/Persistent/Non-Tidal Seasonal/Dike-Impounded (PEM1Ch)

**Geology:**

1. Valley fill sediment; upper stratum consists of fossil limestone
2. Aquifer limestone; highly permeable, brackish

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

LuA (Lualualei clay, Typic Chromusterts)  
 0-2% slopes

**Terrestrial Threatened or Endangered Plant(s):**

No inventory available

**Terrestrial Threatened or Endangered Animal(s):**

Hawaiian Coot (*Fulica americana alai*)  
 Hawaiian Duck (*Anas wyvilliana*)  
 Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)

## **Lualualei Reservoir--Continued**

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Hawaiian Stilt (*Himantopus mexicanus knudseni*)

### **Terrestrial Plant(s):**

Koa haole (*Leucaena leucocephala* (Lam.) deWit)  
 Christmas-berry tree (*Schinus terebinthifolius* Raddi)

### **Aquatic Plant(s):**

California grass (*Brachiaria mutica* (Forsk.) Stapf)  
 Hau (*Hibiscus tiliaceus* L.)  
 Seashore paspalum (*Paspalum vaginatum* Sw.)

### **Terrestrial Animal(s):**

Cattle Egret (*Bubulcus ibis*)  
 Common Myna (*Acridotheres tristis*)  
 House Finch (*Carpodacus mexicanus*)  
 Northern Cardinal (*Cardinalis cardinalis*)  
 Spotted Dove (*Streptopelia chinensis*)  
 Zebra Dove (*Geopelia striata*)  
 Mongoose (*Herpestes auropunctatus*)

### **Aquatic Animal(s):**

Mosquitofish (*Gambusia affinis* (Baird and Girard))  
 Tilapia (*Tilapia mossambica*)

### **Migratory Animal(s):**

Mallard (*Anas platyrhynchos*)

### **Freshwater Origin:**

1. Basal lens is brackish
2. Subsurface waters originate on the underlying fossil coral reef limestone from direct infiltration of rainfall and from runoff into the valley from the surrounding terrain.

### **Comments:**

### **References:**

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
- Elliott, M.E., and Hall, E.M. 1977. Wetlands and wetland vegetation of Hawaii. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 344 p.



### **Appendix C.1.2 Habitat Description of Niulii Reservoir**

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Site: Niulii Reservoir	Lat.: 21°25'43"
Island: O'ahu	Long.: 158°08'42"
Sector: Waianae, 03	El.: 60-80 ft
System: Lualualei (02)	Approx. Area/Length: 4.2 acres

#### **Site Description:**

Niulii Reservoir consists of two separate ponds connected by a drainage pipe. The ponds are used for sewage settling by the Lualualei Naval Magazine. No sewage is permitted to exit the ponds; thus, the sewage is treated through settling and evaporation. However, there is a gate on the makai side of the pond to allow discharge of the effluent.

The adjacent lands are leased to farmers for cattle grazing. The dominant vegetation in the pond is California grass and Kiawe surrounds the pond. Occasionally, the pond is sprayed with insecticide to eliminate the infestation of mosquitos. This activity is coordinated with the Navy's Environmental Department in order to protect nesting water-birds.

<b>Sensitivity Rating:</b>	Bb12m
Main Water Source:	B Not Groundwater
Habitat:	b Artificial
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
<b>Habitat Code:</b>	2-2-3-5-2-4-1-4
Water Source:	2 Other
Habitat Origin/Development:	2 Artificial
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	2 Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	1 Pond
Water Quality:	4 Combination
<b>Aquifer Code:</b>	30302116
Island:	3 O'ahu
Sector:	03 Waianae
Aquifer System:	02 Lualualei
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	6 Sedimentary

**Niulii Reservoir--Continued**

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Status Code: 13311  
 Development Stage: 1 Currently Used  
 Utility: 3 Neither Drinking nor Ecologically Important  
 Salinity: 3 Moderate (1,000-5,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 1 High

Aquifer Code: 30302122  
 Island: 3 O'ahu  
 Sector: 03 Waianae  
 Aquifer System: 02 Lualualei  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 2 Dike

Status Code: 23323  
 Development Stage: 2 Potential Use  
 Utility: 3 Neither Drinking nor Ecologically Important  
 Salinity: 3 Moderate (1,000-5,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 2 Replaceable  
 Vulnerability to Contamination: 3 Low

**U.S. Fish & Wildlife Service Wetland Code:**

Palustrine/Emergent/Persistent/Non-Tidal Seasonal/Non-Tidal Permanent  
 (PEM1CH)

Palustrine/Emergent/Persistent/Non-Tidal Semipermanent/ Dike-Impounded  
 (PEM1Fh)

Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent/ Dike-Impounded  
 (POWHh)

**Geology:**

1. Valley fill sediments capped by fossil limestone stratum beneath shallow alluvium
2. Limestone highly permeable; sediments below mostly dry; volcanic aquifer at great depth

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

LvB (Lualualei stony clay, Typic Chromusterts)  
 2-6% slopes

PsA (Pulehu clay loam, Cumulic Haplustolls)  
 0-3% slopes

## Niulii Reservoir--Continued

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### Terrestrial Threatened or Endangered Plant(s):

No inventory available

### Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)

Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)

Hawaiian Stilt (*Himantopus mexicanus knudseni*)

### Terrestrial Plant(s):

Mesquite (*Prosopis pallida* (Humb. and Bonpl. ex Willd.) HBK.)

### Aquatic Plant(s):

California grass (*Brachiaria mutica* (Forsk.) Stapf)

### Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)

Cattle Egret (*Bubulcus ibis*)

### Aquatic Animal(s):

No inventory available

### Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)

Northern Shoveler (*Anas clypeata*)

Wandering Tattler (*Heteroscelus incanus*)

### Freshwater Origin:

1. Alluvial depression into which surface water drains
2. Surface runoff

### Comments:

### References:

Naval Facilities Engineering Command, Pearl Harbor, Hawaii, Personal Communication.

Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.

Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.





**Appendix C.2 System-Wide Characteristics of Ecologically Sensitive Habitats,  
Aquifers of Waianae Sector, Makaha System**

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Aquifer System: Makaha (04)

Aquifer Sector: Waianae (03)

Island: O'ahu (3)

Water Wells in Aquifer System (Div. of Water and Land Development 1984):

Disposal	1	Domestic	3	Industrial	-
Irrigation	13	Lost	-	Municipal	1
Observation	-	Other	1	Recharge	-
Sealed	-	Unused	1	Unknown	5

(Department of Health 1987):

Drinking	-
Other	-

Total Number of Injection Wells: 6

Water Wells or Sampling Sites Once Contaminated with DBCP, EDB or TCP  
(Water Resources Research Center 1985):

None

Potential Pollutant Sources and Pollutants (see Fig. 2):

Source: Assn. of Apt. Owners of Makaha Shores Condominium (UO 1250)

Pollutants: Secondary treated sewage

Discharge: 18,000 gpd



**Appendix C.2.1 Habitat Description of Mount Ka'ala**

Site: Mount Ka'ala	Lat.: 21°30'30"
Island: O'ahu	Long.: 158°09'00"
Sector: Waianae, 03	El.: 4000-4100 ft
System: Makaha (04)	Approx. Area/Length: 54.2 acres

**Site Description:**

A remnant of the crater of the Waianae volcano, forms a poorly drained, nearly level plateau and bog in a cloud forest (el. 1,228 m [4,027 ft]). A military radar station, consisting of several large domes and buildings, is located on the eastern edge. Numerous antennas are on site.

Densely scattered low 'ohi'a and other native shrubs and grasses are present. Endemic gastropod species are abundant on the vegetation.

<b>Sensitivity Rating:</b>	Aa1
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
<b>Habitat Code:</b>	1-1a-1-5-5-4-4-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1a Natural/Pristine
Ecological Character:	1 Endangered Species
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	4 Marsh
Water Quality:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
<b>Aquifer Code:</b>	30304232
Island:	3 O'ahu
Sector:	03 Waianae
Aquifer System:	04 Makaha
Aquifer Type (Hydrology):	2 High Level
Aquifer Type (Hydrology):	3 Confined or Unconfined
Aquifer Type (Geology):	2 Dike
<b>Status Code:</b>	11111
Development Stage:	1 Currently Used
Utility:	1 Drinking
Salinity:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1 Irreplaceable
Vulnerability to Contamination:	1 High

**Mount Ka'ala--Continued**

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## U.S. Fish &amp; Wildlife Service Wetland Code:

Palustrine/Forested/Broad-Leaved Evergreen/Non-Tidal Saturated (PFO3B)

## Geology:

1. Upper member of Waianae volcanic series
2. Poorly permeable, level massive flow rock

## Soil Conservation Service, U.S. Dept. of Agriculture 1975:

rAAE (Alakai mucky peat, Terric Troposaprists)  
0-30% slopes

## Terrestrial Threatened or Endangered Plant(s):

No inventory available

## Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)

## Terrestrial Plant(s):

Alsinidendron (*Alsinidendron trinerve* Mann)  
Beach spurge (*Euphorbia degeneri* var. *degeneri* Sherff)  
Pelea (*Pelea pallida* Hbd.)  
Kapana (*Phyllostegia mollis* Benth.)  
Ma'oli'oli (*Schiedea globosa* Mann)  
Ma'oli'oli (*Schiedea pubescens* var. *purpurascens* Sherff)  
Tree lobelia (*Rollandia crispa* Gaud.)

## Aquatic Plant(s):

No inventory available

## Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)

## Aquatic Animal(s):

No inventory available

## Migratory Animal(s):

No inventory available

## Freshwater Origin:

1. High-level, perched on dense massive lava
2. Thin sediments and organic material
3. Local rainfall recharge

**Mount Ka'ala--Continued**

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**Comments:****References:**

Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.

Elliott, M.E., and Hall, E.M. 1977. Wetlands and wetland vegetation of Hawaii. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 344 p.



**Appendix D.1 System-Wide Characteristics of Ecologically Sensitive Habitats,  
Aquifers of North Sector, Mokuleia System**

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**Aquifer System: Mokuleia (01)**

**Aquifer Sector: North (04)**

**Island: O'ahu (3)**

**Water Wells in Aquifer System (Div. of Water and Land Development 1984):**

Disposal	-	Domestic	6	Industrial	-
Irrigation	10	Lost	1	Municipal	-
Observation	12	Other	4	Recharge	-
Sealed	26	Unused	9	Unknown	20

**(Department of Health 1987):**

Drinking	-
Other	-

**Total Number of Injection Wells: 2**

**Water Wells or Sampling Sites Once Contaminated with DBCP, EDB or TCP  
(Water Resources Research Center 1985):**

3404-02	DBCP	TCP
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**Potential Pollutant Sources and Pollutants (see Fig. 2):**

**Source: Dillingham Air Field, DOT (UO 1448)**

**Pollutants: Untreated storm water runoff**

**Discharge: Non-point Source**

**Source: Cattle Pasture**

**Pollutants: Fecal coliform**

**Discharge: Non-point Source**





### Appendix D.1.1 Habitat Description of Mokuleia Quarry

---

Site: Mokuleia Quarry	Lat.: 21°34'45"
Island: O'ahu	Long.: 158°12'54"
Sector: North, 04	El.: 20-40 ft
System: Mokuleia (01)	Approx. Area/Length: 4.5 acres

#### Site Description:

This area is a former rock quarry which discontinued operations in the 1970s. The removal of rocks exposed groundwater which now forms the wetland.

Mokuleia has a warm tropical climate, with mean January and July temperatures ranging from 22°-25°C. The wet or rainy season extends from November to April. The dry season generally starts in May and ends in October.

Sensitivity Rating:	Aa12m
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Habitat Code:	1-1b-3-5-5-4-1-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1b Natural/Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	1 Pond
Water Quality:	1 Fresh (<250 mg/l Cl <sup>-</sup> )
Aquifer Code:	30401111
Island:	3 O'ahu
Sector:	04 North
Aquifer System:	01 Mokuleia
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	1 Flank
Status Code:	11111
Development Stage:	1 Currently Used
Utility:	1 Drinking
Salinity:	1 Fresh (<250 mg/l Cl <sup>-</sup> )
Uniqueness:	1 Irreplaceable
Vulnerability to Contamination:	1 High

**Mokuleia Quarry--Continued**

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## U.S. Fish &amp; Wildlife Service Wetland Code:

Lacustrine/Limnetic/Open Water-Unknown Bottom/Non-Tidal  
Permanent/Excavated (L1OWHx)

## Geology:

1. Upper member Waianae volcanic series
2. Thick, massive flows, poorly permeable

Soil Conservation Service, U.S. Dept. of Agriculture 1975:  
(Quarry)

Terrestrial Threatened or Endangered Plant(s):  
No inventory available

Terrestrial Threatened or Endangered Animal(s):  
Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Duck (*Anas wyvilliana*)

Terrestrial Plant(s):  
No inventory available

Aquatic Plant(s):  
No inventory available

Terrestrial Animal(s):  
Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
Cattle Egret (*Bubulcus ibis*)  
Common Myna (*Acridotheres tristis*)  
House Finch (*Carpodacus mexicanus*)  
House Sparrow (*Passer domesticus*)  
Japanese White-eye (*Zosterops japonicus*)  
Japanese Quail (*Coturnis japonica*)  
Northern Cardinal (*Cardinalis cardinalis*)  
Northern Mockingbird (*Mimus polyglottos*)  
Nutmeg Mannikin (*Lonchura punctulata*)  
Red-crested Cardinal (*Paroaria coronata*)  
Red-vented Bulbul (*Pycnonotus cafer*)  
Ring-necked Pheasant (*Phasianus colchicus*)  
Spotted Dove (*Streptopelia chinensis*)  
White-rumped Shama (*Copsychus malabaricus*)  
Zebra Dove (*Geopelia striata*)

**Mokuleia Quarry--Continued**

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**Aquatic Animal(s):**

No inventory available

**Migratory Animal(s):**

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)

**Freshwater Origin:**

1. Basal groundwater
2. Upper member Waianae volcanic series

**Comments:****References:**

- Wilson Okamoto & Associates. 1987. Draft Environmental Impact Statement Waialua-Kahuku regional water system improvements. Prepared for Board of Water Supply, City and County of Honolulu. 135 p. plus app.
- Belt Collins and Associates. 1987. Final Environmental Impact Statement Waialua-Hale'iwa wastewater facilities plan. Prepared for Department of Public Works, City and County of Honolulu, Hawaii. 269 p. plus app.
- Wirawan, N. 1974. Floristic and structural development of native dry forest stands at Mokuleia, N.W. O'ahu. Master thesis, University of Hawaii, Honolulu. 123 p.



## **Appendix D.1.2 Habitat Description of Dillingham Field Pond**

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Site: Dillingham Field Pond	Lat.: 21°34'38"
Island: O'ahu	Long.: 158°12'09"
Sector: North, 04	El.: 20-40 ft
System: Mokuleia (01)	Approx. Area/Length: 20.2 acres

### **Site Description:**

Approximately 400 acres at Dillingham Air Field in Mokuleia are now leased for cattle grazing. Because as many as 110 cattle graze within this pasture, much of the ground is heavily trampled, with well-used pathways throughout. The primary grazing area includes extensive mudflats that are flooded during heavy rains. Vegetative cover on these mudflats depends, in part, on the frequency of grazing and on the amount of time that has passed since the last rainfall and runoff from the steep slopes of the Waianae range. Lantana and pluchea cover the open pasture land, but tall growths of guava, monkeypod, Java plum, and kiawe are also found on the periphery of the mudflats.

The ephemeral nature of the Dillingham Air Field "wetland" provides little waterbird habitat. During both surveys, a small amount of turbid, standing water was present, but even the deepest puddles were less than 6 in. deep. Yet, wrinkled frog adults and tadpoles were observed on each trip. Mongoose are seen throughout Dillingham Air Field; rat runways and burrows were observed in the pastureland. The most abundant invertebrate in this area was the African snail (Shallenberger 1977).

Golden plovers are common to the area but most are confined to abandoned taxiways and open grassland elsewhere in the airfield. Black-crowned night-herons have been reported from the pond. Although these birds are perched in trees at the edge of the mudflat, the only obvious source of food in the general area are frogs in the puddles (Shallenberger 1977).

The Dillingham field area has a warm tropical climate, with mean January and July temperatures of 22°C and 25°C respectively. The wet or rainy season extends from November to April. The dry season generally starts in May and ends in October.

<b>Sensitivity Rating:</b>	Aa12m3f
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Other Value:	3f Sediment Trap

<b>Habitat Code:</b>	1-1c-3-1b-5-3-4-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	1b Agriculture Livestock
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	3 Sediment Trap + Flood Control

**Dillingham Field Pond--Continued**

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Wetland Type: 4 Marsh  
 Water Quality: 1 Fresh (< 250 mg/l Cl<sup>-</sup>)

Aquifer Code: 30401116  
 Island: 3 O'ahu  
 Sector: 04 North  
 Aquifer System: 01 Mokuleia  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 1 Unconfined  
 Aquifer Type (Geology): 6 Sedimentary

Status Code: 13221  
 Development Stage: 1 Currently Used  
 Utility: 3 Neither Drinking nor Ecologically Important  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 2 Replaceable  
 Vulnerability to Contamination: 1 High

Aquifer Code: 30401121  
 Island: 3 O'ahu  
 Sector: 04 North  
 Aquifer System: 01 Mokuleia  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 1 Flank

Status Code: 11113  
 Development Stage: 1 Currently Used  
 Utility: 1 Drinking  
 Salinity: 1 Fresh (< 250 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 3 Low

U.S. Fish & Wildlife Service Wetland Code:  
 Palustrine/Emergent/Persistent/Non-Tidal Seasonal (PEM1C)

Geology:  
 1. Coastal Plain sediments  
 2. Fossil coral reef; highly permeable but limited in extent

Soil Conservation Service, U.S. Dept. of Agriculture 1975:  
 LuA (Lualualei clay, Typic Chromusterts)  
 0-2% slopes

## Dillingham Field Pond--Continued

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### Terrestrial Threatened or Endangered Plant(s):

No inventory available

### Terrestrial Threatened or Endangered Animal(s):

Hawaiian Duck (*Anas wyvilliana*)

Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)

Hawaiian Stilt (*Himantopus mexicanus knudseni*)

### Terrestrial Plant(s):

Perfume plant (*Acacia farnesiana* (L.) Willd.)

Chinese violet (*Asystasia gangetica* (L.) T. Anders.)

Java plum (*Eugenia cuminii* (L.) Druce)

Lantana (*Lantana camara* L.)

Koa haole (*Leucaena leucocephala* (Lam.) deWit)

Pluchea (*Pluchea x fosbergii* Coop. and Gal.)

Mesquite (*Prosopis pallida* (Humb. and Bonpl. ex Willd.) HBK.)

Common guava (*Psidium guajava* L.)

Monkeypod (*Samanea saman* (Jacq.) Merr.)

### Aquatic Plant(s):

California grass (*Brachiaria mutica* (Forsk.) Stapf)

Hairy fleabane (*Pluchea odorata* (L.) Cass.)

### Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)

Cattle Egret (*Bubulcus ibis*)

Common Myna (*Acridotheres tristis*)

House Finch (*Carpodacus mexicanus*)

House Sparrow (*Passer domesticus*)

Japanese White-eye (*Zosterops japonicus*)

Japanese Quail (*Coturnis japonica*)

Laysan Albatross (*Diomedea immutabilis*)

Northern Cardinal (*Cardinalis cardinalis*)

Red-crested Cardinal (*Paroaria coronata*)

Spotted Dove (*Streptopelia chinensis*)

Zebra Dove (*Geopelia striata*)

Mongoose (*Herpestes auropunctatus*)

### Aquatic Animal(s):

Wrinkled Frog (*Rana rugosa*)

### Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica fulva*)

**Dillingham Field Pond--Continued**

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**Freshwater Origin:**

1. Basal
2. Occurs in unconfined fossil reef
3. Groundwater originates as local recharge and perhaps from upward seepage from volcanic aquifer

**Comments:****References:**

Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.

Wilson Okamoto & Associates. 1987. Draft Environmental Impact Statement Waialua-Kahuku regional water system improvements. Prepared for Board of Water Supply, City and County of Honolulu. 135 p. plus app.

Wirawan, N. 1974. Floristic and structural development of native dry forest stands at Mokuleia, N.W. O'ahu. Master thesis, University of Hawaii, Honolulu. 123 p.



### **Appendix D.1.3 Habitat Description of Crowbar Ranch Pond**

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Site:	Crowbar Ranch Pond	Lat.:	21°34'53"
Island:	O'ahu	Long.:	158°10'33"
Sector:	North, 04	El.:	20-40 ft
System:	Mokuleia (01)	Approx. Area/Length:	5.7 acres

#### **Site Description:**

This is a small, man-made and privately owned pond near Mokuleia on the North Shore of O'ahu. It is a former rock quarry which provides a good habitat for a number of coots.

The project area is predominantly pasture land of open to semi-open grassy areas. In the semi-open areas, there are scattered trees and shrubs. Cattle egrets, associated with horses and cattle, are often seen in the lower pastures. Bird densities and varieties are high in this habitat, with a number of seed eating species present. Birds and several small mammal species, such as the mongoose and the house mouse, are frequently encountered around the livestock watering troughs.

Crowbar Ranch has a warm tropical climate. The wet season extends from November through April; the dry from May through October. Rainfall in the upper elevations of the Waianaes is a consistent source of groundwater recharge. Prevailing breezes are northeast trade winds.

<b>Sensitivity Rating:</b>		Aa12m3f
Main Water Source:	A	Groundwater
Habitat:	a	Natural
Endangered Species:	1	Observed
Wetland Avifauna:	2m	Migratory Fowl
Other Value:	3f	Sediment Trap
<b>Habitat Code:</b>		1-1b-3-1b-5-3-4-1
Water Source:	1	Groundwater
Habitat Origin/Development:	1b	Natural/Altered
Ecological Character:	3	Endangered Species + Migratory Birds
Present Activities:	1b	Agriculture Livestock
Social Significance:	5	Neither Historic nor Wildlife Protected
Physical Significance:	3	Sediment Trap + Flood Control
Wetland Type:	4	Marsh
Water Quality:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
<b>Aquifer Code:</b>		30401116
Island:	3	O'ahu
Sector:	04	North
Aquifer System:	01	Mokuleia
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary

**Crowbar Ranch Pond--Continued**

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Status Code: 13221  
 Development Stage: 1 Currently Used  
 Utility: 3 Neither Drinking nor Ecologically Important  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 2 Replaceable  
 Vulnerability to Contamination: 1 High

Aquifer Code: 30401121  
 Island: 3 O'ahu  
 Sector: 04 North  
 Aquifer System: 01 Mokuleia  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 1 Flank

Status Code: 11113  
 Development Stage: 1 Currently Used  
 Utility: 1 Drinking  
 Salinity: 1 Fresh (< 250 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 3 Low

U.S. Fish & Wildlife Service Wetland Code:  
 Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent/ Excavated  
 (POWHx)

Geology:  
 1. Coastal Plain sediments  
 2. Fossil coral reef; highly permeable but limited in extent

Soil Conservation Service, U.S. Dept. of Agriculture 1975:  
 Mt (Mokuleia clay loam, Typic Haplustolls)

PsA (Pulehu clay loam, Cumulic Haplustolls)  
 0-3% slopes

Terrestrial Threatened or Endangered Plant(s):  
 No inventory available

Terrestrial Threatened or Endangered Animal(s):  
 Hawaiian Coot (*Fulica americana alai*)  
 Hawaiian Duck (*Anas wyvilliana*)  
 Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
 Hawaiian Stilt (*Himantopus mexicanus knudseni*)

## Crowbar Ranch Pond--Continued

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### Terrestrial Plant(s):

- Perfume plant (*Acacia farnesiana* (L.) Willd.)
- Java plum (*Eugenia cuminii* (L.) Druce)
- Koa haole (*Leucaena leucocephala* (Lam.) deWit)
- Cherry tomato (*Lycopersicon esculentum* Mill.)
- Guinea grass (*Panicum maximum* Jacq.)
- Mesquite (*Prosopis pallida* (Humb. and Bonpl. ex Willd.) HBK.)

### Aquatic Plant(s):

- California grass (*Brachiaria mutica* (Forsk.) Stapf)

### Terrestrial Animal(s):

- Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)
- Cattle Egret (*Bubulcus ibis*)
- Common Myna (*Acridotheres tristis*)
- House Finch (*Carpodacus mexicanus*)
- House Sparrow (*Passer domesticus*)
- Japanese White-eye (*Zosterops japonicus*)
- Northern Cardinal (*Cardinalis cardinalis*)
- Northern Mockingbird (*Mimus polyglottos*)
- Red Avadavat (*Amandava amandava*)
- Red-crested Cardinal (*Paroaria coronata*)
- Red-vented Bulbul (*Pycnonotus cafer*)
- Ring-necked Pheasant (*Phasianus colchicus*)
- Spotted Dove (*Streptopelia chinensis*)
- Zebra Dove (*Geopelia striata*)
- Mongoose (*Herpestes auropunctatus*)

### Aquatic Animal(s):

- Bluegill Sunfish (*Lepomis macrochirus Rafinesque*)
- Chinese Catfish (*Clarias fuscus*)
- Cichlid (*Cichlasoma* sp.)
- Common Carp (*Cyprinus carpio* (Linnaeus))
- Electrid (*Eleotris sandwicensis Vaillant and Sauvage*)
- Green Swordtail (*Xiphophorus helleri* (Heckel))
- Guppy (*Poecilia reticulata Peters*)
- Silver Perch (*Kuhlia sandwicensis*)
- Mosquitofish (*Gambusia affinis* (Baird and Girard))
- Tilapia (*Tilapia mossambica*)
- 'O'opu 'alamo'o (*Lentipes concolor*)
- 'O'opu nakea (*Awaous stamineus*)
- 'O'opu naniha (*Awaous genivittatus*)
- 'O'opu nopili (*Sicydium stimsonii*)
- Oriental Weatherfish (*Misgurnus anguillicaudatus* (Cantor))

**Crowbar Ranch Pond--Continued**

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Sailfin Molly (*Poecilia latipinna* (Lesueur))  
 Shortfin Molly (*Poecilia mexicana*)  
 Smallmouth Bass (*Micropterus dolomieu* Lacepede)  
 Snakehead (*Ophicephalus striatus*)  
 Southern Platyfish (*Xiphophorus maculatus* (Gunther))  
 Top Minnow (*Poecilia vittata*)

**Migratory Animal(s):**

Lesser Golden-Plover (*Pluvialis dominica* (fulva))  
 Ruddy Turnstone (*Arenaria interpres*)  
 Sanderling (*Calidris alba*)  
 Wandering Tattler (*Heteroscelus incanus*)

**Freshwater Origin:**

1. Basal
2. Occurs in unconfined fossil reef
3. Groundwater originates as local recharge and perhaps from upward seepage from volcanic aquifer

**Comments:****References:**

- Wanket, W.E. Inc. 1987. Final Environmental Impact Statement Mokuleia development proposal, Mokuleia, O'ahu. 120 p. plus app.
- Okuda, Barry R. Inc. 1987. Final Environmental Impact Statement for the proposed general plan secondary resort area at Mokuleia. 107 p.
- Department of Land and Natural Resources. 1984. Surveys and inventories of waterbirds in the State of Hawaii. Project no. W-18-R-8; Job no. R-III-A. 33 p.
- U.S. Fish and Wildlife Service. 1985. Recovery plan for the Hawaiian Waterbirds. Prepared for U.S. Fish and Wildlife Service, Portland, Oregon. 99 p.
- Wirawan, N. 1974. Floristic and structural development of native dry forest stands at Mokuleia, N.W. O'ahu. Master thesis, University of Hawaii, Honolulu. 123 p.

**Appendix D.2 System-Wide Characteristics of Ecologically Sensitive Habitats,  
Aquifers of North Sector, Waialua System**

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Aquifer System: Waialua (02)

Aquifer Sector: North (04)

Island: O'ahu (3)

Water Wells in Aquifer System (Div. of Water and Land Development 1984):

Disposal	-	Domestic	-	Industrial	1
Irrigation	27	Lost	-	Municipal	4
Observation	9	Other	2	Recharge	-
Sealed	6	Unused	3	Unknown	37

(Department of Health 1987):

Drinking	-
Other	-

Total Number of Injection Wells: 14

Water Wells or Sampling Sites Once Contaminated with DBCP, EDB or TCP  
(Water Resources Research Center 1985):

3404-02	DBCP	TCP
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Potential Pollutant Sources and Pollutants (see Fig. 2):

Source: Waialua Sugar Company, Inc. (NPDES 230)

Pollutants: Agricultural wastes

Discharge: 14 mgd

Source: Assn. of Apt. Owners of Puuiki Hale Condominium (UO 1202)

Pollutants: Secondary treated sewage

Discharge: 4,000 gpd

Source: C & C of Honolulu, Paalaa Kai WWTP (UO 1258)

Pollutants: Secondary treated sewage

Discharge: 55,000 gpd

Source: Hawaii Civic Service, Inc. Hale'iwa Senior Center (UO 1350)

Pollutants: Secondary treated sewage

Discharge: 13,000 gpd

Source: Sunset Shores STP under Chaney, Brooks and Company (UO 1324)

Pollutants: Secondary treated sewage

Discharge: 13,000 gpd

Source: Assn. of Apartment Owners of Ono Vista Condominium (UO 1305)

Pollutants: Secondary treated sewage

Discharge: 23,000 gpd

**Waialua--Continued**

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**Source:** Stormwater Runoff

**Pollutants:** Petroleum products, heavy metals, and fine sediments

**Discharge:** Non-point Source

## Appendix D.2.1 Habitat Description of Waialua Sugar Settling Basins

Site:	Waialua Sugar Settling Basins	Lat.:	21°34'40"
Island:	O'ahu	Long.:	158°08'30"
Sector:	North, 04; North, 04	El.:	0-40 ft
System:	Mokuleia (01); Waialua (02)	Approx. Area/Length:	217.6 acres

### Site Description:

These are large settling basins used by the sugar plantation to settle out the sediments from irrigation overflow.

Sensitivity Rating:	Bb12m3f
Main Water Source:	B Not Groundwater
Habitat:	b Artificial
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Other Value:	3f Sediment Trap
Habitat Code:	2-2-3-1a-5-1-1-4
Water Source:	2 Other
Habitat Origin/Development:	2 Artificial
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	1a Agriculture Crops
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	1 Sediment Trap
Wetland Type:	1 Pond
Water Quality:	4 Combination
Aquifer Code:	30401116
Island:	3 O'ahu
Sector:	04 North
Aquifer System:	01 Mokuleia
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	6 Sedimentary
Status Code:	13221
Development Stage:	1 Currently Used
Utility:	3 Neither Drinking nor Ecologically Important
Salinity:	2 Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	2 Replaceable
Vulnerability to Contamination:	1 High
Aquifer Code:	30401121
Island:	3 O'ahu
Sector:	04 North

**Waialua Sugar Settling Basins--Continued**


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Aquifer System:	01	Mokuleia
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank
Status Code:		11113
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	3	Low
Aquifer Code:		30402116
Island:	3	O'ahu
Sector:	04	North
Aquifer System:	02	Waialua
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30402121
Island:	3	O'ahu
Sector:	04	North
Aquifer System:	02	Waialua
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank
Status Code:		11213
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	3	Low



## Waialua Sugar Settling Basins--Continued

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### U.S. Fish & Wildlife Service Wetland Code:

Palustrine/Emergent/Persistent/Tidal Artificial/Non-Tidal  
Semipermanent/Dike-Impounded (PEM1KFh)

### Geology:

1. Coastal plain sediments
2. Caprock on deeper Koolau basaltic aquifer

### Soil Conservation Service, U.S. Dept. of Agriculture 1975:

Fd (Fill land)

KmA (Keaau clay, Typic Tropaquepts)  
0-2% slopes

Ph (Pearl Harbor clay, Typic Tropaquepts)

WkA (Waialua silty clay, Vertic Haplustolls)  
0-3% slopes

### Terrestrial Threatened or Endangered Plant(s):

No inventory available

### Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)

### Terrestrial Plant(s):

No inventory available

### Aquatic Plant(s):

No inventory available

### Terrestrial Animal(s):

No inventory available

### Aquatic Animal(s):

No inventory available

### Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
Ruddy Turnstone (*Arenaria interpres*)  
Sanderling (*Calidris alba*)  
Wandering Tattler (*Heteroscelus incanus*)

**Waialua Sugar Settling Basins--Continued**

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**Freshwater Origin:**

1. Basal
2. Sediments
3. Artesian seepage from confined Koolau aquifer

**Comments:****References:**

- Wilson Okamoto & Associates. 1987. Draft Environmental Impact Statement Waialua-Kahuku regional water system improvements. Prepared for Board of Water Supply, City and County of Honolulu. 135 p. plus app.
- Belt Collins and Associates. 1987. Final Environmental Impact Statement Waialua-Hale'iwa wastewater facilities plan. Prepared for Department of Public Works, City and County of Honolulu, Hawaii. 269 p. plus app.

### Appendix D.3 System-Wide Characteristics of Ecologically Sensitive Habitats, Aquifers of North Sector, Kawaiiloa System

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Aquifer System: Kawaiiloa (03)

Aquifer Sector: North (04)

Island: O'ahu (3)

Water Wells in Aquifer System (Div. of Water and Land Development 1984):

Disposal	-	Domestic	2	Industrial	1
Irrigation	27	Lost	-	Municipal	4
Observation	9	Other	2	Recharge	-
Sealed	12	Unused	11	Unknown	37

(Department of Health 1987):

Drinking	-
Other	-

Total Number of Injection Wells: 10

Water Wells or Sampling Sites Once Contaminated with DBCP, EDB or TCP  
(Water Resources Research Center 1985):

3404-02	DBCP	TCP
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Potential Pollutant Sources and Pollutants (see Fig. 2):

Source: Agricultural Runoff  
Pollutants: Nitrates, soil adsorbed herbicides, Dalapon, and 2,4D  
Discharge: Non-point Source

Source: Associates Four dba Waimea Falls Park (UO 1227)  
Pollutants: Primary treated sewage  
Discharge: 13,000 gpd

Source: C & C of Honolulu, Ke Nui Road Drainage System #1 (UO 1209)  
Pollutants: Untreated storm water runoff  
Discharge: Non-point Source

Source: C & C of Honolulu, Ke Nui Road Drainage System #2 (UO 1210)  
Pollutants: Untreated storm water runoff  
Discharge: Non-point Source

Source: Sunset Development Co., Inc. Treatment Facility (UO 1216)  
Pollutants: Secondary treated domestic sewage  
Discharge: 6,624 gpd

Source: Sunset Vista, Robert N. Moran, Owner (UO 1247)  
Pollutants: Secondary treated sewage  
Discharge: 4,000 gpd

**Kawailoa--Continued**

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Source: Velzyland II, Velzy, Inc. (UO 1328)

Pollutants: Secondary treated sewage

Discharge: 38,400 gpd

Source: Cattle Pasture

Pollutants: Fecal coliform

Discharge: Non-point Source

Source: Kawailoa Landfill

Pollutants: Landfill runoff, leachates

Discharge: Non-point Source

Source: Stormwater Runoff

Pollutants: Petroleum products, heavy metals, and fine sediments

Discharge: Non-point Source

Source: Waialua Sugar Company, Inc. (NPDES 230)

Pollutants: Agricultural wastes

Discharge: 14 mgd

### Appendix D.3.1 Habitat Description of Waimea Falls Arboretum

---

Site: Waimea Falls Arboretum	Lat.: 21°37'58"
Island: O'ahu	Long.: 158°02'37"
Sector: North, 04	El.: 0-200 ft
System: Kawailoa (03)	Approx. Area/Length: 1.5 miles

#### Site Description:

Waimea Bay, on the northwestern coast of O'ahu, is the drowned lower portion of a valley eroded in the bedrock lavas of the Koolau volcano. The upper end of Waimea valley is in the high rainfall crest area of the Koolau Range. Waimea River, which enters the Bay on the narrow sedimentary fill of the upper part of the submerged valley, is tidal for about 610 m (2,000 ft). During the summer the river is frequently cut off entirely from the ocean by a sand bar; the dry weather flow enters entirely by seepage through the beach.

The ephemeral wetland along the lower portion of Waimea River provides only a marginal waterbird habitat because of frequent fluctuations in water level and the encroachment of grasses. The river is also subjected to continuing human disturbance associated with the beach park and Waimea Falls Park. Dogs, cats, and mongoose are common in the area and presumably inhibit nesting along the river (Shallenberger 1977).

Tilapia, mullet, and mosquitofish are found in the lower reaches of Waimea River. Northern cardinals, common mynas, Japanese white-eyes, barred and spotted doves, and spotted munia are common to the area (Shallenberger 1977).

Several species of exotic ducks have been released by the management at Waimea Falls Park. Whether or not these captive-reared birds are breeding successfully in the area has not been determined. An employee at the park reported infrequent observations of Hawaiian coots in the stream (Shallenberger 1977).

Due to its location and topography Waimea Valley has two distinct climatic conditions. The mauka section of the valley receives an annual average rainfall of about 70 in. The makai coastal third of the valley receives an average annual rainfall of close to 30 in.

Sensitivity Rating:	Aa12wm3fh
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Status:	2w Wildlife Protected
Wetland Avifauna:	m Migratory Fowl
Other Value:	3f Sediment Trap
Other Value:	h Historical Value
Habitat Code:	1-1c-3-4-4-3-2-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds

**Waimea Falls Arboretum--Continued**

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Present Activities:	4	Recreation
Social Significance:	4	Historic Not Registered + Wildlife Protected
Physical Significance:	3	Sediment Trap + Flood Control
Wetland Type:	2	Stream
Water Quality:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )

Aquifer Code:		30403111
Island:	3	O'ahu
Sector:	04	North
Aquifer System:	03	Kawailoa
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	1	Flank

Status Code:		11111
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High

## U.S. Fish &amp; Wildlife Service Wetland Code:

Estuarine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal (E1OWL)

Estuarine/Intertidal/Emergent/Persistent/Tidal Regular (E2EM1N)

Estuarine/Intertidal/Forested/Broad-Leaved Evergreen/Tidal Regular (E2FO3N)

Estuarine/Intertidal/Forested/Broad-Leaved Evergreen/Tidal Irregular (E2FO3P)

Estuarine/Intertidal/Scrub-Shrub/Broad-Leaved Evergreen/ Tidal Irregular  
(E2SS3P/EM1)

Palustrine/Forested/Broad-Leaved Evergreen/Non-Tidal Seasonal (PFO3C)

## Geology:

1. Shallow alluvial fill overlying Koolau volcanic series
2. Alluvium less permeable than volcanic rock; water table in Koolau formation is below alluvial fill

## Soil Conservation Service, U.S. Dept. of Agriculture 1975:

BS (Beaches)

## Waimea Falls Arboretum--Continued

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HnA (Hanalei silty clay, Typic Fluvaquents)  
0-2% slopes

JaC (Jaucas sand, Typic Ustipsamments)  
0-15% slopes

KlaB (Kawaihapai stony clay loam, Cumulic Haplustolls)  
2-6% slopes

Terrestrial Threatened or Endangered Plant(s):  
No inventory available

Terrestrial Threatened or Endangered Animal(s):  
Hawaiian Crow (*Corvus hawaiiensis*)  
Hawaiian Duck (*Anas wyvilliana*)  
Hawaiian Gallinule (*Gallinula chloropus sandwichensis*)

Terrestrial Plant(s):  
Koa (*Acacia koa* Gray)  
Candlenut tree (*Aleurites moluccana* (L.) Willd.)  
Water hyssop (*Bacopa monnieri* (L.) Pennell)  
Kolomona (*Cassia surattensis* Burm. f.)  
Ti (*Cordyline terminalis* (L.) Kunth)  
Hawaiian coral bean (*Erythrina sandwichensis* Deg.)  
Java plum (*Eugenia cuminii* (L.) Druce)  
Lantana (*Lantana camara* L.)  
Indian mulberry (*Morinda citrifolia* L.)  
Screw pine (*Pandanus odoratissimus* L. f.)  
Yellow liliko'i (*Passiflora edulis* f. *flavicarpa* Deg.)  
Honey tree (*Pleomele aurea* (Mann) N.E. Br.)  
Common guava (*Psidium guajava* L.)  
Christmas-berry tree (*Schinus terebinthifolius* Raddi)

Aquatic Plant(s):  
California grass (*Brachiaria mutica* (Forsk.) Stapf)  
Seashore paspalum (*Paspalum vaginatum* Sw.)  
California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)  
Great bulrush (*Scirpus validus* Vahl)

Terrestrial Animal(s):  
'Apapane (*Himatione sanguinea*)  
Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
Common Myna (*Acridotheres tristis*)  
'Elepaio (*Chasiempis sandwichensis sandwichensis*)

## Waimea Falls Arboretum--Continued

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House Sparrow (*Passer domesticus*)  
 Japanese White-eye (*Zosterops japonicus*)  
 Northern Cardinal (*Cardinalis cardinalis*)  
 Nutmeg Mannikin (*Lonchura punctulata*)  
 O'ahu 'amakihi (*Hemignathus virens chloris*)  
 Red-crested Cardinal (*Paroaria coronata*)  
 Ring-necked Pheasant (*Phasianus colchicus*)  
 Spotted Dove (*Streptopelia chinensis*)  
 White-rumped Shama (*Copsychus malabaricus*)  
 Zebra Dove (*Geopelia striata*)  
 Mongoose (*Herpestes auropunctatus*)

### Aquatic Animal(s):

Mosquitofish (*Gambusia affinis (Baird and Girard)*)  
 Tilapia (*Tilapia mossambica*)  
 Striped Mullet (*Mugil cephalus L.*)

### Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
 Mallard (*Anas platyrhynchos*)

### Freshwater Origin:

1. High level water
2. Shallow alluvium
3. Stream water and local recharge

### Comments:

### References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
- Elliott, M.E. 1981. Wetlands and wetland vegetation of the Hawaiian Islands. Master thesis (Geography), University of Hawaii, Honolulu. 228 p.
- Hall, D.H. 1970. Use of agricultural chemicals and factors contributing to their transport to estuaries in Hawaii. Technical report no. 30, Water Resources Research Center, University of Hawaii, Honolulu. 44 p.
- Bishop Corporation. 1974. An Assessment of Environmental Impact resulting from the proposed expansion of Waimea Falls Park. 37 p. plus app.



**Waimea Falls Arboretum--Continued**

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Cox, D.C., and Gordon, L.C. Jr. 1970. Estuarine pollution in the State of Hawaii. Technical report no. 31, Water Resources Research Center, University of Hawaii, Honolulu. 151 p.

Wilson Okamoto & Associates. 1987. Draft Environmental Impact Statement Waialua-Kahuku regional water system improvements. Prepared for Board of Water Supply, City and County of Honolulu. 135 p. plus app.



### Appendix D.3.2 Habitat Description of Kalou Marsh

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Site:	Kalou Marsh	Lat.:	21°41'25"
Island:	O'ahu	Long.:	158°01'45"
Sector:	North, 04	El.:	20-40 ft
System:	Kawailoa (03)	Approx. Area/Length:	14.7 acres

#### Site Description:

Kalou Marsh is in the Waiale'e district of O'ahu, within the University of Hawaii Agricultural Experiment Station. The Waiale'e Livestock Research Center (WLRC) is located within the narrow coastal area between Sunset Beach and Kawela Bay on O'ahu's North Shore (Mogi 1980).

The marsh is a spring-fed pond which drains into the sea via a culvert through the sand dunes along the shore. It is an inland pond, altered by man, and covers approximately one acre. There is a retaining wall around the pond and a fence around part of the perimeter. The pond was formerly used by the old Waiale'e Boy's Home for its taro farming activities. It is currently used by the WLRC to irrigate pastures. The pond is in poor condition because of inadequate use and maintenance and is currently only a fraction of its former size. Parts of the northeastern section of the pond have been previously bulldozed and much of the pond has become overgrown. A flock of geese is kept at the site to prevent pondside weeds and vegetation from completely covering the pond.

Sensitivity Rating:	Aa12m3h
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Other Value:	3h Historical Value
Habitat Code:	1-1c-3-1b-1a-4-1-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	1b Agriculture Livestock
Social Significance:	1a Historic Registered
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	1 Pond
Water Quality:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:	30403116
Island:	3 O'ahu
Sector:	04 North
Aquifer System:	03 Kawailoa
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined

**Kalou Marsh--Continued**

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Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30403122
Island:	3	O'ahu
Sector:	04	North
Aquifer System:	03	Kawailoa
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	2	Dike
Status Code:		21112
Development Stage:	2	Potential Use
Utility:	1	Drinking
Salinity:	1	Fresh (<250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	2	Moderate
U.S. Fish & Wildlife Service Wetland Code:		
		Palustrine/Emergent/Persistent/Non-Tidal Semipermanent/ Dike-Impounded (PEM1Fh)
		Palustrine/Emergent/Persistent/Tidal Artificial/Non-Tidal Semipermanent/Dike-Impounded (PEM1KFh)
		Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent/ Dike-Impounded (POWHh)
Geology:		
		1. Termination of northern rift zone of Koolau volcano
		2. Lavas intersected by vertical dikes in marginal dike zone
Soil Conservation Service, U.S. Dept. of Agriculture 1975:		
		Ph (Pearl Harbor clay, Typic Tropaquepts)
Terrestrial Threatened or Endangered Plant(s):		
		No inventory available

## Kalou Marsh--Continued

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### Terrestrial Threatened or Endangered Animal(s):

- Hawaiian Coot (*Fulica americana alai*)
- Hawaiian Duck (*Anas wyvilliana*)
- Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)

### Terrestrial Plant(s):

- Common ironwood (*Casuarina equisetifolia* L.)
- Coconut tree (*Cocos nucifera* L.)
- Pangola grass (*Digitaria decumbens* Stent)
- Poinsettia (*Euphorbia pulcherrima* Willd.)
- Koa haole (*Leucaena leucocephala* (Lam.) deWit)
- Mango (*Mangifera indica* L.)
- Guinea grass (*Panicum maximum* Jacq.)
- Kikuyu grass (*Pennisetum clandestinum* Hochst.)
- Date palm (*Phoenix dactylifera* L.)
- Plumeria (*Plumeria* sp.)
- Royal palm (*Roystonea regia* (HBK.) Cook)
- Christmas-berry tree (*Schinus terebinthifolius* Raddi)
- False kamani (*Terminalia catappa* L.)
- Portia tree (*Thespesia populnea* (L.) Sol.)
- Large flowered caltrop (*Tribulus cistoides* L.)

### Aquatic Plant(s):

- California grass (*Brachiaria mutica* (Forsk.) Stapf)
- Hau (*Hibiscus tiliaceus* L.)
- Primrose willow (*Ludwigia octovalvis* (Jacq.) Raven)
- California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)
- Great bulrush (*Scirpus validus* Vahl)

### Terrestrial Animal(s):

- Cattle Egret (*Bubulcus ibis*)
- Common Myna (*Acridotheres tristis*)
- House Finch (*Carpodacus mexicanus*)
- House Sparrow (*Passer domesticus*)
- Northern Cardinal (*Cardinalis cardinalis*)
- Mongoose (*Herpestes auropunctatus*)

### Aquatic Animal(s):

No inventory available

### Migratory Animal(s):

- Lesser Golden-Plover (*Pluvialis dominica (fulva)*)

**Kalou Marsh--Continued**

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**Freshwater Origin:**

1. Basal, but in dike compartments
2. Shallow alluvium on Koolau volcanic series

**Comments:**

Once known as Kalou Fishpond, this site is listed in the Hawaii Register of Historic Places.

**References:**

Elliott, M.E. 1981. Wetlands and wetland vegetation of the Hawaiian Islands. Master thesis (Geography), University of Hawaii, Honolulu. 228 p.

Elliott, M.E., and Hall, E.M. 1977. Wetlands and wetland vegetation of Hawaii. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 344 p.

H. Mogi Planning and Research, Inc. 1980. Draft Environmental Impact Statement for Waiale'e livestock research center. Prepared for the Department of Accounting and General Services, State of Hawaii. 86 p. plus app.

Wilson Okamoto & Associates. 1987. Draft Environmental Impact Statement Waialua-Kahuku regional water system improvements. Prepared for Board of Water Supply, City and County of Honolulu. 135 p. plus app.

### Appendix D.3.3 Habitat Description of 'Uko'a Pond

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Site: 'Uko'a Pond	Lat.: 21°36'25"
Island: O'ahu	Long.: 158°05'50"
Sector: North, 04	El.: 20-40 ft
System: Kawailoa (03)	Approx. Area/Length: 144.2 acres

#### Site Description:

'Uko'a Pond and its surrounding marsh are located approximately one mile north-northeast of Hale'iwa and south of Kawailoa Landfill. Water from this basal, spring-fed coastal marsh has been tapped and pumped for sugar cane irrigation.

The large water body is generally less than 0.9 to 1 m (3-4 ft) deep, somewhat deeper at the east end. The formal channel to Loko Ea is choked with California grass, bulrush and other vegetation, but there is still some movement between the two sites during heavy rains. Towards the southwestern portion of the marsh, conditions are favorable in dry seasons for cattle grazing.

Much of this privately owned marsh has been overtaken by exotic grasses. 95% of the open waters of the pond and stream are covered by water lettuce, water hyacinth, and bulrushes. The area surrounding the marsh consists of fairly dry, scrub vegetation.

Average annual rainfall in the area is less than 30 in., of which about 75% falls between October and April. Average annual temperature is 73°F, with humidity ranging from 60 to 80%. The cooling northeast trade winds are present 60% of the time.

Sensitivity Rating:	Aa12m3f
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Other Value:	3f Sediment Trap
Habitat Code:	1-1c-3-1b-5-3-1-4
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	1b Agriculture Livestock
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	1 Pond
Water Quality:	4 Combination
Aquifer Code:	30403116
Island:	3 O'ahu
Sector:	04 North
Aquifer System:	03 Kawailoa
Aquifer Type (Hydrology):	1 Basal

**‘Uko‘a Pond--Continued**

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Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30403121
Island:	3	O‘ahu
Sector:	04	North
Aquifer System:	03	Kawailoa
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank
Status Code:		12312
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	3	Moderate (1,000-5,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	2	Moderate
U.S. Fish & Wildlife Service Wetland Code:		
		Palustrine/Emergent/Persistent/Non-Tidal Semipermanent (PEM1F)
		Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent (POWH)
		Palustrine/Scrub-Shrub/Broad-Leaved Evergreen/Non-Tidal Seasonal (PSS3/EM1C)
Geology:		
		1. Coastal plain sediments on Koolau lava
		2. Sediments form a caprock, confining groundwater in the Koolau formation
Soil Conservation Service, U.S. Dept. of Agriculture 1975:		
		JaC (Jaucas sand, Typic Ustipsamments)
		0-15% slopes
		MZ (Marsh)
		MnC (Mamala stony silty clay loam, Typic Tropofolists)
		0-12% slopes



## 'Uko'a Pond--Continued

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### TR (Tropaquepts)

#### Terrestrial Threatened or Endangered Plant(s):

No inventory available

#### Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)  
 Hawaiian Duck (*Anas wyvilliana*)  
 Hawaiian Gallinule (*Gallinula chloropus sandwicensis*)  
 Hawaiian Owl (*Asio flammeus sandwichensis*)  
 Hawaiian Stilt (*Himantopus mexicanus knudseni*)

#### Terrestrial Plant(s):

Water hyssop (*Bacopa monnieri* (L.) Pennell)  
 Vasey grass (*Paspalum urvillei* Steud.)  
 Pluchea (*Pluchea x fosbergii* Coop. and Gal.)

#### Aquatic Plant(s):

California grass (*Brachiaria mutica* (Forsk.) Stapf)  
 Day flower (*Commelina diffusa* Burm. f.)  
 Water lettuce (*Pistia stratiotes* L.)  
 Hairy fleabane (*Pluchea odorata* (L.) Cass.)  
 California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)  
 Great bulrush (*Scirpus validus* Vahl)

#### Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
 Cattle Egret (*Bubulcus ibis*)  
 Common Myna (*Acridotheres tristis*)  
 House Finch (*Carpodacus mexicanus*)  
 Northern Cardinal (*Cardinalis cardinalis*)  
 Spotted Dove (*Streptopelia chinensis*)  
 Zebra Dove (*Geopelia striata*)  
 Mongoose (*Herpestes auropunctatus*)

#### Aquatic Animal(s):

Crayfish (*Procambarus clarkii*)  
 Common Carp (*Cyprinus carpio* (Linnaeus))  
 Green Swordtail (*Xiphophorus helleri* (Heckel))  
 Guppy (*Poecilia reticulata* Peters)  
 Tilapia (*Tilapia mossambica*)  
 Sailfin Molly (*Poecilia latipinna* (Lesueur))  
 American Bullfrog (*Rana catesbeiana*)  
 Giant Neotropical Toad (*Bufo marinus*)

**'Uko'a Pond--Continued**

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Wrinkled Frog (*Rana rugosa*)

Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)

Northern Pintail (*Anas acuta*)

Ruddy Turnstone (*Arenaria interpres*)

Wandering Tattler (*Heteroscelus incanus*)

Freshwater Origin:

1. Basal, confined
2. Coastal plain sediment, shallow
3. Artesian flow from underlying Koolau formation

Comments:

Much of the land surrounding this marsh is used for ranching or dairying; other nearby land use includes sugar cane production and a small pumping station. These interests, in addition to the landfill and roads in the vicinity, raise the potential for disturbance of this environment (Elliott 1981).

References:

Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.

Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.

Elliott, M.E. 1981. Wetlands and wetland vegetation of the Hawaiian Islands. Master thesis (Geography), University of Hawaii, Honolulu. 228 p.

Elliott, M.E., and Hall, E.M. 1977. Wetlands and wetland vegetation of Hawaii. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 344 p.

U.S. Fish and Wildlife Service. 1985. Recovery plan for the Hawaiian Waterbirds. Prepared for U.S. Fish and Wildlife Service, Portland, Oregon. 99 p.

Wilson Okamoto & Associates. 1987. Draft Environmental Impact Statement Waialua-Kahuku regional water system improvements. Prepared for Board of Water Supply, City and County of Honolulu. 135 p. plus app.

**'Uko'a Pond--Continued**

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Belt Collins and Associates. 1987. Final Environmental Impact Statement Waialua-Hale'iwa wastewater facilities plan. Prepared for Department of Public Works, City and County of Honolulu, Hawaii. 269 p. plus app.



### Appendix D.3.4 Habitat Description of Loko Ea

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Site: Loko Ea	Lat.: 21°35'55"
Island: O'ahu	Long.: 158°06'17"
Sector: North, 04	El.: 20-40 ft
System: Kawaihoa (03)	Approx. Area/Length: 6.2 acres

#### Site Description:

Loko Ea is a "natural" pond immediately north of the mouth of Anahulu Stream. Open water formerly connected this pond with 'Uko'a Pond, but encroaching vegetation has choked the original channel. Prior to WWII there were more than 150 separate water impoundments being used in this area for production of aquatic food. The taro and lotus fields are fed by springs, wells and the perennial streams, depending upon their location. Some additional wetland habitat is created by canals that accommodate irrigation runoff from cane fields (Shallenberger 1977).

Average annual rainfall in the area is less than 30 in., of which about 75% occurs between October and April. Average annual temperature is 73°F, with humidity ranging from 60 to 80%. The cooling northeast trade winds are present about 60% of the time.

Sensitivity Rating:	Aa12m3f
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Other Value:	3f Sediment Trap
Habitat Code:	1-1c-3-5-5-3-1-4
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	1 Pond
Water Quality:	4 Combination
Aquifer Code:	30403116
Island:	3 O'ahu
Sector:	04 North
Aquifer System:	03 Kawaihoa
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	6 Sedimentary

**Loko Ea--Continued**

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Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30403121
Island:	3	O'ahu
Sector:	04	North
Aquifer System:	03	Kawailoa
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank
Status Code:		12312
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	3	Moderate (1,000-5,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	2	Moderate

**U.S. Fish & Wildlife Service Wetland Code:**

Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent/ Dike-Impounded (POWHh)

**Geology:**

1. Coastal plain sediments on Koolau lava
2. Sediments form a caprock, confining groundwater in the Koolau formation

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

TR (Tropaquepts)

**Terrestrial Threatened or Endangered Plant(s):**

No inventory available

**Terrestrial Threatened or Endangered Animal(s):**

Hawaiian Duck (*Anas wyvilliana*)  
 Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
 Hawaiian Stilt (*Himantopus mexicanus knudseni*)

**Terrestrial Plant(s):**

No inventory available

**Loko Ea--Continued**

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## Aquatic Plant(s):

No inventory available

## Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)

## Aquatic Animal(s):

No inventory available

## Migratory Animal(s):

Bufflehead (*Bucephala albeola*)

Common Black-headed Gull (*Larus ridibundus*)

Semipalmated Plover (*Charadrius semipalmatus*)

Wandering Tattler (*Heteroscelus incanus*)

White-faced Ibis (*Plegadis chihi*)

## Freshwater Origin:

1. Basal, confined
2. Coastal plain sediment, shallow
3. Artesian flow from underlying Koolau formation

## Comments:

## References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.
- Hall, D.H. 1970. Use of agricultural chemicals and factors contributing to their transport to estuaries in Hawaii. Technical report no. 30, Water Resources Research Center, University of Hawaii, Honolulu. 44 p.
- Department of Land and Natural Resources. 1984. Surveys and inventories of waterbirds in the State of Hawaii. Project no. W-18-R-8; Job no. R-III-A. 33 p.





### Appendix D.3.5 Habitat Description of Hale'iwa Lotus Farms

---

Site:	Hale'iwa Lotus Farms	Lat.:	21°35'35"
Island:	O'ahu	Long.:	158°06'30"
Sector:	North, 04	El.:	20-40 ft
System:	Waialua (02)	Approx. Area/Length:	64.3 acres

#### Site Description:

The Hale'iwa Lotus Farms wetland area is a cultivated natural marsh with a majority of the area supporting lotus, taro, and ung-choi. Uncultivated areas support dense growths of California grass, bulrush, and honohono grass. Open waters are often covered by tiny floating water ferns (Elliott 1981).

Over half of this marsh is used for the production of aquatic food crops (lotus, taro, and swamp cabbage). Areas of natural vegetation in the marsh are dominated by dense stands of *Brachiaria mutica* and *Scirpus validus*, with occasional patches of ginger. The marsh is spring-fed and running water can sometimes be heard beneath the vegetation. In the central and northeastern sections, the vegetation overlies mucky brown soil with standing water 0.3 to 0.6 m (1-2 ft) deep. Surrounding the marsh are trees and shrubs. Rural residents use the edge of marsh for various aquatic gardens.

The cool northeast trade winds are present about 60% of the time. The area averages about 760 mm (30 in.) of rainfall per year and 75% of this occurs between October and April.

Sensitivity Rating:	Aa12tm3f
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Use:	2t Traditional
Wetland Avifauna:	m Migratory Fowl
Other Value:	3f Sediment Trap
Habitat Code:	1-1c-3-1a-1b-3-1-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	1a Agriculture Crops
Social Significance:	1b Historic Not Registered
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	1 Pond
Water Quality:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:	30402116
Island:	3 O'ahu
Sector:	04 North
Aquifer System:	02 Waialua
Aquifer Type (Hydrology):	1 Basal

**Hale'iwa Lotus Farms--Continued**

---

Aquifer Type (Hydrology): 1 Unconfined  
 Aquifer Type (Geology): 6 Sedimentary

Status Code: 12211  
 Development Stage: 1 Currently Used  
 Utility: 2 Ecologically Important  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 1 High

Aquifer Code: 30402121  
 Island: 3 O'ahu  
 Sector: 04 North  
 Aquifer System: 02 Waialua  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 1 Flank

Status Code: 11213  
 Development Stage: 1 Currently Used  
 Utility: 1 Drinking  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 3 Low

**U.S. Fish & Wildlife Service Wetland Code:**

Palustrine/Emergent/Persistent/Tidal Artificial/Non-Tidal Semipermanent/  
 Dike-Impounded (PEM1KFh)

Palustrine/Scrub-Shrub/Broad-Leaved Deciduous/Non-Tidal Seasonal  
 [Emergent/Persistent/Non-Tidal Seasonal] (PSS/EM1C)

**Geology:**

1. Coastal plain sediment on Koolau volcanic series
2. Sediments act as leaky caprock to confine Koolau aquifer

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

HeA (Hale'iwa silty clay, Typic Haplustolls)  
 0-2% slopes

**Terrestrial Threatened or Endangered Plant(s):**

No inventory available

## Hale'iwa Lotus Farms--Continued

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### Terrestrial Threatened or Endangered Animal(s):

- Hawaiian Coot (*Fulica americana alai*)
- Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)
- Hawaiian Stilt (*Himantopus mexicanus knudseni*)

### Terrestrial Plant(s):

- Ornamental canna (*Canna indica* L.)
- Swamp cabbage (*Ipomea aquatica* Forsk.)
- Banana (*Musa paradisiaca* L.)
- Oriental hawksbeard (*Youngia japonica* (L.) DC.)

### Aquatic Plant(s):

- Water fern (*Azolla filiculoides* Lam.)
- California grass (*Brachiaria mutica* (Forsk.) Stapf)
- Taro (*Colocasia esculenta* (L.) Schott)
- Day flower (*Commelina diffusa* Burm. f.)
- Barnyard grass (*Echinochloa crusgalli* (L.) Beauv.)
- False daisy (*Eclipta alba* (L.) Hassk.)
- White ginger (*Hedychium coronarium* Koenig)
- Primrose willow (*Ludwigia octovalvis* (Jacq.) Raven)
- Lotus (*Nelumbo nucifera* Gaertn.)
- Indian pluchea (*Pluchea indica* (L.) Less.)
- California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)
- Great bulrush (*Scirpus validus* Vahl)

### Terrestrial Animal(s):

- Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)
- Common Myna (*Acridotheres tristis*)
- House Finch (*Carpodacus mexicanus*)
- House Sparrow (*Passer domesticus*)
- Northern Cardinal (*Cardinalis cardinalis*)
- Nutmeg Mannikin (*Lonchura punctulata*)
- Red-crested Cardinal (*Paroaria coronata*)
- Spotted Dove (*Streptopelia chinensis*)
- Zebra Dove (*Geopelia striata*)
- Mongoose (*Herpestes auropunctatus*)

### Aquatic Animal(s):

- Green Swordtail (*Xiphophorus helleri* (Heckel))
- Mosquitofish (*Gambusia affinis* (Baird and Girard))
- Tilapia (*Tilapia mossambica*)
- Sailfin Molly (*Poecilia latipinna* (Lesueur))
- Striped Mullet (*Mugil cephalus* L.)

**Hale'iwa Lotus Farms--Continued**

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## Migratory Animal(s):

Ruddy Turnstone (*Arenaria interpres*)

## Freshwater Origin:

1. Basal, confined
2. Shallow sediments of coastal plain
3. Artesian seepage from Koolau aquifer

## Comments:

## References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.
- Elliott, M.E. 1981. Wetlands and wetland vegetation of the Hawaiian Islands. Master thesis (Geography), University of Hawaii, Honolulu. 228 p.
- Elliott, M.E., and Hall, E.M. 1977. Wetlands and wetland vegetation of Hawaii. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 344 p.
- Hall, D.H. 1970. Use of agricultural chemicals and factors contributing to their transport to estuaries in Hawaii. Technical report no. 30, Water Resources Research Center, University of Hawaii, Honolulu. 44 p.
- Department of Land and Natural Resources. 1983. Statewide waterbird marking/movement study. Project no. W-18-R-8; Job no. R-III-F. 7 p.
- Park Engineering, Inc. 1977. Environmental Impact Statement for Hale'iwa Road drainage improvement project. Department of Public Works, City and County of Honolulu. 36 p. plus app.

## Appendix E.1 System-Wide Characteristics of Ecologically Sensitive Habitats, Aquifers of Windward Sector, Koolauloa System

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Aquifer System: Koolauloa (01)

Aquifer Sector: Windward (06)

Island: O'ahu (3)

Water Wells in Aquifer System (Div. of Water and Land Development 1984):

Disposal	-	Domestic	9	Industrial	4
Irrigation	57	Lost	1	Municipal	13
Observation	1	Other	4	Recharge	-
Sealed	9	Unused	10	Unknown	3

(Department of Health 1987):

Drinking	2
Other	3

Total Number of Injection Wells: 9

Water Wells or Sampling Sites Once Contaminated with DBCP, EDB or TCP  
(Water Resources Research Center 1985):

None

Potential Pollutant Sources and Pollutants (see Fig. 2):

Source: Brigham Young University Hawaii Campus (NPDES 20478)  
Pollutants: Domestic wastes from Laie STP  
Discharge: 500,000 gpd

Source: C & C of Honolulu, Laie Cesspool Sump (UO 1261)  
Pollutants: Untreated sewage  
Discharge: 17,000 gpd

Source: C & C of Honolulu, Kahuku WWTP Injection Wells (UO 1257)  
Pollutants: Secondary treated sewage  
Discharge: 42,000 gpd

Source: Marine Culture Enterprises (UO 1315)  
Pollutants: Untreated aquacultural wastewater  
Discharge: 10 mgd

Source: Pat's at Punalu'u Assn. of Apartment Owners (UO 1342)  
Pollutants: Secondary treated sewage  
Discharge: 40,000 gpd

Source: Kuilima Sewage Treatment Pond  
Pollutants: Domestic sewage

**Koolauloa--Continued**

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Source: Agricultural and aquaculture Runoff

Pollutants: Nitrates and phosphates

Discharge: Non-point Source

### Appendix E.1.1 Habitat Description of Kuilima Sewage Treatment Pond

Site:	Kuilima Sewage Treatment Pond	Lat.:	21°42'13"
Island:	O'ahu	Long.:	157°59'25"
Sector:	Windward, 06	El.:	20-40 ft
System:	Koolauloa (01)	Approx. Area/Length:	5.0 acres

#### Site Description:

The site is located on the relatively flat Kahuku coastal plain. The vast majority of the area surrounding the site is between 5 and 10 ft above sea level.

The Sewage Treatment Pond is fenced around the entire perimeter, and bordered by sloping grass-covered dikes that provide suitable resting sites for waterfowl. Water level in the sewage pond is relatively stable year round.

The mean wind speed is approximately 18 mph, among the higher average wind speeds for an O'ahu location. The trade winds are most persistent between the months of May and October during the hotter and drier season. The months between October and April are characterized by cooler temperatures and rain.

Sensitivity Rating:	Bb12m
Main Water Source:	B Not Groundwater
Habitat:	b Artificial
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Habitat Code:	2-2-3-5-5-4-1-4
Water Source:	2 Other
Habitat Origin/Development:	2 Artificial
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	1 Pond
Water Quality:	4 Combination
Aquifer Code:	30601116
Island:	3 O'ahu
Sector:	06 Windward
Aquifer System:	01 Koolauloa
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	6 Sedimentary
Status Code:	12211
Development Stage:	1 Currently Used
Utility:	2 Ecologically Important.

**Kuilima Sewage Treatment Pond--Continued**

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Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High

Aquifer Code:		30601121
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	01	Koolauloa
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank

Status Code:		12213
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	3	Low

## U.S. Fish &amp; Wildlife Service Wetland Code:

Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent/ Dike-Impounded  
(POWHh)

## Geology:

1. Kahuku coastal plain sediments
2. Alluvial sediments grade to fossil coral reef near coast; coastal plain sediment confine Koolau lava aquifer

## Soil Conservation Service, U.S. Dept. of Agriculture 1975:

LaC (Lahaina silty clay)  
7-15% slopes

## Terrestrial Threatened or Endangered Plant(s):

No inventory available

## Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)

## Terrestrial Plant(s):

Perfume plant (*Acacia farnesiana* (L.) Willd.)  
Ageratum (*Ageratum conyzoides* L.)  
Water hyssop (*Bacopa monnieri* (L.) Pennell)  
Hairy horseweed (*Bidens pilosa* L.)



## Kuilima Sewage Treatment Pond--Continued

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Spiderling (*Boerhavia diffusa* Heimerl.)  
 Maunaloa (*Dioclea violacea* Mart.)  
 Partridge pea (*Cassia leschenaultiana* DC.)  
 Common ironwood (*Casuarina equisetifolia* L.)  
 Sandbur (*Cenchrus echinatus* L.)  
 Lamb's quarters (*Chenopodium album* L.)  
 Swollen finger grass (*Chloris inflata* Link)  
 Bermuda grass (*Cynodon dactylon* (L.) Pers.)  
 Beach wiregrass (*Dactyloctenium aegyptium* (L.) Willd.)  
 Slender mimosa (*Desmanthus virgatus* (L.) Willd.)  
 Flora's paint brush (*Emilia fosbergii* Nicolson)  
 Flora's paint brush (*Emilia sonchifolia* (L.) DC.)  
 Java plum (*Eugenia cuminii* (L.) Druce)  
 Graceful spurge (*Euphorbia glomerifera* (Millsp.) L. C. Wheeler)  
 Moreton Bay fig (*Ficus macrophylla* Desf.)  
 Gaillardia (*Gaillardia pulchella* Foug.)  
 Common morning-glory (*Ipomoea purpurea* (L.) Roth)  
 Lantana (*Lantana camara* L.)  
 Koa haole (*Leucaena leucocephala* (Lam.) deWit)  
 Hawaiian wolfberry (*Lycium sandwicense* Gray)  
 Yellow sweet clover (*Melilotus indica* (L.) All.)  
 Sensitive plant (*Mimosa pudica* L.)  
 Banana (*Musa paradisiaca* L.)  
 Guinea grass (*Panicum maximum* Jacq.)  
 Hilo grass (*Paspalum conjugatum* Berg.)  
 Scarlet fruited passion flower (*Passiflora foetida* L.)  
 Wild bean (*Phaseolus lathyroides* L.)  
 Narrow-leaved plantain (*Plantago lanceolata* L.)  
 Pluchea (*Pluchea x fosbergii* Coop. and Gal.)  
 Mesquite (*Prosopis pallida* (Humb. and Bonpl. ex Willd.) HBK.)  
 Castor bean (*Ricinus communis* L.)  
 Sugar cane (*Saccharum officinarum* L.)  
 Beach naupaka (*Scaevola taccada* (Gaertn.) Roxb.)  
 Christmas-berry tree (*Schinus terebinthifolius* Raddi)  
 Sida (*Sida acuta* var. *carpinifolia* Brum. f.)  
 'Ilima (*Sida fallax* Walp.)  
 Apple of Sodom (*Solanum sodomaeum* L.)  
 Sow thistle (*Sonchus oleraceus* L.)  
 Duckweed (*Spirodela punctata* (G. F. W. Meyer))  
 Jamaica vervain (*Stachytarpheta jamaicensis* (L.) Vahl)  
 Yellow oleander (*Thevetia peruviana* (Pers.) K. Schum.)  
 Sourgrass (*Trichachne insularis* (L.) Nees)  
 Cattail (*Typha latifolia* L.)  
 Golden crown-beard (*Verbesina encelioides* (Cav.) Benth. and Hook.)

## Kuilima Sewage Treatment Pond--Continued

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Hi'aloa (*Waltheria americana* L.)  
 Cocklebur (*Xanthium saccharatum* Wallr.)  
 Oriental hawksbeard (*Youngia japonica* (L.) DC.)  
 Indian corn (*Zea mays* L.)  
 Beach morning-glory (*Ipomoea brasiliensis* (L.) Sweet)  
 Morning-glory (*Ipomoea congesta* R. Br.)  
 Sedge (*Cyperus polystachyus* Rottb.)

### Aquatic Plant(s):

California grass (*Brachiaria mutica* (Forsk.) Stapf)  
 Native sawgrass (*Cladium leptostachyum* Nees & Meyen)  
 Marsh Cyperus (*Cyperus javanicus* Houtt.)  
 Spike rush (*Eleocharis acicularis* (L.) R. and S.)  
 Spike rush (*Eleocharis geniculata* (L.) R. and S.)  
 Spike sedge (*Eleocharis obtusa* (Willd.) Schult.)  
 Hau (*Hibiscus tiliaceus* L.)  
 Lesser duckweed (*Lemna minor* L.)  
 Primrose willow (*Ludwigia octovalvis* (Jacq.) Raven)  
 Indian pluchea (*Pluchea indica* (L.) Less.)  
 Hairy fleabane (*Pluchea odorata* (L.) Cass.)  
 California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)  
 Great bulrush (*Scirpus validus* Vahl)  
 Sea purslane (*Sesuvium portulacastrum* L.)  
 Cattail (*Typha angustata* Bory & Chau.)

### Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
 Black-rumped Waxbill (*Estrilda troglodytes*)  
 Cattle Egret (*Bubulcus ibis*)  
 Common Barn-Owl (*Tyto alba*)  
 Common Myna (*Acridotheres tristis*)  
 House Finch (*Carpodacus mexicanus*)  
 House Sparrow (*Passer domesticus*)  
 Japanese White-eye (*Zosterops japonicus*)  
 Japanese Quail (*Coturnis japonica*)  
 Melodious Laughing-thrush (*Garrulax canorus*)  
 Nutmeg Mannikin (*Lonchura punctulata*)  
 Red-crested Cardinal (*Paroaria coronata*)  
 Red-vented Bulbul (*Pycnonotus cafer*)  
 Spotted Dove (*Streptopelia chinensis*)  
 White-rumped Shama (*Copsychus malabaricus*)  
 Zebra Dove (*Geopelia striata*)  
 Hawaiian Rat (*Rattus exulans hawaiiensis*)  
 House Mouse (*Mus musculus domesticus*)

**Kuilima Sewage Treatment Pond--Continued**

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Mongoose (*Herpestes auropunctatus*)  
Norway Rat (*Rattus norvegicus*)  
Roof Rat (*Rattus rattus*)

## Aquatic Animal(s):

American Bullfrog (*Rana catesbeiana*)  
Giant Neotropical Toad (*Bufo marinus*)  
Wrinkled Frog (*Rana rugosa*)

## Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
Mallard (*Anas platyrhynchos*)  
Osprey (*Pandion haliaetus*)

## Freshwater Origin:

1. Basal
2. Alluvial sediment
3. Effluent from sewage treatment plant
4. Artesian seepage

## Comments:

## References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
- Group 70, Planners. 1985. Revised Environmental Impact Statement for the proposed Kuilima Resort expansion, Vol I. Prepared for Kuilima Development Company, Honolulu, Hawaii. 200 p. plus app.
- .



## Appendix E.1.2 Habitat Description of Punahoolapa

Site: Punahoolapa	Lat.: 21°42'10"
Island: O'ahu	Long.: 157°59'00"
Sector: Windward, 06	El.: 20-40 ft
System: Koolauloa (01)	Approx. Area/Length: 83.6 acres

### Site Description:

The revised Hawaiian Waterbirds Recovery plan (1985) indicates Punahoolapa Pond and adjacent marsh have "been highly altered in recent years due to drainage, conversion agriculture and loss of water supply." Yet, the existing configuration appears to be virtually unchanged from that depicted on a topographic map prepared in the early 1940's. The pond is actually a series of interconnected pools and channels, and is supplied by runoff and leakage from the groundwater basal aquifer.

The surface of the marsh, between an elevation of 2 and 5 ft, is very level and is underlaid by peat and organic clayey silt up to 20 ft thick (EIS 1985).

Pond depth ranges from 6 in. to more than 8 to 10 ft, and water coverage of nearby mudflats varies with rainfall. The water collected within the marsh seeps into the ground and does not flow elsewhere. Geologic features pertaining to groundwater near Punahoolapa reveal a deep confined aquifer occurring in relatively porous basalt lavas beneath a limestone cap. A large marshy area north of the open pond is choked with bulrush and California grass.

The mean wind speed is about 18 mph, a higher than average wind speed for O'ahu. The trade winds are most persistent between the months of May and October during the hotter and dryer season. The months between October and April are characterized by cooler temperatures and rain.

Sensitivity Rating:	Aa12wm3f
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Status:	2w Wildlife Protected
Wetland Avifauna:	m Migratory Fowl
Other Value:	3f Sediment Trap
Habitat Code:	1-1c-3-5-2-3-4-2
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	2 Wildlife Protected
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	4 Marsh
Water Quality:	2 Brackish (250-15,000 mg/l Cl <sup>-</sup> )

**Punahoolapa--Continued**

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Aquifer Code: 30601116  
 Island: 3 O'ahu  
 Sector: 06 . Windward  
 Aquifer System: 01 Koolauloa  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 1 Unconfined  
 Aquifer Type (Geology): 6 Sedimentary

Status Code: 12211  
 Development Stage: 1 Currently Used  
 Utility: 2 Ecologically Important  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 1 High

Aquifer Code: 30601121  
 Island: 3 O'ahu  
 Sector: 06 Windward  
 Aquifer System: 01 Koolauloa  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 1 Flank

Status Code: 12213  
 Development Stage: 1 Currently Used  
 Utility: 2 Ecologically Important  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 3 Low

**U.S. Fish & Wildlife Service Wetland Code:**

Palustrine/Emergent/Persistent/Non-Tidal Semipermanent (PEM1F)

Palustrine/Forested/Broad-Leaved Evergreen/Non-Tidal Seasonal (PFO3C)

Palustrine/Scrub-Shrub/Broad-Leaved Evergreen/Non-Tidal  
Semipermanent/Partially Drained Ditched [Emergent/Persistent /Non-Tidal  
Semipermanent/Partially Drained-Ditched] (PSS3/EM1Fd)

Palustrine/Scrub-Shrub/Broad-Leaved Evergreen/Non-Tidal Seasonal (PSS3C)

**Geology:**

1. Kahuku coastal plain sediment
2. Pond sediments consist of alluvial materials; no coral except near sea coast

## Punahoolapa--Continued

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Soil Conservation Service, U.S. Dept. of Agriculture 1975:  
Ph (Pearl Harbor clay, Typic Tropaquepts)

WkA (Waialua silty clay, Vertic Haplustolls)  
0-3% slopes

Terrestrial Threatened or Endangered Plant(s):  
No inventory available

Terrestrial Threatened or Endangered Animal(s):  
Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Duck (*Anas wyvilliana*)  
Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)

Terrestrial Plant(s):  
Perfume plant (*Acacia farnesiana* (L.) Willd.)  
Ageratum (*Ageratum conyzoides* L.)  
Spiny amaranth (*Amaranthus spinosus* L.)  
Chinese violet (*Asystasia gangetica* (L.) T. Anders.)  
Water hyssop (*Bacopa monnieri* (L.) Pennell)  
Hairy horseweed (*Bidens pilosa* L.)  
Maunaloa (*Dioclea violacea* Mart.)  
Partridge pea (*Cassia leschenaultiana* DC.)  
Common ironwood (*Casuarina equisetifolia* L.)  
Sandbur (*Cenchrus echinatus* L.)  
Lamb's quarters (*Chenopodium album* L.)  
Swollen finger grass (*Chloris inflata* Link)  
Bermuda grass (*Cynodon dactylon* (L.) Pers.)  
Umbrella plant (*Cyperus alternifolius* L.)  
Beach wiregrass (*Dactyloctenium aegyptium* (L.) Willd.)  
Slender mimosa (*Desmanthus virgatus* (L.) Willd.)  
Flora's paint brush (*Emilia fosbergii* Nicolson)  
Eucalyptus (*Eucalyptus* sp.)  
Java plum (*Eugenia cuminii* (L.) Druce)  
Graceful spurge (*Euphorbia glomerifera* (Millsp.) L. C. Wheeler)  
Moreton Bay fig (*Ficus macrophylla* Desf.)  
Gaillardia (*Gaillardia pulchella* Foug.)  
Sweet potato (*Ipomoea batatas* (L.) Lam.)  
Common morning-glory (*Ipomoea purpurea* (L.) Roth)  
Lantana (*Lantana camara* L.)  
Koa haole (*Leucaena leucocephala* (Lam.) de Wit)  
Hawaiian wolfberry (*Lycium sandwicense* Gray)  
Yellow sweet clover (*Melilotus indica* (L.) All.)

**Punahoolapa--Continued**

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Sensitive plant (*Mimosa pudica* L.)  
 Banana (*Musa paradisiaca* L.)  
 Guinea grass (*Panicum maximum* Jacq.)  
 Hilo grass (*Paspalum conjugatum* Berg.)  
 Knottgrass (*Paspalum distichum* L.)  
 Scarlet fruited passion flower (*Passiflora foetida* L.)  
 Buffel grass (*Pennisetum ciliare* (L.) Link)  
 Wild bean (*Phaseolus lathyroides* L.)  
 Narrow-leaved plantain (*Plantago lanceolata* L.)  
 Pluchea (*Pluchea x fosbergii* Coop. and Gal.)  
 Mesquite (*Prosopis pallida* (Humb. and Bonpl. ex Willd.) HBK.)  
 Castor bean (*Ricinus communis* L.)  
 Sugar cane (*Saccharum officinarum* L.)  
 Christmas-berry tree (*Schinus terebinthifolius* Raddi)  
 Bristly foxtail (*Setaria verticillata* (L.) Beauv.)  
 Sida (*Sida acuta* var. *carpinifolia* Brum. f.)  
 'Ilima (*Sida fallax* Walp.)  
 Apple of Sodom (*Solanum sodomium* L.)  
 Duckweed (*Spirodela punctata* (G. F. W. Meyer))  
 Jamaica vervain (*Stachytarpheta jamaicensis* (L.) Vahl)  
 Yellow oleander (*Thevetia peruviana* (Pers.) K. Schum.)  
 Sourgrass (*Trichachne insularis* (L.) Nees)  
 Golden crown-beard (*Verbesina encelioides* (Cav.) Benth. and Hook.)  
 Hi'aloa (*Waltheria americana* L.)  
 Cocklebur (*Xanthium saccharatum* Wallr.)  
 Oriental hawkbeard (*Youngia japonica* (L.) DC.)  
 Indian corn (*Zea mays* L.)  
 Beach morning-glory (*Ipomoea brasiliensis* (L.) Sweet)  
 Morning-glory (*Ipomoea congesta* R. Br.)  
 Makaloa (*Cyperus laevigatus* L.)  
 Swamp cyclosorus (*Cyclosorus gongylodes* (Schkuhr) Link)  
 Sedge (*Cyperus polystachyus* Rottb.)  
 Maui wormwood (*Artemisia mauiensis* (Gray) Skottsb.)

**Aquatic Plant(s):**

Pickle-weed (*Batis maritima* L.)  
 California grass (*Brachiaria mutica* (Forsk.) Stapf)  
 Native sawgrass (*Cladium leptostachyum* Nees & Meyen)  
 Marsh Cyperus (*Cyperus javanicus* Houtt.)  
 Spike rush (*Eleocharis acicularis* (L.) R. and S.)  
 Spike rush (*Eleocharis geniculata* (L.) R. and S.)  
 Spike sedge (*Eleocharis obtusa* (Willd.) Schult.)  
 Hau (*Hibiscus tiliaceus* L.)  
 Lesser duckweed (*Lemna minor* L.)



## Punahoolapa--Continued

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Primrose willow (*Ludwigia octovalvis* (Jacq.) Raven)  
 Seashore paspalum (*Paspalum vaginatum* Sw.)  
 Indian pluchea (*Pluchea indica* (L.) Less.)  
 Hairy fleabane (*Pluchea odorata* (L.) Cass.)  
 California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)  
 Great Bulrush (*Scirpus validus* Vahl)  
 Sea purslane (*Sesuvium portulacastrum* L.)  
 Beach dropseed (*Sporobolus virginicus* (L.) Kunth)  
 Cattail (*Typha angustata* Bory & Chau.)

### Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
 Black-rumped Waxbill (*Estrilda troglodytes*)  
 Cattle Egret (*Bubulcus ibis*)  
 Common Barn-Owl (*Tyto alba*)  
 Common Myna (*Acridotheres tristis*)  
 House Finch (*Carpodacus mexicanus*)  
 House Sparrow (*Passer domesticus*)  
 Japanese White-eye (*Zosterops japonicus*)  
 Japanese Quail (*Coturnis japonica*)  
 Melodious Laughing-thrush (*Garrulax canorus*)  
 Northern Cardinal (*Cardinalis cardinalis*)  
 Nutmeg Mannikin (*Lonchura punctulata*)  
 Red-crested Cardinal (*Paroaria coronata*)  
 Ring-necked Pheasant (*Phasianus colchicus*)  
 Spotted Dove (*Streptopelia chinensis*)  
 White-rumped Shama (*Copsychus malabaricus*)  
 Zebra Dove (*Geopelia striata*)  
 Hawaiian Rat (*Rattus exulans hawaiiensis*)  
 House Mouse (*Mus musculus domesticus*)  
 Mongoose (*Herpestes auropunctatus*)  
 Norway Rat (*Rattus norvegicus*)  
 Roof Rat (*Rattus rattus*)

### Aquatic Animal(s):

Guppy (*Poecilia reticulata* Peters)  
 Mosquitofish (*Gambusia affinis* (Baird and Girard))  
 Tilapia (*Tilapia mossambica*)  
 Shortfin Molly (*Poecilia mexicana*)  
 Wrinkled Frog (*Rana rugosa*)  
 American Bullfrog (*Rana catesbeiana*)

**Punahoolapa--Continued**

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**Migratory Animal(s):**

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
Osprey (*Pandion haliaetus*)

**Freshwater Origin:**

1. Basal confined
2. Alluvial sediments
3. Upward seepage from confined Koolau aquifer

**Comments:**

The State Historic Preservation Office has determined that Punahoolapa Marsh is eligible for inclusion on the National Register of Historic Places. Their determination is based on the site's potential for archaeological research.

**References:**

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
- AECOS, Inc. 1983. Draft Environmental Impact Assessment Marine Culture Enterprises Kahuku Aquaculture Facility, Kahuku, O'ahu, Hawaii. Prepared for Marine Culture Enterprises, Tucson, Arizona. 222 p.
- Group 70, Planners. 1985. Revised Environmental Impact Statement for the proposed Kuilima Resort expansion, Vol I. Prepared for Kuilima Development Company, Honolulu, Hawaii. 200 p. plus app.
- U.S. Fish and Wildlife Service. 1985. Recovery plan for the Hawaiian Waterbirds. Prepared for U.S. Fish and Wildlife Service, Portland, Oregon. 99 p.

### **Appendix E.1.3 Habitat Description of Punamano National Wildlife Refuge**

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Site:	Punamano National Wildlife Refuge	Lat.:	21°42'00"
Island:	O'ahu	Long.:	157°58'30"
Sector:	Windward, 06	El.:	0-10 ft
System:	Koolauloa (01)	Approx. Area/Length:	34.9 acres

#### **Site Description:**

Punamano National Wildlife Refuge is part of the James Campbell National Wildlife Refuge established in 1977 and is located near the northern tip of the island of O'ahu. The Punamano Refuge encompasses a spring-fed natural wetland situated about one mile from the sea and one mile west of the Kii National Wildlife Refuge, on the nearly flat Kahuku flood plain on the north shore of O'ahu. At least part of the pond's water comes from a freshwater spring with an unknown flow rate, located just off the refuge. Additional springs may be located within the pond. The Kii drainage ditch connects the Punamano Pond with the Kii unit and the ocean.

Encroachment of exotic and native vegetation is diminishing the open water area of Punamano, and silt is slowly increasing the substrate within the vegetation. Eugene Kridler (Endangered Species Coordinator, USF&WS) reports he has seen this pond go dry on occasion and suggests that present ditching systems may prevent Punamano spring from supplying this pond on a permanent basis. In winter months, the area of the pond may increase as much as twenty per cent.

Non-agricultural terrestrial habitats adjacent to the refuge are dominated by dense shrubs, particularly koa haole and Christmas-berry tree in dry areas and pluchea, bulrush, hau, and pickle-weed on moist sites. Open areas have patches of California grass. These plants, provide cover for exotic mammalian predators like mongoose, feral dogs, cats, and rats. Migrant shorebirds and water fowl also seasonally frequent the area.

In periods of low rainfall, exposed mudflats provide a limited feeding habitat for shorebirds and wading birds. Dead pluchea stems exposed in shallow areas provide nest sites for coots.

The Refuge is exposed to relatively strong trade winds estimated at about 18 mph on the average. Trade winds are more persistent during the hotter and drier summer months. Between October and April cooler temperatures, heavy cloud cover, and rain are more common.

Sensitivity Rating:		Aa12wm3f
Main Water Source:	A	Groundwater
Habitat:	a	Natural
Endangered Species:	1	Observed
Wetland Status:	2w	Wildlife Protected
Wetland Avifauna:	m	Migratory Fowl
Other Value:	3f	Sediment Trap

**Punamano National Wildlife Refuge--Continued**

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Habitat Code: 1-1c-3-5-2-3-4-2  
 Water Source: 1 Groundwater  
 Habitat Origin/Development: 1c Natural/Pristine + Altered  
 Ecological Character: 3 Endangered Species + Migratory Birds  
 Present Activities: 5 Neither Agriculture, Aquaculture, nor Recreation  
 Social Significance: 2 Wildlife Protected  
 Physical Significance: 3 Sediment Trap + Flood Control  
 Wetland Type: 4 Marsh  
 Water Quality: 2 Brackish (250-15,000 mg/l Cl<sup>-</sup>)

Aquifer Code: 30601116  
 Island: 3 O'ahu  
 Sector: 06 Windward  
 Aquifer System: 01 Koolauloa  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 1 Unconfined  
 Aquifer Type (Geology): 6 Sedimentary

Status Code: 12211  
 Development Stage: 1 Currently Used  
 Utility: 2 Ecologically Important  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 1 High

Aquifer Code: 30601121  
 Island: 3 O'ahu  
 Sector: 06 Windward  
 Aquifer System: 01 Koolauloa  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 1 Flank

Status Code: 12213  
 Development Stage: 1 Currently Used  
 Utility: 2 Ecologically Important  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 3 Low

U.S. Fish & Wildlife Service Wetland Code:  
 Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent (POWH)

**Punamano National Wildlife Refuge--Continued**

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Palustrine/Scrub-Shrub/Broad-Leaved Evergreen/Non-Tidal  
Semipermanent [Emergent/Persistent/Non-Tidal Semipermanent] (PSS3/EM1F)

Geology:

1. Kahuku coastal plain sediment
2. Pond sediments-consist of alluvial materials; no coral except near sea coast

Soil Conservation Service, U.S. Dept. of Agriculture 1975:  
CR (Coral outcrop)

Ph (Pearl Harbor clay, Typic Tropaquepts)

Terrestrial Threatened or Endangered Plant(s):  
No inventory available

Terrestrial Threatened or Endangered Animal(s):  
Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Duck (*Anas wyvilliana*)  
Hawaiian Gallinule (*Gallinula chloropus sandwicensis*)  
Hawaiian Owl (*Asio flammeus sandwichensis*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)

Terrestrial Plant(s):  
Water hyssop (*Bacopa monnieri* (L.) Pennell)  
Common ironwood (*Casuarina equisetifolia* L.)  
Bermuda grass (*Cynodon dactylon* (L.) Pers.)  
Nena (*Heliotropium anomalum* var. *argenteum* Gray)  
Seaside heliotrope (*Heliotropium curassavicum* L.)  
Koa haole (*Leucaena leucocephala* (Lam.) deWit)  
Hilo grass (*Paspalum conjugatum* Berg.)  
Knottgrass (*Paspalum distichum* L.)  
Shrubby fleabane (*Pluchea symphytifolia* L. (Mill.) Gillis)  
Pluchea (*Pluchea x fosbergii* Coop. and Gal.)  
Beach naupaka (*Scaevola taccada* (Gaertn.) Roxb.)  
Christmas-berry tree (*Schinus terebinthifolius* Raddi)

Aquatic Plant(s):  
Pickle-weed (*Batis maritima* L.)  
California grass (*Brachiaria mutica* (Forsk.) Stapf)  
Hau (*Hibiscus tiliaceus* L.)  
Hairy fleabane (*Pluchea odorata* (L.) Less.)  
California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)  
Makai (*Scirpus maritimus* L. var. *paludosus* (A. Nels.) Kuk.)  
Great Bulrush (*Scirpus validus* Vahl)

## Punamano National Wildlife Refuge--Continued

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Sea purslane (*Sesuvium portulacastrum* L.)

### Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
 Cattle Egret (*Bubulcus ibis*)  
 Common Barn-Owl (*Tyto alba*)  
 Common Myna (*Acridotheres tristis*)  
 House Finch (*Carpodacus mexicanus*)  
 Nutmeg Mannikin (*Lonchura punctulata*)  
 Red-vented Bulbul (*Pycnonotus cafer*)  
 Spotted Dove (*Streptopelia chinensis*)  
 Zebra Dove (*Geopelia striata*)  
 House Mouse (*Mus musculus domesticus*)  
 Mongoose (*Herpestes auropunctatus*)  
 Roof Rat (*Rattus rattus*)

### Aquatic Animal(s):

American Bullfrog (*Rana catesbeiana*)  
 Mosquitofish (*Gambusia affinis* (Baird and Girard))  
 Tilapia (*Tilapia mossambica*)

### Migratory Animal(s):

Common Black-headed Gull (*Larus ridibundus*)  
 Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
 Lesser Scaup (*Aythya affinis*)  
 Lesser Yellowlegs (*Tringa flavipes*)  
 Long-billed Dowitcher (*Limnodromus scolopaceus*)  
 Mallard (*Anas platyrhynchos*)  
 Northern Pintail (*Anas acuta*)  
 Northern Shoveler (*Anas clypeata*)  
 Pectoral Sandpiper (*Calidris melanotos*)  
 Ruddy Turnstone (*Arenaria interpres*)  
 Sharp-tailed Sandpiper (*Calidris acuminata*)

### Freshwater Origin:

1. Basal confined
2. Alluvial sediments
3. Upward seepage from confined Koolau aquifer

### Comments:

Primary objectives of the refuge are to protect and provide a habitat for endangered species; to expand understanding and appreciation of the environment; and to provide refuge-oriented research opportunities.

**Punamano National Wildlife Refuge--Continued**

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**References:**

Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.

U.S. Fish and Wildlife Service. 1985. Master plan for the Hawaiian Wetlands National Wildlife Refuge Complex. U.S. Fish and Wildlife Service, Honolulu, Hawaii. 77 p.





### Appendix E.1.4 Habitat Description of Amorient

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Site: Amorient	Lat.: 21°41'30"
Island: O'ahu	Long.: 157°58'00"
Sector: Windward, 06	El.: 20-40 ft
System: Koolauloa (01)	Approx. Area/Length: 274.1 acres

#### Site Description:

This is one of the largest commercial aquaculture developments in the state. Good feeding and marginal nesting habitats are available for all endangered waterbird species. Predation on prawns by waterbirds, particularly herons and egrets, is of serious concern to the owner who has switched to saltwater shrimp farming. Predation remains a problem.

Sensitivity Rating:	Ab12m
Main Water Source:	A Groundwater
Habitat:	b Artificial
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Habitat Code:	1-2-3-2-5-4-1-3
Water Source:	1 Groundwater
Habitat Origin/Development:	2 Artificial
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	2 Aquaculture
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	1 Pond
Water Quality:	3 Marine (> 15,000 mg/l Cl <sup>-</sup> )
Aquifer Code:	30601116
Island:	3 O'ahu
Sector:	06 Windward
Aquifer System:	01 Koolauloa
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	6 Sedimentary
Status Code:	12211
Development Stage:	1 Currently Used
Utility:	2 Ecologically Important
Salinity:	2 Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1 Irreplaceable
Vulnerability to Contamination:	1 High

**Amorient--Continued**

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Aquifer Code: 30601121  
 Island: 3 O'ahu  
 Sector: 06 Windward  
 Aquifer System: 01 Koolauloa  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 1 Flank

Status Code: 12213  
 Development Stage: 1 Currently Used  
 Utility: 2 Ecologically Important  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 3 Low

**U.S. Fish & Wildlife Service Wetland Code:**

Palustrine/Scrub-Shrub/Broad-Leaved Evergreen/Non-Tidal Seasonal/Partially Drained-Ditched (PSS3Cd)

Palustrine/Scrub-Shrub/Broad-Leaved Evergreen/Non-Tidal Seasonal/Excavated (PSS3Cx)

Upland [Non-Wetland] (U)

**Geology:**

1. Kahuku coastal plain sediments
2. Pond sediments consist of alluvial material; no coral except near sea coast

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

Kfa (Kaloko clay, Typic Calciaquolls)

WkA (Waialua silty clay, Vertic Haplustolls)  
0-3% slopes

WkB (Waialua silty clay, Vertic Haplustolls)  
3-8% slopes

**Terrestrial Threatened or Endangered Plant(s):**

No inventory available

**Terrestrial Threatened or Endangered Animal(s):**

Hawaiian Coot (*Fulica americana alai*)

Hawaiian Duck (*Anas wyvilliana*)

Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)

## Amorient--Continued

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Hawaiian Stilt (*Himantopus mexicanus knudseni*)

Terrestrial Plant(s):

No inventory available

Aquatic Plant(s):

No inventory available

Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)

Cattle Egret (*Bubulcus ibis*)

Aquatic Animal(s):

No inventory available

Migratory Animal(s):

Fulvous Whistling-Duck (*Dendrocygna bicolor*)

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)

Long-billed Dowitcher (*Limnodromus scolopaceus*)

Ruddy Turnstone (*Arenaria interpres*)

Sanderling (*Calidris alba*)

Wandering Tattler (*Heteroscelus incanus*)

Freshwater Origin:

1. Basal
2. Shallow alluvium at inner margin of coastal plain
3. Water originates as pumpage from wells which exploit the deep Koolauloa aquifer

Comments:

According to the lease agreement, the land will be returned to its previous condition once operations cease at Amorient. The land was not previously a wetland (Borzell 1988).

References:

U.S. Fish and Wildlife Service. 1985. Recovery plan for the Hawaiian Waterbirds. Prepared for U.S. Fish and Wildlife Service, Portland, Oregon. 99 p.



**Appendix E.1.5 Habitat Description of Coconut Grove**

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Site:	Coconut Grove	Lat.:	21°41'52"
Island:	O'ahu	Long.:	157°58'07"
Sector:	Windward, 06	El.:	20-40 ft
System:	Koolauloa (01)	Approx. Area/Length:	6.5 acres

**Site Description:**

This wetland site adjacent to the Amorient shrimp farm consists of several wetland ponds which are not usually connected by surface flows. During intense rainfall water will flow between ponds.

<b>Sensitivity Rating:</b>	Aa12m
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
<b>Habitat Code:</b>	1-1c-3-5-5-3-4-4
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	4 Marsh
Water Quality:	4 Combination
<b>Aquifer Code:</b>	30601116
Island:	3 O'ahu
Sector:	06 Windward
Aquifer System:	01 Koolauloa
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	6 Sedimentary
<b>Status Code:</b>	12211
Development Stage:	1 Currently Used
Utility:	2 Ecologically Important
Salinity:	2 Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1 Irreplaceable
Vulnerability to Contamination:	1 High

**Coconut Grove--Continued**

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Aquifer Code: 30601121  
 Island: 3 O'ahu  
 Sector: 06 Windward  
 Aquifer System: 01 Koolauloa  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 1 Flank

Status Code: 12213  
 Development Stage: 1 Currently Used  
 Utility: 2 Ecologically Important  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 3 Low

U.S. Fish & Wildlife Service Wetland Code:  
 Palustrine/Scrub-Shrub/Broad-Leaved Evergreen/Non-Tidal  
 Semipermanent/Partially Drained and Ditched [Emergent/ Persistent/Non-Tidal  
 Semipermanent/Partially Drained-Ditched] (PSS3/EM1Fd)

**Geology:**

1. Kahuku coastal plain sediment
2. Pond sediment consists of alluvial material; no coral except near sea coast

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

Kfa (Kaloko clay, Typic Calciaquolls)

**Terrestrial Threatened or Endangered Plant(s):**

No inventory available

**Terrestrial Threatened or Endangered Animal(s):**

Hawaiian Coot (*Fulica americana alai*)  
 Hawaiian Duck (*Anas wyvilliana*)  
 Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
 Hawaiian Stilt (*Himantopus mexicanus knudseni*)

**Terrestrial Plant(s):**

No inventory available

**Aquatic Plant(s):**

No inventory available

**Coconut Grove--Continued**

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## Terrestrial Animal(s):

- Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)
- Cattle Egret (*Bubulcus ibis*)

## Aquatic Animal(s):

No inventory available

## Migratory Animal(s):

- Lesser Golden-Plover (*Pluvialis dominica (fulva)*)

## Freshwater Origin:

1. Basal confined
2. Alluvial sediments
3. Upward seepage from confined Koolau aquifer

## Comments:

## References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.
- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.





### Appendix E.1.6 Habitat Description of Ki'i National Wildlife Refuge

Site:	Ki'i National Wildlife Refuge	Lat.:	21°41'30"
Island:	O'ahu	Long.:	157°57'20"
Sector:	Windward, 06	El.:	20-40 ft
System:	Koolauloa (01)	Approx. Area/Length:	117.5 acres

#### Site Description:

Ki'i National Wildlife Refuge, part of the James Campbell National Wildlife Refuge established in 1977, lies on the nearly flat Kahuku plain and is separated from the sea by a line of dunes up to 20 ft high. The effluent settling basins and waste disposal area for the Kahuku Sugar Mill have been incorporated into the Refuge. Ki'i outlet, a man made feature, was constructed to provide drainage of the Kahuku Plain for the sugar industry, and is still in use.

Water for impoundments on the refuge includes rainfall runoff and water pumped from several wells dug and maintained by the Refuge staff. Salinity of the water pumped into impoundments has sometimes been a problem. The nearby discharge of waste water from Amorient Aquaculture Farm, Inc. is currently drained by gravity flow or pumped directly to the ocean.

The coastal terrestrial ecosystem at Kahuku, like most other areas in Hawaii has been highly modified. Except for a few species of native plants surviving on the dunes (e.g., *Scavola*) nearly all species are exotics. A fringe of trees and shrubs along the northwestern edge of the refuge is composed primarily of hau, Java plum, koa haole, and pluchea. The terrestrial habitats, particularly brush areas, include introduced predators (feral dogs and cats, rats, mongooses). The freshwater ponds serve as habitat for a number of wetland birds, including the endangered Hawaiian stilt, Hawaiian coot, Hawaiian moorhen, and Hawaiian duck. The most common exotic birds are the common myna, barred and spotted doves, spotted munia, and house finch. Ring-necked pheasants, cattle egrets, and black-crowned night- herons also frequent the complex.

The Refuge is exposed to relatively strong trade winds estimated at about 18 mph. Trade winds are more persistent during the summer months, the hottest and driest season. Winter months between October and April bring cooler temperatures, heavy cloud cover, and rain.

Sensitivity Rating:		Ab12wm3f
Main Water Source:	A	Groundwater
Habitat:	b	Artificial
Endangered Species:	1	Observed
Wetland Status:	2w	Wildlife Protected
Wetland Avifauna:	m	Migratory Fowl
Other Value:	3f	Sediment Trap
Habitat Code:		1-2-3-5-2-3-4-2
Water Source:	1	Groundwater
Habitat Origin/Development:	2	Artificial

**Ki'i National Wildlife Refuge--Continued**

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Ecological Character:	3	Endangered Species + Migratory Birds
Present Activities:	5	Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	2	Wildlife Protected
Physical Significance:	3	Sediment Trap + Flood Control
Wetland Type:	4	Marsh
Water Quality:	2	Brackish (250-15,000 mg/l Cl <sup>-</sup> )
Aquifer Code:		30601116
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	01	Koolauloa
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30601121
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	01	Koolauloa
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank
Status Code:		12213
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	3	Low
U.S. Fish & Wildlife Service Wetland Code:		
		Palustrine/Scrub-Shrub/Broad-Leaved Evergreen/Non-Tidal Seasonal/Partially Drained-Ditched [Emergent/Persistent/ Non-Tidal Seasonal/Partially Drained-Ditched] (PSS3/EM1Cd)

## Ki'i National Wildlife Refuge--Continued

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Palustrine/Scrub-Shrub/Broad-Leaved Evergreen/Non-Tidal  
Semipermanent/Partially Drained-Ditched [Emergent/Persistent /Non-Tidal  
Semipermanent/Partially Drained-Ditched](PSS3/EM1 Fd)

### Geology:

1. Kahuku coastal plain sediment
2. Pond sediments consist of alluvial material; no coral except near sea coast

### Soil Conservation Service, U.S. Dept. of Agriculture 1975:

Fd (Fill land)

KmbA (Keaau clay, saline, Typic Tropaquepts)  
0-2% slopes

Ph (Pearl Harbor clay, Typic Tropaquepts)

### Terrestrial Threatened or Endangered Plant(s):

No inventory available

### Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Duck (*Anas wyvilliana*)  
Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
Hawaiian Owl (*Asio flammeus sandwichensis*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)  
'I'iwi (*Vestiaria coccinea*)

### Terrestrial Plant(s):

Water hyssop (*Bacopa monnieri* (L.) Pennell)  
Common ironwood (*Casuarina equisetifolia* L.)  
Bermuda grass (*Cynodon dactylon* (L.) Pers.)  
Java plum (*Eugenia cuminii* (L.) Druce)  
Nena (*Heliotropium anomalum* var. *argenteum* Gray)  
Seaside heliotrope (*Heliotropium curassavicum* L.)  
Night-blooming cereus (*Hylocereus undatus* (Haw.) Britt. and Rose)  
Koa haole (*Leucaena leucocephala* (Lam.) de Wit)  
Knottgrass (*Paspalum distichum* L.)  
Beach naupaka (*Scaevola taccada* (Gaertn.) Roxb.)  
Beach morning-glory (*Ipomoea brasiliensis* (L.) Sweet)

### Aquatic Plant(s):

California grass (*Brachiaria muticai* (Forsk.) Stapf)  
Hau (*Hibiscus tiliaceus* L.)  
Makai (*Scirpus maritimus* L. var. *paludosus* (A. Nels.) Kuk.)

## Ki'i National Wildlife Refuge--Continued

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### Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
 Cattle Egret (*Bubulcus ibis*)  
 Common Barn-Owl (*Tyto alba*)  
 Common Myna (*Acridotheres tristis*)  
 House Finch (*Carpodacus mexicanus*)  
 House Sparrow (*Passer domesticus*)  
 Japanese White-eye (*Zosterops japonicus*)  
 Northern Mockingbird (*Mimus polyglottos*)  
 Nutmeg Mannikin (*Lonchura punctulata*)  
 Red-vented Bulbul (*Pycnonotus cafer*)  
 Ring-necked Pheasant (*Phasianus colchicus*)  
 Spotted Dove (*Streptopelia chinensis*)  
 Zebra Dove (*Geopelia striata*)  
 House Mouse (*Mus musculus domesticus*)  
 Mongoose (*Herpestes auropunctatus*)  
 Roof Rat (*Rattus rattus*)

### Aquatic Animal(s):

American Bullfrog (*Rana catesbeiana*)  
 Mosquitofish (*Gambusia affinis (Baird and Girard)*)  
 Tilapia (*Tilapia mossambica*)

### Migratory Animal(s):

Fulvous Whistling-Duck (*Dendrocygna bicolor*)  
 Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
 Long-billed Dowitcher (*Limnodromus scolopaceus*)  
 Mallard (*Anas platyrhynchos*)  
 Northern Pintail (*Anas acuta*)  
 Ruddy Turnstone (*Arenaria interpres*)  
 Sanderling (*Calidris alba*)  
 Wandering Tattler (*Heteroscelus incanus*)

### Freshwater Origin:

1. Basal confined
2. Alluvial sediments
3. Upward seepage from confined Koolau aquifer

### Comments:

Primary objectives of the refuge include: to protect and provide a habitat for endangered species, to expand understanding and appreciation of the environment, and to provide refuge-oriented research opportunities.

**Ki'i National Wildlife Refuge--Continued**

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## References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.
- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
- AECOS, Inc. 1983. Draft Environmental Impact Assessment Marine Culture Enterprises Kahuku Aquaculture Facility, Kahuku, O'ahu, Hawaii. Prepared for Marine Culture Enterprises, Tucson, Arizona. 222 p.
- Elliott, M.E. 1981. Wetlands and wetland vegetation of the Hawaiian Islands. Master thesis (Geography), University of Hawaii, Honolulu. 228 p.
- Department of Land and Natural Resources. 1983. Statewide waterbird marking/movement study. Project no. W-18-R-8; Job no. R-III-F. 7 p.
- Department of Land and Natural Resources. 1984. Statewide waterbird marking, movement, and disease study. Project no. W-18-R-9, Job no. R-III-F. 5 p.
- U.S. Fish and Wildlife Service. 1985. Master plan for the Hawaiian Wetlands National Wildlife Refuge Complex. U.S. Fish and Wildlife Service, Honolulu, Hawaii. 77 p.
- Timbol, A.S., and Maciolek, J.A. 1978. Stream channel modification in Hawaii. Part A: Statewide inventory of streams, habitat factors and associated biota. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 157 p.



### **Appendix E.1.7 Habitat Description of Kaluanui Stream**

Site:	Kaluanui Stream	Lat.:	21°34'27"
Island:	O'ahu	Long.:	157°55'17"
Sector:	Windward, 06	El.:	0-1800 ft
System:	Koolauloa (01)	Approx. Area/Length:	2 miles

#### Site Description:

Kaluanui Stream has gentle slopes below an elevation of about 340 ft (Sacred Falls Pool). However, the stream's mauka reach is very steep and includes seven waterfalls. The stream channel is relatively narrow at high elevations, but broadens as the gradient flattens. Available data indicate that Kaluanui Stream is perennial at high elevations and is naturally intermittent in the middle and lower portion of Kaluanui Valley when the stream water percolates into the streambed during the dry weather periods. This is because the sources of stream flow are runoff from rainfall and high level dike-confined groundwater but not basal groundwater. The main stream channel from the mouth up to the Sacred Falls can be divided into three segments based on overall physical features. Moving upstream, the first kilometer has no riparian canopy, the second and third kilometers have some vegetative cover, and beyond Sacred Falls, an almost pristine condition exists.

Most rain in Koolauloa results from cooling of warm moist air when the predominant northeast trade winds are deflected upward by the Koolau Range. Kona (southerly) winds may reflect the more major North Pacific storm systems and occasionally bring torrential and more persistent winter rains to the island.

Sensitivity Rating:	Aa13h
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Other Value:	3h Historical Value
Habitat Code:	1-1c-1-5-1b-4-2-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	1 Endangered Species
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	1b Historic Not Registered
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	2 Stream
Water Quality:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:	30601111
Island:	3 O'ahu
Sector:	06 Windward
Aquifer System:	01 Koolauloa

**Kaluanui Stream--Continued**

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Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 1 Unconfined  
 Aquifer Type (Geology): 1 Flank

Status Code: 11111  
 Development Stage: 1 Currently Used  
 Utility: 1 Drinking  
 Salinity: 1 Fresh (< 250 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 1 High

Aquifer Code: 30601212  
 Island: 3 O'ahu  
 Sector: 06 Windward  
 Aquifer System: 01 Koolauloa  
 Aquifer Type (Hydrology): 2 High Level  
 Aquifer Type (Hydrology): 1 Unconfined  
 Aquifer Type (Geology): 2 Dike

Status Code: 21111  
 Development Stage: 2 Potential Use  
 Utility: 1 Drinking  
 Salinity: 1 Fresh (< 250 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 1 High

**U.S. Fish & Wildlife Service Wetland Code:**

Palustrine/Emergent/Persistent/Non-Tidal Seasonal/Partially Drained-Ditched  
 (PEM1Cd)

Palustrine/Forested/Broad-Leaved Evergreen/Non-Tidal Seasonal (PFO3C)

Riverine/Lower Perennial/Open Water-Unknown Bottom/Non-Tidal Permanent  
 (R2OWH)

Upland [Non-Wetland] (U)

**Geology:**

1. Marginal dike zone of Koolau volcanic series
2. Water is held at high levels by dikes, generating the base flow of the stream

Soil Conservation Service, U.S. Dept. of Agriculture 1975:  
 BS (Beaches)



## Kaluanui Stream--Continued

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JaC (Jaucas sand, Typic Ustipsamments)  
0-15% slopes

KIG (Kapaa silty clay)  
40-100% slopes

KIA (Kawaihapai clay loam, Cumulic Haplustolls)  
0-2% slopes

KlaA (Kawaihapai stony clay loam, Cumulic Haplustolls)  
0-2% slopes

KlaB (Kawaihapai stony clay loam, Cumulic Haplustolls)  
2-6% slopes

Ms (Mokuleia loam, Typic Haplustolls)

WIB (Waialua stony silty clay, Vertic Haplustolls)  
3-8% slopes

WpF (Waikane silty clay, Humoxic Tropohumults)  
40-70% slopes

rRK (Rock land)

Terrestrial Threatened or Endangered Plant(s):  
No inventory available

Terrestrial Threatened or Endangered Animal(s):  
Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)  
'I'iwi (*Vestiaria coccinea*)

Terrestrial Plant(s):  
Candlenut tree (*Aleurites moluccana* (L.) Willd.)  
Bamboo (*Bambusa vulgaris* Schrad. ex Wendl.)  
Hairy horseweed (*Bidens pilosa* L.)  
Octopus tree (*Brassaia actinophylla* Endl.)  
Partridge pea (*Cassia leschenaultiana* DC.)  
Asiatic pennywort (*Centella asiatica* (L.) Urban)  
Downy wood fern (*Christella dentata*)  
Ti (*Cordyline terminalis* (L.) Kunth)  
Spanish clover (*Desmodium canum* (Gmel.) Schinz & Thellung)

## Kaluanui Stream--Continued

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Spanish clover (*Desmodium intortum* (Mill.) Urban)  
 Spanish clover (*Desmodium uncinatum* (Jacq.) DC.)  
 Wiregrass (*Eleusine indica* (L.) Gaertn.)  
 Java plum (*Eugenia cuminii* (L.) Druce)  
 Lantana (*Lantana camara* L.)  
 Koa haole (*Leucaena leucocephala* (Lam.) deWit)  
 Mango (*Mangifera indica* L.)  
 East Indian polypody (*Microsorium scolopendria* (Burm.) Copel.)  
 Banana (*Musa paradisiaca* L.)  
 'Okupukupu (*Nephrolepis multiflora*)  
 Yellow wood-sorrel (*Oxalis corniculata* L.)  
 Yellow liliko'i (*Passiflora edulis* f. *flavicarpa* Deg.)  
 Cork passion flower (*Passiflora suberosa* L.)  
 Broad-leaved plantain (*Plantago major* L.)  
 Plucheia (*Plucheia x fosbergii* Coop. and Gal.)  
 Common guava (*Psidium guajava* L.)  
 Sugar cane (*Saccharum officinarum* L.)  
 Christmas-berry tree (*Schinus terebinthifolius* Raddi)  
 Malayan ground orchid (*Spathoglottis plicata* Bl.)  
 Jamaica vervain (*Stachytarpheta jamaicensis* (L.) Vahl)  
 Golden crown-beard (*Verbesina encelioides* (Cav.) Benth. and Hook.)  
 False 'ohelo (*Wikstroemia oahuensis* (Gray) Rock)  
 Tree lobelia (*Lobelia* sp.)  
 Kauai night shade (*Solanum kauaiense* Hbd.)  
 (*Diellia falcata*)  
 (*Hesperomannia arborescens*)  
 (*Myrsine fosbergii*)  
 (*Pteris lidgatei*)  
 (*Rollandia humboldtiana*)  
 (*Viola oahuensis*)

### Aquatic Plant(s):

California grass (*Brachiaria mutica* (Forsk.) Stapf)  
 Job's tears (*Coix lachryma-jobi* L.)  
 Day flower (*Commelina diffusa* Burm. f.)  
 Hairy fleabane (*Plucheia odorata* (L.) Cass.)

### Terrestrial Animal(s):

Common Barn-Owl (*Tyto alba*)  
 Hawaiian Thrush (*Phaeornis obscurus*)  
 Japanese White-eye (*Zosterops japonicus*)  
 Red-necked Pheasant (*Phasianus colchicus*)  
 Spotted Dove (*Streptopelia chinensis*)  
 Zebra Dove (*Geopelia striata*)

## Kaluanui Stream--Continued

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Mongoose (*Herpestes auropunctatus*)  
 Roof Rat (*Rattus rattus*)

### Aquatic Animal(s):

Chinese Catfish (*Clarias fuscus*)  
 Electrid (*Eleotris sandwicensis Vaillant and Sauvage*)  
 Green Swordtail (*Xiphophorus helleri (Heckel)*)  
 Silver Perch (*Kuhlia sandwicensis*)  
 Tilapia (*Tilapia mossambica*)  
 'O'opu (*Vitraria clarescens Jordan and Evermann*)  
 'O'opu 'alamo'o (*Lentipes concolor*)  
 'O'opu nakea (*Awaous stamineus*)  
 'O'opu naniha (*Awaous genivittatus*)  
 'O'opu nopili (*Sicydium stimsonii*)  
 Oriental Weatherfish (*Misgurnus anguillicaudatus (Cantor)*)  
 Striped Mullet (*Mugil cephalus L.*)  
 Wrinkled Frog (*Rana rugosa*)  
 Giant Neotropical Toad (*Bufo marinus*)

### Migratory Animal(s):

No inventory available

### Freshwater Origin:

1. High level
2. Dike zone Koolau volcanic series

### Comments:

### References:

- Board of Water Supply. 1984. Revised Environmental Impact Statement for the Kaluanui Wells, Koolauloa, O'ahu, Hawaii. City and County of Honolulu. 50 p. plus app.
- Chinn, S.S., Tateishi, G.A., and Yee, J.J.S. 1985. Water resources data/Hawaii and other Pacific areas/water year 1985/volume 1. U.S. Geological Survey Water-Data Report HI-85-1, prepared in cooperation with Division of Water and Land Development, Dept. of Land and Natural Resources, State of Hawaii, Honolulu. 302 p.
- Timbol, A.S., Sutter, A.J., and Parrish, J.D. 1980. Distribution and relative abundance of the endemic freshwater goby, *Lentipes concolor*, in Hawaii. Technical report no. 80-1, Hawaii Cooperative Fishery Research Unit, University of Hawaii, Honolulu. 117 p.

**Kaluanui Stream--Continued**

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Kinzie, R.A., and Ford, J.I. 1982. Population biology in small Hawaiian streams. Technical report no. 147, Water Resources Research Center, University of Hawaii, Honolulu. 60 p.

### Appendix E.1.8 Habitat Description of Kahuku Prawn Farm

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Site:	Kahuku Prawn Farm	Lat.:	21°40'00"
Island:	O'ahu	Long.:	157°56'47"
Sector:	Windward, 06	El.:	20-40 ft
System:	Koolauloa (01)	Approx. Area/Length:	39.5 acres

#### Site Description:

The Kahuku Prawn Farm has a similar development and environment as the Amorient Prawn Farm. The climate in the area is generally uniform and mild. The mean annual rainfall is about 38 in. and the mean temperature is 75°F. Average wind speed is 10 mph from the northeasterly direction and the mean annual relative humidity is 70%.

Sensitivity Rating:		Ab1
Main Water Source:	A	Groundwater
Habitat:	b	Artificial
Endangered Species:	1	Observed
Habitat Code:		1-2-1-2-5-4-1-3
Water Source:	1	Groundwater
Habitat Origin/Development:	2	Artificial
Ecological Character:	1	Endangered Species
Present Activities:	2	Aquaculture
Social Significance:	5	Neither Historic nor Wildlife Protected
Physical Significance:	4	Neither Sediment Trap nor Flood Control
Wetland Type:	1	Pond
Water Quality:	3	Marine (> 15,000 mg/l Cl <sup>-</sup> )
Aquifer Code:		30601116
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	01	Koolauloa
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High

**Kahuku Prawn Farm--Continued**

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Aquifer Code:		30601121
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	01	Koolauloa
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank
Status Code:		12213
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	3	Low

U.S. Fish & Wildlife Service Wetland Code:

**Geology:**

1. Coastal plain sediments
2. Sediments form caprock on Koolauloa aquifer

Soil Conservation Service, U.S. Dept. of Agriculture 1975:

KIA (Kawaihapai clay loam, Cumulic Haplustolls)  
0-2% slopes

KmA (Keaau clay, Typic Trophaquepts)  
0-2% slopes

Terrestrial Threatened or Endangered Plant(s):

No inventory available

Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)

Terrestrial Plant(s):

No inventory available

Aquatic Plant(s):

No inventory available

Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
Cattle Egret (*Bubulcus ibis*)

**Kahuku Prawn Farm--Continued**

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Spotted Dove (*Streptopelia chinensis*)  
Zebra Dove (*Geopelia striata*)  
Common Myna (*Acridotheres tristis*)  
Red-crested Cardinal (*Paroaria coronata*)  
Northern Cardinal (*Cardinalis cardinalis*)

## Aquatic Animal(s):

Wrinkled Frog (*Rana rugosa*)

## Migratory Animal(s):

No inventory available

## Freshwater Origin:

1. Basal water, pumped from wells in Koolauloa aquifer
2. Shallow sediment
3. Koolauloa aquifer

## Comments:

## References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.
- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
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- Elliott, M.E. 1981. Wetlands and wetland vegetation of the Hawaiian Islands. Master thesis (Geography), University of Hawaii, Honolulu. 228 p.
- Department of Land and Natural Resources. 1983. Statewide waterbird marking/movement study. Project no. W-18-R-8; Job no. R-III-F. 7 p.
- Department of Land and Natural Resources. 1984. Statewide waterbird marking, movement, and disease study. Project no. W-18-R-9, Job no. R-III-F. 5 p.
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**Kahuku Prawn Farm--Continued**

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Timbol, A.S., and Maciolek, J.A. 1978. Stream channel modification in Hawaii. Part A: Statewide inventory of streams, habitat factors and associated biota. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 157 p.



### Appendix E.1.9 Habitat Description of Laie Prawn Farm

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Site:	Laie Prawn Farm	Lat.:	21°39'17"
Island:	O'ahu	Long.:	157°56'38"
Sector:	Windward, 06	El.:	60-120 ft
System:	Koolauloa (01)	Approx. Area/Length:	8.2 acres

#### Site Description:

Laie Prawn Farm is another artificial wetland similar to the other prawn farms, most of which have recently switched to marine shrimp farming.

The climate in the area is generally uniform and mild. The mean annual rainfall is about 40 in. and the average temperature is 75°F. Mean wind speed is an estimated 10 mph from the northeasterly direction and the average annual relative humidity is 70%.

#### Sensitivity Rating:

	Ab12m
Main Water Source:	A Groundwater
Habitat:	b Artificial
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl

#### Habitat Code:

	1-2-3-2-5-4-1-3
Water Source:	1 Groundwater
Habitat Origin/Development:	2 Artificial
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	2 Aquaculture
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	1 Pond
Water Quality:	3 Marine (> 15,000 mg/l Cl <sup>-</sup> )

#### Aquifer Code:

	30601111
Island:	3 O'ahu
Sector:	06 Windward
Aquifer System:	01 Koolauloa
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	1 Flank

#### Status Code:

	11111
Development Stage:	1 Currently Used
Utility:	1 Drinking
Salinity:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1 Irreplaceable
Vulnerability to Contamination:	1 High

## Laie Prawn Farm--Continued

---

U.S. Fish & Wildlife Service Wetland Code:

Geology:

1. Coastal plain sediments
2. Sediments form caprock on Koolauloa aquifer

Soil Conservation Service, U.S. Dept. of Agriculture 1975:

LaC (Lahaina silty clay)  
7-15% slopes

PeB (Paumalu silty clay)  
3-8% slopes

PeF (Paumalu silty clay)  
40-70% slopes

Terrestrial Threatened or Endangered Plant(s):

No inventory available

Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Duck (*Anas wyvilliana*)  
Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)

Terrestrial Plant(s):

No inventory available

Aquatic Plant(s):

No inventory available

Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
Cattle Egret (*Bubulcus ibis*)

Aquatic Animal(s):

No inventory available

Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
Ruddy Turnstone (*Arenaria interpres*)

**Laie Prawn Farm--Continued**

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## Freshwater Origin:

1. Basal water, pumped from wells in Koolauloa aquifer
2. Shallow sediments
3. Koolauloa aquifer

## Comments:

## References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.



### Appendix E.1.10 Habitat Description of Punalu'u Prawn Farm

Site:	Punalu'u Prawn Farm	Lat.:	21°35'33"
Island:	O'ahu	Long.:	157°53'08"
Sector:	Windward, 06	El.:	0-40 ft
System:	Koolauloa (01)	Approx. Area/Length:	14.9 acres

#### Site Description:

Punalu'u Prawn Farm is an artificial wetland similar to the other prawn farm wetlands. Environment and habitat are similar to Amorient.

The climate of the project area is fairly uniform throughout the year, as is generally characteristic of the entire island of O'ahu. Winds are typically from the north, northeast.

#### Sensitivity Rating:

	Ab12m
Main Water Source:	A Groundwater
Habitat:	b Artificial
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl

#### Habitat Code:

	1-2-3-2-5-4-1-3
Water Source:	1 Groundwater
Habitat Origin/Development:	2 Artificial
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	2 Aquaculture
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	1 Pond
Water Quality:	3 Marine (> 15,000 mg/l Cl <sup>-</sup> )

#### Aquifer Code:

	30601116
Island:	3 O'ahu
Sector:	06 Windward
Aquifer System:	01 Koolauloa
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	6 Sedimentary

#### Status Code:

	12211
Development Stage:	1 Currently Used
Utility:	2 Ecologically Important
Salinity:	2 Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1 Irreplaceable
Vulnerability to Contamination:	1 High

**Punalu'u Prawn Farm--Continued**

---

Aquifer Code:		30601121
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	01	Koolauloa
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	1	Flank
Status Code:		12213
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	3	Low

## U.S. Fish &amp; Wildlife Service Wetland Code:

## Geology:

1. Coastal plain sediments
2. Sediments on caprock over Koolauloa aquifer

## Soil Conservation Service, U.S. Dept. of Agriculture 1975:

KmA (Keaau clay, Typic Tropaquepts)  
0-2% slopes

Mt (Mokuleia clay loam, Typic Haplustolls)

## Terrestrial Threatened or Endangered Plant(s):

No inventory available

## Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Owl (*Asio flammeus sandwichensis*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)  
'Iiwi (*Vestiaria coccinea*)

## Terrestrial Plant(s):

No inventory available

## Aquatic Plant(s):

No inventory available

## Punalu'u Prawn Farm--Continued

### Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
 Cattle Egret (*Bubulcus ibis*)  
 Common Myna (*Acridotheres tristis*)  
 'Elepaio (*Chasiempis sandwichensis sandwichensis*)  
 House Finch (*Carpodacus mexicanus*)  
 House Sparrow (*Passer domesticus*)  
 Japanese White-eye (*Zosterops japonicus*)  
 Nutmeg Mannikin (*Lonchura punctulata*)  
 Spotted Dove (*Streptopelia chinensis*)  
 Zebra Dove (*Geopelia striata*)  
 Hawaiian Rat (*Rattus exulans hawaiiensis*)  
 House Mouse (*Mus musculus domesticus*)  
 Mongoose (*Herpestes auropunctatus*)  
 Roof Rat (*Rattus rattus*)

### Aquatic Animal(s):

No inventory available

### Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica fulva*)  
 Mallard (*Anas platyrhynchos*)  
 Ruddy Turnstone (*Arenaria interpres*)

### Freshwater Origin:

1. Basal
2. Sediments
3. Seepage from confined Koolauloa aquifer; and water from wells in Koolauloa aquifer

### Comments:

### References:

Environmental Communications, Inc. 1981. Final Environmental Impact Statement for the proposed Punalu'u Shores Project : Punalu'u, Koolauloa, O'ahu. 128 p. plus app.





**Appendix E.2 System-Wide Characteristics of Ecologically Sensitive Habitats,  
Aquifers of Windward Sector, Kahana System**

---

Aquifer System: Kahana (02)

Aquifer Sector: Windward (06)

Island: O'ahu (3)

Water Wells in Aquifer System (Div. of Water and Land Development 1984):

Disposal	-	Domestic	1	Industrial	-
Irrigation	1	Lost	1	Municipal	4
Observation	-	Other	-	Recharge	-
Sealed	1	Unused	5	Unknown	-

(Department of Health 1987):

Drinking	-
Other	2

Total Number of Injection Wells: 3

Water Wells or Sampling Sites Once Contaminated with DBCP, EDB or TCP  
(Water Resources Research Center 1985):

None

Potential Pollutant Sources and Pollutants (see Fig. 2):

Source: Cattle Pasture  
Pollutants: Fecal coliform  
Discharge: Non-point Source

Source: Surface Runoff  
Pollutants: Nitrates and Phosphates  
Discharge: Non-point Source

Source: Assn. of Apt. Owners of Makaua Village Condominium (UO 1382)  
Pollutants: Secondary treated sewage  
Discharge: 26,000 gpd



## Appendix E.2.1 Habitat Description of Ka'a'awa Stream

---

Site:	Ka'a'awa Stream	Lat.:	21°31'48"
Island:	O'ahu	Long.:	157°51'30"
Sector:	Windward, 06	El.:	0-280 ft
System:	Kahana (02)	Approx. Area/Length:	2.2 miles

### Site Description:

Ka'a'awa and Makaua streamflow contributes to the Ka'a'awa flood plain on the east coast of the island of O'ahu. This rectangular area of approximately 80 ha is a low coastal plain that receives runoff from the surrounding.

Approximately one-half mile south of the Ka'a'awa Stream, a partially flooded pastureland is identified on the Kahana topographic map as marshland. Presumably the site receives its water from underground springs and possibly seepage from Ka'a'awa Stream. The pasture is covered with California grass and patches of hau, bulrush, and a few common ironwood trees. Standing water under the grass varies between 10-30 cm deep, and the soft mud bottom is between 15-35 cm thick. The site is part of Kualoa Ranch property and is heavily grazed by cattle (Shallenberger 1977).

A large number (60-70) of cattle egrets were counted during a recent survey of the site. The site is of limited value to native waterbirds because of the limited water, dense vegetation, and grazing cattle. However, gallinules have been reported at the site. The extent of the present grass cover somewhat limits the use of the site by water birds except after heavy rains. The density of vegetation and a poorly developed aquatic fauna prevent the site from being more than a marginal habitat (Shallenberger 1977).

Sensitivity Rating:	Aa13f
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Other Value:	3f Sediment Trap
Habitat Code:	1-1c-1-5-5-3-2-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	1 Endangered Species
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	2 Stream
Water Quality:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:	30602212
Island:	3 O'ahu
Sector:	06 Windward
Aquifer System:	02 Kahana

**Ka'a'awa Stream--Continued**

---

Aquifer Type (Hydrology):	2	High Level
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	2	Dike

Status Code:		11111
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High

**U.S. Fish & Wildlife Service Wetland Code:**

Palustrine/Emergent/Persistent/Non-Tidal Seasonal (PEM1C)

Palustrine/Emergent/Persistent/Non-Tidal Semipermanent (PEM1F)

Palustrine/Emergent/Persistent/Tidal Artificial/Non-Tidal  
Semipermanent/Dike-Impounded (PEM1KFh)

Palustrine/Forested/Broad-Leaved Evergreen/Non-Tidal Seasonal (PFO3C)

Palustrine/Scrub-Shrub/Broad-Leaved Evergreen/Non-Tidal Seasonal (PSS3C)

**Geology:**

1. Marginal dike zone Koolau rift
2. Small aquifers between dikes

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

HoB (Hanalei stony silty clay)  
2-6% slopes

JaC (Jaucas sand, Typic Ustipsamments)  
0-15% slopes

LoE (Lolekaa silty clay, Humoxic Tropohumults)  
25-40% slopes

MZ (Marsh)

**Terrestrial Threatened or Endangered Plant(s):**

No inventory available

## Ka'a'awa Stream--Continued

---

### Terrestrial Threatened or Endangered Animal(s):

- Hawaiian Coot (*Fulica americana alai*)
- Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)

### Terrestrial Plant(s):

- Common ironwood (*Casuarina equisetifolia* L.)

### Aquatic Plant(s):

- California grass (*Brachiaria mutica* (Forsk.) Stapf)
- Hau (*Hibiscus tiliaceus* L.)
- California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)
- Great Bulrush (*Scirpus validus* Vahl)

### Terrestrial Animal(s):

- Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)
- Cattle Egret (*Bubulcus ibis*)

### Aquatic Animal(s):

- Surgeonfish (*Acanthurus sandvicensis*)

### Migratory Animal(s):

- No inventory available

### Freshwater Origin:

1. High level
2. Koolau dike zone

### Comments:

The limited capacity of Ka'a'awa Stream channel, the existing drainage system, and man-made structures such as Kamehameha Highway and concrete rubble masonry retaining walls contribute to the flood problems associated with the flood plain area (U.S. Army Corps 1969).

### References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.
- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
- Elliott, M.E. 1981. Wetlands and wetland vegetation of the Hawaiian Islands. Master thesis (Geography), University of Hawaii, Honolulu. 228 p.

**Ka'a'awa Stream--Continued**

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- Chinn, S.S., Tateishi, G.A., and Yee, J.J.S. 1985. Water resources data/Hawaii and other Pacific areas/water year 1985/volume 1. U.S. Geological Survey Water-Data Report HI-85-1, prepared in cooperation with Division of Water and Land Development, Dept. of Land and Natural Resources, State of Hawaii, Honolulu. 302 p.
- U.S. Army Corps of Engineers. 1969. Flood plain information: Ka'a'awa, O'ahu, Hawaii. Prepared for the State of Hawaii and the City and County of Honolulu. 25 p.

## Appendix E.2.2 Habitat Description of Punalu'u Stream

---

Site:	Punalu'u Stream	Lat.:	21°32'20"
Island:	O'ahu	Long.:	157°54'22"
Sector:	Windward, 06	El.:	0-600 ft
System:	Kahana (02)	Approx. Area/Length:	3.6 miles

### Site Description:

Punalu'u Stream is a perennial stream bordered by relatively flat bottom lands, much of which are flooded regularly with heavy rains. Farther from the stream, on both sides, are low ridges and relatively dry gulches with intermittent streams; these gulches become progressively narrower and steeper as they reach the sides of the major ridges that extend NE from the Koolau mountains (Denison 1975).

The climate of the wetland area is fairly uniform throughout the year, as is generally characteristic of the entire island of O'ahu. Trade winds are typically from the north, northeast.

Sensitivity Rating:	Aa12wt3f
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Status:	2w Wildlife Protected
Wetland Use:	t Traditional
Other Value:	3f Sediment Trap
Habitat Code:	1-1c-1-5-5-3-2-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	1 Endangered Species
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	2 Stream
Water Quality:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:	30602212
Island:	3 O'ahu
Sector:	06 Windward
Aquifer System:	02 Kahana
Aquifer Type (Hydrology):	2 High Level
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	2 Dike
Status Code:	11111
Development Stage:	1 Currently Used
Utility:	1 Drinking

**Punalu'u Stream--Continued**

---

Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High

Aquifer Code:		30602112
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	02	Kahana
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	2	Dike

Status Code:		11111
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High

**U.S. Fish & Wildlife Service Wetland Code:**

Palustrine/Emergent/Persistent/Non-Tidal Seasonal (PEM1C)

Palustrine/Forested/Broad-Leaved Evergreen/Non-Tidal Seasonal (PFO3C)

Palustrine/Scrub-Shrub/Broad-Leaved Deciduous/Non-Tidal Semipermanent  
[Emergent/Persistent/Non-Tidal Semipermanent] (PSS/EM1F)

Riverine/Upper Perennial/Open Water-Unknown Bottom/Non-Tidal Permanent  
(R3OWH)

**Geology:**

1. Marginal dike zone of Koolau volcanic series and coastal plain sediment
2. Water is held at high levels by dikes, generating the baseflow of the stream; sediments act as caprock on Koolau aquifer

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

HnA (Hanalei silty clay, Typic Fluvaquents)  
0-2% slopes

HoB (Hanalei stony silty clay, Typic Fluvaquents)  
2-6% slopes

JaC (Jaucas sand, Typic Ustipsamments)  
0-15% slopes



## **Punalu'u Stream--Continued**

---

Ph (Pearl Harbor clay, Typic Tropaquepts)

WIB (Waialua stony silty clay, Veric Haplustolls)  
3-8% slopes

WpE (Waikane silty clay, Humoxic Tropohumults)  
25-40% slopes

Terrestrial Threatened or Endangered Plant(s):  
No inventory available

Terrestrial Threatened or Endangered Animal(s):  
Hawaiian Owl (*Asio flammeus sandwichensis*)  
'I'iwi (*Vestiaria coccinea*)

Terrestrial Plant(s):  
No inventory available

Aquatic Plant(s):  
No inventory available

Terrestrial Animal(s):  
Common Myna (*Acridotheres tristis*)  
'Elepaio (*Chasiempis sandwichensis sandwichensis*)  
House Sparrow (*Passer domesticus*)  
Japanese White-eye (*Zosterops japonicus*)  
Nutmeg Mannikin (*Lonchura punctulata*)  
Spotted Dove (*Streptopelia chinensis*)  
Zebra Dove (*Geopelia striata*)  
Hawaiian Rat (*Rattus exulans hawaiiensis*)  
House Mouse (*Mus musculus domesticus*)  
Mongoose (*Herpestes auropunctatus*)  
Roof Rat (*Rattus rattus*)

Aquatic Animal(s):  
Chinese Catfish (*Clarias fuscus*)  
Green Swordtail (*Xiphophorus helleri* (Heckel))  
Guppy (*Poecilia reticulata* Peters)  
Silver Perch (*Kuhlia sandvicensis*)  
'O'opu (*Vitraria clarescens* Jordan and Evermann)  
'O'opu 'alamo'o (*Lentipes concolor*)  
'O'opu nakea (*Awaous stamineus*)  
'O'opu naniha (*Awaous genivittatus*)  
'O'opu nopili (*Sicydium stimsonii*)

**Punalu'u Stream--Continued**

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**Migratory Animal(s):**

No inventory available

**Freshwater Origin:**

1. High level inland of coastal plain; basal in and beneath coastal plain
2. Marginal dike zone inland of coastal plain; sediments of coastal plain
3. Most groundwater originates in Koolau formation

**Comments:**

Stream waters are diverted in eight areas.

**References:**

- Chinn, S.S., Tateishi, G.A., and Yee, J.J.S. 1985. Water resources data/Hawaii and other Pacific areas/water year 1985/volume 1. U.S. Geological Survey Water-Data Report HI-85-1, prepared in cooperation with Division of Water and Land Development, Dept. of Land and Natural Resources, State of Hawaii, Honolulu. 302 p.
- Timbol, A.S., and Maciolek, J.A. 1978. Stream channel modification in Hawaii. Part A: Statewide inventory of streams, habitat factors and associated biota. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 157 p.
- Environmental Communications, Inc. 1981. Final Environmental Impact Statement for the proposed Punalu'u Shores Project : Punalu'u, Koolauloa, O'ahu. 128 p. plus app.
- Denison, D.O. 1975. An archaeological reconnaissance survey of Punalu'u Lands, Punalu'u, O'ahu. Prepared by Bernice P. Bishop Museum for Kaluanui Ventures, Department of Anthropology. 43 p.

### Appendix E.2.3 Habitat Description of Kahana Stream

Site:	Kahana Stream	Lat.:	21°30'31"
Island:	O'ahu	Long.:	157°53'58"
Sector:	Windward, 06	El.:	0-1200 ft
System:	Kahana (02)	Approx. Area/Length:	4.8 miles

#### Site Description:

Kahana Bay near the middle of the northeast coast of O'ahu, is the drowned lower portion of a valley eroded in the lava flow flank of the Koolau Range. Kahana Stream, entering the bay across the sedimentary fill of the upper part of the unchanged valley, is tidal for about half a mile. The upper end of the valley is cut into the dike complex in the high rainfall part of the Koolau Range and the dry weather flow of the stream is supplied by dike springs. The valley is bordered on three sides by the Koolau Range and two spur ridges. Upper slopes of the valley are utilized for pasture and cattle grazing.

The estuary located at the end of the stream shows strong vertical stratification of salinity and temperature. Stream discharge into the estuary is seasonal with high flows during winter/spring and low flows during summer/fall. Because of the large stream discharge relative to estuarine breadth and weak tides, mixing in the upper layer is the primary result of flow. Assuming that stream water occupies the upper half of the watermass when it is stratified, under average discharge conditions residence time is about 13 hr (Maciolek 1972).

The forested lower valley at this site provides habitat for a variety of exotic birds, including shama, melodious laughing-thrush, Japanese bush-warbler as well as those listed in terrestrial animals. Mongoose occur near the fishpond and in the upper pasture area. Dogs and cats run loose throughout most of the lower valley. Relatively few cattle graze in the upper pasture. In the stream and lower marsh area, mullet, barracuda, and tilapia are present (Shallenberger 1977).

Sensitivity Rating:		Aa12wtm3fh
Main Water Source:	A	Groundwater
Habitat:	a	Natural
Endangered Species:	1	Observed
Wetland Status:	2w	Wildlife Protected
Wetland Use:	t	Traditional
Wetland Avifauna:	m	Migratory Fowl
Other Value:	3f	Sediment Trap
Other Value:	h	Historical Value

Habitat Code:		1-1c-3-5-4-3-2-1
Water Source:	1	Groundwater
Habitat Origin/Development:	1c	Natural/Pristine + Altered
Ecological Character:	3	Endangered Species + Migratory Birds
Present Activities:	5	Neither Agriculture, Aquaculture, nor Recreation

**Kahana Stream--Continued**

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Social Significance:	4	Historic Not Registered + Wildlife Protected
Physical Significance:	3	Sediment Trap + Flood Control
Wetland Type:	2	Stream
Water Quality:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:		30602212
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	02	Kahana
Aquifer Type (Hydrology):	2	High Level
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	2	Dike
Status Code:		11111
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30602116
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	02	Kahana
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30602122
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	02	Kahana
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	2	Dike

**Kahana Stream--Continued**

---

Status Code: 11113  
 Development Stage: 1 Currently Used  
 Utility: 1 Drinking  
 Salinity: 1 Fresh (< 250 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 3 Low

## U.S. Fish &amp; Wildlife Service Wetland Code:

Estuarine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal (E1OWL)

Estuarine/Intertidal/Emergent/Persistent/Tidal Irregular (E2EM1P)

Palustrine/Emergent/Persistent/Non-Tidal Seasonal (PEM1C)

Palustrine/Emergent/Persistent/Tidal Artificial/Non-Tidal  
 Semipermanent/Dike-Impounded (PEM1KFh)

Palustrine/Forested/Broad-Leaved Evergreen/Non-Tidal Seasonal (PFO3C)

Palustrine/Scrub-Shrub/Broad-Leaved Evergreen/Non-Tidal Seasonal (PSS3C)

Riverine/Upper Perennial/Open Water-Unknown Bottom/Non-Tidal Permanent  
 (R3OWH)

## Geology:

1. Marginal dike zone of Koolau volcanic series and coastal plain sediments
2. Water is held at high levels by dikes, generating the base flow of the stream; sediments act as caprock on Koolau aquifer

## Soil Conservation Service, U.S. Dept. of Agriculture 1975:

HaB (Haiku silty clay, Humoxic Tropohumults)

3-7% slopes

HnA (Hanalei silty clay, Typic Fluvaquents)

0-2% slopes

JaC (Jaucas sand, Typic Ustipsamments)

0-15% slopes

KmA (Keaau clay, Typic Trophaquepts)

0-2% slopes

Mt (Mokuleia clay loam, Typic Haplustolls)

**Kahana Stream--Continued**

---

TR (Tropaquepts)

WpF (Waikane silty clay, Humoxic Tropohumults)  
40-70% slopes

rRT (Rough mountainous land)

Terrestrial Threatened or Endangered Plant(s):  
No inventory available

Terrestrial Threatened or Endangered Animal(s):  
Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)  
Hawaiian Bat (*Lasiurus cinereus semotus*)

Terrestrial Plant(s):  
Koa (*Acacia koa* Gray)  
Molucca albizia (*Albizia falcataria* (L.) Fosb.)  
Candlenut tree (*Aleurites moluccana* (L.) Willd.)  
Maile (*Alyxia olivaeformis* Gaud.)  
Broomsedge (*Andropogon virginicus* L.)  
Antidesma (*Antidesma pulvinatum* Hbd.)  
Breadfruit (*Artocarpus altilis* (Parkins.) Fosb.)  
Bamboo (*Bambusa vulgaris* Schrad. ex Wendl.)  
Hairy horseweed (*Bidens pilosa* L.)  
Arnotto tree (*Bixa orellana* L.)  
Octopus tree (*Brassaia actinophylla* Endl.)  
Maunaloa (*Dioclea violacea* Mart.)  
Common ironwood (*Casuarina equisetifolia* L.)  
Papala (*Charpentiera obovata*)  
Downy wood fern (*Christella dentata*)  
Monkeyarm cibotium (*Cibotium chamissoi* Kaulf.)  
Shiny cibotium (*Cibotium splendens* (Gaud.) Krajina)  
Koster's curse (*Clidemia hirta* (L.) D. Don)  
Coconut tree (*Cocos nucifera* L.)  
Ti (*Cordyline terminalis* (L.) Kunth)  
Laukahi (*Plantago major* L.)  
Dodder (*Cuscuta sandwichiana* Choisy)  
Cyrtrandra (*Cyrtrandra* sp.)  
False staghorn fern (*Dicranopteris linearis* (Burm.) Underw.)  
Bitter yam (*Dioscorea bulbifera* L.)  
Lama (*Diospyros ferrea* (Willd.) Bakh.)  
Elaeocarpus (*Elaeocarpus bifidus* H. and A.)

## Kahana Stream--Continued

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Eucalyptus (*Eucalyptus* sp.)  
 Java plum (*Eugenia cuminii* (L.) Druce)  
 Rose apple (*Eugenia jambos* L.)  
 Mountain apple (*Eugenia malaccensis* L.)  
 Cliffeu patorium (*Eupatorium riparium* Regel)  
 Hawaiian freycinetia (*Freycinetia arborea* Gaud.)  
 Lantana (*Lantana camara* L.)  
 Mango (*Mangifera indica* L.)  
 Ironwood (*Metrosideros collina* (J. R. and G. Forst.) Gray)  
 East Indian polypody (*Microsorium scolopendria* (Burm.) Copel.)  
 Sensitive plant (*Mimosa pudica* L.)  
 Indian mulberry (*Morinda citrifolia* L.)  
 'Okupukupu (*Nephrolepis multiflora*)  
 Basket grass (*Oplismenus hirtellus* (L.) Beauv.)  
 Hawaiian olive (*Osmanthus sandwicensis* (A. Gray) B. and H.)  
 Screw pine (*Pandanus odoratissimus* L. f.)  
 Hilo grass (*Paspalum conjugatum* Berg.)  
 Scarlet fruited passion flower (*Passiflora foetida* L.)  
 Cork passion flower (*Passiflora suberosa* L.)  
 Peperomia (*Peperomia* sp.)  
 Papala kepau (*Pisonia umbellifera* (J.R. and G. Forst.) Seem)  
 Gold and silver feras (*Pityrogramma* sp.)  
 Lulu (*Pritchardia* sp.)  
 Strawberry guave (*Psidium cattleianum* Sabine)  
 Common guava (*Psidium guajava* L.)  
 Psilotum (*Psilotum* sp.)  
 Kopiko'ula (*Psychotria* sp.)  
 Thimbleberry (*Rubus rosaeifolius* Sm.)  
 Mountain naupaka (*Scaevola gaudichaudiana* Cham.)  
 Beach naupaka (*Scaevola taccada* (Gaertn.) Roxb.)  
 Christmas-berry tree (*Schinus terebinthifolius* Raddi)  
 Sida (*Sida acuta* var. *carpinifolia* Brum. f.)  
 'Ilima (*Sida fallax* Walp.)  
 Jamaica vervain (*Stachytarpheta jamaicensis* (L.) Vahl)  
 Pukiawe (*Styphelia tameiameia* (Cham.) F. Muell.)  
 False kamani (*Terminalia catappa* L.)  
 Olona (*Touchardia latifolia* Gaud.)  
 False 'ohelo (*Wikstroemia oahuensis* (Gray) Rock)  
 Wild ginger (*Zingiber zerumbet* (L.) Smith)  
 Kaumahana (*Korthalsella complanata*)

### Aquatic Plant(s):

California grass (*Brachiaria mutica* (Forsk.) Stapf)  
 Oriental mangrove (*Bruguiera gymnorhiza* Lam.)

**Kahana Stream--Continued**

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Taro (*Colocasia esculenta* (L.) Schott)  
 Day flower (*Commelina diffusa* Burm. f.)  
 White ginger (*Hedychium coronarium* Koenig)  
 Yellow ginger (*Hedychium flavescens* Carey)  
 Hau (*Hibiscus tiliaceus* L.)  
 Red mangrove (*Rhizophora mangle* L.)  
 California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)  
 Great Bulrush (*Scirpus validus* Vahl)

## Terrestrial Animal(s):

'Apapane (*Himatione sanguinea*)  
 Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
 Cattle Egret (*Bubulcus ibis*)  
 Common Myna (*Acridotheres tristis*)  
 House Finch (*Carpodacus mexicanus*)  
 House Sparrow (*Passer domesticus*)  
 Japanese White-eye (*Zosterops japonicus*)  
 Japanese Quail (*Coturnis japonica*)  
 Melodious Laughing-thrush (*Garrulax canorus*)  
 Northern Cardinal (*Cardinalis cardinalis*)  
 Nutmeg Mannikin (*Lonchura punctulata*)  
 Spotted Dove (*Streptopelia chinensis*)  
 White-rumped Shama (*Copsychus malabaricus*)  
 Zebra Dove (*Geopelia striata*)  
 Mongoose (*Herpestes auropunctatus*)

## Aquatic Animal(s):

Bonefish (*Albula vulpes*)  
 Amberjack (*Seriola dumerilii* (Risso))  
 Balloon Fish (*Diodon holocanthus* (Linnaeus))  
 Barracuda (*Sphyræna barracuda* (Walbaum))  
 Chinese Catfish (*Clarias fuscus*)  
 Cornetfish (*Fistularia commersoni* Lacepede's)  
 Damsel fish (*Abudefduf abdominalis*)  
 Electrid (*Eleotris sandwicensis* Vaillant and Sauvage)  
 Engel's Mullet (*Chelon engeli* (Bleeker))  
 Whitespot Goatfish (*Parupeneus porphyreus*)  
 Green Swordtail (*Xiphophorus helleri* (Heckel))  
 Gunther Grouper (*Epinephelus spiniger* (Gunther))  
 Guppy (*Poecilia reticulata* Peters)  
 Silver Perch (*Kuhlia sandwicensis*)  
 Makimaki (*Arothron hispidus*)  
 Milkfish (*Chanos chanos* (Forsk.)  
 Moonfish (*Lampris guttatus* (Brunnich))



## Kahana Stream--Continued

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Mosquitofish (*Gambusia affinis* (Baird and Girard))  
 Tilapia (*Tilapia mossambica*)  
 Striped Mullet (*Mugil cephalus* L.)  
 'O'opu (*Vitraria clarescens* Jordan and Evermann)  
 'O'opu 'alamo'o (*Lentipes concolor*)  
 'O'opu nakea (*Awaous stamineus*)  
 'O'opu naniha (*Awaous genivittatus*)  
 'O'opu nopili (*Sicydium stimsonii*)  
 Papio (*Caranx* sp.)  
 Pointed-tail Goby (*Oxyurichthys lonchotus* (Jenkins))  
 Samoan Crab (*Scylla serrata*)  
 White Goatfish (*Mulloidés flavolineatus*)  
 Short-lined Cardinal Fish (*Foa brachygramma*)  
 Slender Lizard Fish (*Saurida gracilis* (Quoy and Gaimard))  
 Spotted Flounder (*Bothus pantherinus*)  
 Spotted Puffer (*Arothron meleagris*)  
 Surgeonfish (*Acanthurus sandvicensis*)  
 Uouoa (*Neomyxus chaptalii* (Eydoux and Souleyet))  
 White Jack (*Caranx ignobilis*)  
 'Opae 'oeha'a (*Macrobrachium grandimanus*)

### Migratory Animal(s):

American Wigeon (*Anas americana*)  
 Lesser Golden-Plover (*Pluvialis dominica* (fulva))  
 Ruddy Turnstone (*Arenaria interpres*)  
 Wandering Tattler (*Heteroscelus incanus*)

### Freshwater Origin:

1. High level inland of coastal plain; basal in and beneath coastal plain
2. Marginal dike zone inland of coastal plain; sediments of coastal plain
3. Most groundwater originates from Koolau formation

### Comments:

The increased use of gasoline-powered equipment in the estuary in recent years coincides with the disappearance of nopili and hihiwai (*Neritina grandosa*) from Kahana Stream. Larvae and young of both species must traverse the estuary and are therefore potentially exposed to this pollutant.

### References:

Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.

**Kahana Stream--Continued**

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- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
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- Timbol, A.S. 1972. Trophic ecology and macrofauna of Kahana Estuary, O'ahu. PHD. thesis (Zoology), University of Hawaii, Honolulu. 228 p.
- H. Mogi Planning and Research, Inc. 1974. Kahana Valley State Park, O'ahu, Hawaii. Prepared for State of Hawaii Department of Land and Natural Resources, Division of State Parks. 63 p.
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- Timbol, A.S. 1979. Limnological survey of Kahana Stream, O'ahu. U.S. Army Corps of Engineers, Pacific Ocean Division. 48 p.
- Archer, K.M., Timbol, A.S., and Parrish, J.D. 1980. Biological survey of Kahana Stream system: final report. Technical report no. 80-2, Hawaii Cooperative Fishery Research Unit, Honolulu. 40 p. plus app.
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- U.S. Fish and Wildlife Service. 1985. Recovery plan for the Hawaiian Waterbirds. Prepared for U.S. Fish and Wildlife Service, Portland, Oregon. 99 p.
- Towill, R.M., Corp. 1983. Revised Environmental Impact Statement for Kahana 315 Reservoir project. Prepared for Board of Water Supply, City and County of Honolulu. 43 p.

**Kahana Stream--Continued**

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- H. Mogi Planning and Research, Inc. 1978. Draft Environmental Impact Statement for Kahana Valley State Park. 173 p.
- Towill, R.M., Corp. 1981. Environmental Impact Statement for the Kahana Valley water development project. 62 p. plus app.
- Cox, D.C., and Gordon, L.C. Jr. 1970. Estuarine pollution in the State of Hawaii. Technical report no. 31, Water Resources Research Center, University of Hawaii, Honolulu. 151 p.
- De Ausen, T.T. 1966. Coastline ecosystems in O'ahu, Hawaii. Master thesis (Botany), University of Hawaii, Honolulu. 114 p. plus app.
- Maciolek, John A. 1972. Diadromous Macrofauna and the Kahana Stream-Estuary Ecosystem. Terminal report for U.S. Fish and Wildlife Service, contract periods: 15 June 1970 to 15 June 1971 and 15 June 1971 to 15 June 1972. Contract numbers: 14-16-0001-4085; 14-16-0001-3476. 22 p.



### Appendix E.2.4 Habitat Description of Hakipu'u Stream

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Site:	Hakipu'u Stream	Lat.:	21°30'48"
Island:	O'ahu	Long.:	157°52'05"
Sector:	Windward, 06	El.:	0-240 ft
System:	Kahana (02)	Approx. Area/Length:	1 mile

#### Site Description:

Although literature specifically relating to Hakipu'u Stream was unavailable, it is believed that the stream exhibits similar environmental characteristics as the Waikane Stream.

Sensitivity Rating:	Aa1
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Habitat Code:	1-1c-1-1b-5-4-2-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	1 Endangered Species
Present Activities:	1b Agriculture Livestock
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	2 Stream
Water Quality:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:	30602212
Island:	3 O'ahu
Sector:	06 Windward
Aquifer System:	02 Kahana
Aquifer Type (Hydrology):	2 High Level
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	2 Dike
Status Code:	11111
Development Stage:	1 Currently Used
Utility:	1 Drinking
Salinity:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1 Irreplaceable
Vulnerability to Contamination:	1 High

#### U.S. Fish & Wildlife Service Wetland Code:

Palustrine/Forested/Broad-Leaved Evergreen/Non-Tidal Seasonal (PFO3C)

## Hakipu'u Stream--Continued

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### Geology:

1. Marginal dike zone of Koolau volcanic series and coastal plain sediments
2. Water held at high levels by dikes, generating the base flow of the stream; sediments act as caprock on Koolau aquifer

### Soil Conservation Service, U.S. Dept. of Agriculture 1975:

HnA (Hanalei silty clay, Typic Fluvaquents)

0-2% slopes

HnB (Hanalei silty clay, Typic Fluvaquents)

2-6% slopes

LoE (Lolekaa silty clay, Humoxic Tropohumults)

25-40% slopes

WpE (Waikane silty clay, Humoxic Tropohumults)

25-40% slopes

### Terrestrial Threatened or Endangered Plant(s):

No inventory available

### Terrestrial Threatened or Endangered Animal(s):

Hawaiian Stilt (*Himantopus mexicanus knudseni*)

### Terrestrial Plant(s):

No inventory available

### Aquatic Plant(s):

No inventory available

### Terrestrial Animal(s):

Common Myna (*Acridotheres tristis*)

House Finch (*Carpodacus mexicanus*)

House Sparrow (*Passer domesticus*)

Spotted Dove (*Streptopelia chinensis*)

Zebra Dove (*Geopelia striata*)

Mongoose (*Herpestes auropunctatus*)

### Aquatic Animal(s):

Striped Mullet (*Mugil cephalus* L.)

### Migratory Animal(s):

No inventory available

## **Hakipu'u Stream--Continued**

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### **Freshwater Origin:**

1. High level inland of coastal plain; basal in and beneath coastal plain
2. Marginal dike zone inland of coastal plain; sediments of coastal plain
3. Most groundwater originates from Koolau formation

### **Comments:**

### **References:**

- Towill, R.M., Corp. 1979. Environmental Impact Statement for the Kahalu'u wastewater treatment and disposal system. Prepared for the Department of Public Works, City and County of Honolulu, Hawaii. 124 p. plus app.





### Appendix E.2.5 Habitat Description of Mariculture Research Center UH

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Site:	Mariculture Research Center UH	Lat.:	21°30'35"
Island:	O'ahu	Long.:	157°51'25"
Sector:	Windward, 06	El.:	20-40 ft
System:	Kahana (02)	Approx. Area/Length:	6.2 acres

#### Site Description:

The University of Hawaii's Mariculture Research Center is an aquaculture research facility. The facility consists of 12 ponds ranging from 0.25-1.0 acres in size. Various aquatic resources are grown in the ponds including marine shrimp, catfish, prawns and tilapia. The water supply for the operation is derived from streams, the ocean and from city supplied water. Direct groundwater is not used in the ponds; however, future plans are to drill wells and pump groundwater into the ponds. Once these plans are initiated the sensitivity rating will change from its present rating of Bb12m to Ab12m.

#### Sensitivity Rating:

		Bb12m
Main Water Source:	B	Not Groundwater
Habitat:	b	Artificial
Endangered Species:	1	Observed
Wetland Avifauna:	2m	Migratory Fowl

#### Habitat Code:

		2-2-3-2-5-4-1-4
Water Source:	2	Other
Habitat Origin/Development:	2	Artificial
Ecological Character:	3	Endangered Species + Migratory Birds
Present Activities:	2	Aquaculture
Social Significance:	5	Neither Historic nor Wildlife Protected
Physical Significance:	4	Neither Sediment Trap nor Flood Control
Wetland Type:	1	Pond
Water Quality:	4	Combination

#### Aquifer Code:

		30602116
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	02	Kahana
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary

#### Status Code:

		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High

**Mariculture Research Center UH--Continued**


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Aquifer Code: 30602122  
 Island: 3 O'ahu  
 Sector: 06 Windward  
 Aquifer System: 02 Kahana  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 2 Dike

Status Code: 11113  
 Development Stage: 1 Currently Used  
 Utility: 1 Drinking  
 Salinity: 1 Fresh (< 250 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 3 Low

U.S. Fish & Wildlife Service Wetland Code:  
 Palustrine/Emergent/Persistent/Tidal Artificial/Non-Tidal  
 Semipermanent/Dike-Impounded (PEM1KFh)

Geology:  
 1. Sediments on dike complex

Soil Conservation Service, U.S. Dept. of Agriculture 1975:  
 HnA (Hanalei silty clay, Typic Fluvaquents)  
 0-2% slopes

MZ (Marsh)

WpE (Waikane silty clay, Humoxic Tropohumults)  
 25-40% slopes

Terrestrial Threatened or Endangered Plant(s):  
 No inventory available

Terrestrial Threatened or Endangered Animal(s):  
 Hawaiian Coot (*Fulica americana alai*)  
 Hawaiian Stilt (*Himantopus mexicanus knudseni*)

Terrestrial Plant(s):  
 No inventory available

Aquatic Plant(s):  
 No inventory available

**Mariculture Research Center UH--Continued**

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## Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
Cattle Egret (*Bubulcus ibis*)

## Aquatic Animal(s):

No inventory available

## Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
Mallard (*Anas platyrhynchos*)

## Freshwater Origin:

1. Hakipu'u Stream

## Comments:

## References:

Towill, R.M., Corp. 1979. Environmental Impact Statement for the Kahalu'u wastewater treatment and disposal system. Prepared for the Department of Public Works, City and County of Honolulu, Hawaii. 124 p. plus app.



## Appendix E.2.6 Habitat Description of Moli'i Pond

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Site: Moli'i Pond	Lat.: 21°30'46"
Island: O'ahu	Long.: 157°50'55"
Sector: Windward, 06	El.: 0-20 ft
System: Kahana (02)	Approx. Area/Length: 120.1 acres

### Site Description:

Moli'i Fishpond is one of the few coastal fishponds in the State that is still in operation. It is supplied with water by springs and by rainfall runoff but its variable salinity may approach that of seawater due to several gates in the long wall. Although the present landowner is continuing to rear mullet in the pond, some biologists are concerned about the possible adverse impacts of runoff from agricultural lands that may contain agricultural chemicals (Shallenberger 1977).

Much of the outer wall of Moli'i Fishpond is lined with a dense growth of mangrove. The remainder of the fishpond shores are covered with California grass and various shrubs, but a dense stand of bulrush is also found in the northeast corner of the site. Most of the bottom is sandy, although areas of suspended silt or dense mud are present as well (Shallenberger 1977). A large deposit of sand lies about 450 m off Moli'i Pond (U.S. Army Corps 1977).

The climate is characterized by a two-season year (summer and winter), mild and uniform temperatures, marked variations in rainfall due to geographic differences, and a general dominance of the northeast trade winds 80-90% of the time during summer dropping to 50-80% in winter.

Sensitivity Rating:	Aa12wtm3fh
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Status:	2w Wildlife Protected
Wetland Use:	t Traditional
Wetland Avifauna:	m Migratory Fowl
Other Value:	3f Sediment Trap
Other Value:	h Historical Value
Habitat Code:	1-1b-3-2-4-3-1-2
Water Source:	1 Groundwater
Habitat Origin/Development:	1b Natural/Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	2 Aquaculture
Social Significance:	4 Historic Not Registered + Wildlife Protected
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	1 Pond
Water Quality:	2 Brackish (250-15,000 mg/l Cl <sup>-</sup> )

**Moli'i Pond--Continued**

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Aquifer Code: 30602116  
 Island: 3 O'ahu  
 Sector: 06 Windward  
 Aquifer System: 02 Kahana  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 1 Unconfined  
 Aquifer Type (Geology): 6 Sedimentary  
  
 Status Code: 12211  
 Development Stage: 1 Currently Used  
 Utility: 2 Ecologically Important  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 1 High

Aquifer Code: 30602122  
 Island: 3 O'ahu  
 Sector: 06 Windward  
 Aquifer System: 02 Kahana  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 2 Dike

Status Code: 11113  
 Development Stage: 1 Currently Used  
 Utility: 1 Drinking  
 Salinity: 1 Fresh (< 250 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 3 Low

**U.S. Fish & Wildlife Service Wetland Code:**

Estuarine/Intertidal/Emergent/Persistent/Tidal Irregular (E2EM1P)

Estuarine/Intertidal/Forested/Broad-Leaved Evergreen/Tidal Regular (E2FO3N)

Estuarine/Intertidal/Scrub-Shrub/Broad-Leaved Evergreen/ Tidal Regular (E2SS3N)

Marine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal/ Dike-Impounded  
(M1OWLh)

**Geology:**

1. Coastal plain sediments overlying dike complex
2. Shallow sediments; underlying dike complex, poorly permeable

## Moli'i Pond--Continued

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Soil Conservation Service, U.S. Dept. of Agriculture 1975:

HnA (Hanalei silty clay, Typic Fluvaquents)

0-2% slopes

JaC (Jaucas sand, Typic Ustipsamments)

0-15% slopes

LoB (Lolekaa silty clay, Humoxic Tropohumults)

3-8% slopes

MZ (Marsh)

Ms (Mokuleia loam, Typic Haplustolls)

WpaE (Waikane stony silty clay, Humoxic Tropohumults)

15-30% slopes

Terrestrial Threatened or Endangered Plant(s):

No inventory available

Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)

Hawaiian Duck (*Anas wyvilliana*)

Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)

Hawaiian Owl (*Asio flammeus sandwichensis*)

Hawaiian Stilt (*Himantopus mexicanus knudseni*)

O'ahu Creeper (*Paroreomyza maculata*)

Terrestrial Plant(s):

No inventory available

Aquatic Plant(s):

California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)

Great Bulrush (*Scirpus validus* Vahl)

Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)

Cattle Egret (*Bubulcus ibis*)

Common Myna (*Acridotheres tristis*)

House Finch (*Carpodacus mexicanus*)

Japanese White-eye (*Zosterops japonicus*)

Northern Cardinal (*Cardinalis cardinalis*)

Red-crested Cardinal (*Paroaria coronata*)

Spotted Dove (*Streptopelia chinensis*)

**Moli'i Pond--Continued**

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White-rumped Shama (*Copsychus malabaricus*)  
Zebra Dove (*Geopelia striata*)  
Mongoose (*Herpestes auropunctatus*)

## Aquatic Animal(s):

Bonefish (*Albula vulpes*)  
Barracuda (*Sphyraena barracuda* (Walbaum))  
Silver Perch (*Kuhlia sandvicensis*)  
Milkfish (*Chanos chanos* (Forsk.)  
Tilapia (*Tilapia mossambica*)  
Striped Mullet (*Mugil cephalus* L.)

## Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
Ruddy Turnstone (*Arenaria interpres*)  
Sanderling (*Calidris alba*)  
Wandering Tattler (*Heteroscelus incanus*)

## Freshwater Origin:

1. Stream runoff
2. Springs

## Comments:

## References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.
- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
- U.S. Army Corps of Engineers, Engineer District, Honolulu. 1977. Detailed project report, beach erosion control and Final Environmental Statement for Kualoa regional park, O'ahu, Hawaii. 78 p. plus app.



## Appendix E.2.7 Habitat Description of Kualoa Fish Pond

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Site: Kualoa Fish Pond	Lat.: 21°30'45"
Island: O'ahu	Long.: 157°50'25"
Sector: Windward, 06	El.: 0-20 ft
System: Kahana (02)	Approx. Area/Length: 3.9 acres

### Site Description:

The site is generally flat, having an average elevation of about 1.8 m (6 ft) above mean lower low water (MLLW). A fringing coral reef extends approximately 600 m (2,000 ft) seaward of the eastern park shoreline. Within the park boundaries is a small pond of a few hectares. It is managed by the City and County and is used by stilts. A large sand deposit lies about 450 m (1,500 ft) off the southern park shore and Moli'i fishpond. The exposure of Kualoa Beach makes it most susceptible to attack by waves traveling from the northerly quadrants, especially the northeast (Corps of Engineers 1977).

The bottom of Kualoa fish pond is mixed sand and mud. It is surrounded by koa haole forest and scrubland with pickle-weed, pluchea, milo, hau, and various other shrubs and small trees. This pond is within the boundaries of Kualoa Regional Park and is managed as a waterbird sanctuary by the City and County of Honolulu (Shallenberger 1977).

The climate is characterized by a two-season year (summer and winter), mild and uniform temperatures, marked variations in rainfall due to geographic differences, and a general dominance of the northeast trade winds 80-90% of the time during summer dropping to 50-80% in winter.

Sensitivity Rating:	Aa12wtm3fh
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Status:	2w Wildlife Protected
Wetland Use:	t Traditional
Wetland Avifauna:	m Migratory Fowl
Other Value:	3f Sediment Trap
Other Value:	h Historical Value
Habitat Code:	1-1b-3-2-4-3-1-2
Water Source:	1 Groundwater
Habitat Origin/Development:	1b Natural/Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	2 Aquaculture
Social Significance:	4 Historic Not Registered + Wildlife Protected
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	1 Pond
Water Quality:	2 Brackish (250-15,000 mg/l Cl <sup>-</sup> )

**Kualoa Fish Pond--Continued**

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Aquifer Code: 30602116  
 Island: 3 O'ahu  
 Sector: 06 Windward  
 Aquifer System: 02 Kahana  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 1 Unconfined  
 Aquifer Type (Geology): 6 Sedimentary  
  
 Status Code: 12211  
 Development Stage: 1 Currently Used  
 Utility: 2 Ecologically Important  
 Salinity: 2 Low (250-1,000 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 1 High

Aquifer Code: 30602122  
 Island: 3 O'ahu  
 Sector: 06 Windward  
 Aquifer System: 02 Kahana  
 Aquifer Type (Hydrology): 1 Basal  
 Aquifer Type (Hydrology): 2 Confined  
 Aquifer Type (Geology): 2 Dike

Status Code: 11113  
 Development Stage: 1 Currently Used  
 Utility: 1 Drinking  
 Salinity: 1 Fresh (< 250 mg/l Cl<sup>-</sup>)  
 Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 3 Low

U.S. Fish & Wildlife Service Wetland Code:  
 Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent/ Dike-Impounded  
 (POWHh)

Geology:  
 1. Coastal plain sediments overlying dike complex  
 2. Shallow sediments; underlying dike complex, poorly permeable

Soil Conservation Service, U.S. Dept. of Agriculture 1975:  
 JaC (Jaucas sand, Typic Ustipsamments)  
 0-15% slopes

Terrestrial Threatened or Endangered Plant(s):  
 No inventory available

## Kualoa Fish Pond--Continued

### Terrestrial Threatened or Endangered Animal(s):

- Hawaiian Coot (*Fulica americana alai*)
- Hawaiian Duck (*Anas wyvilliana*)
- Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)
- Hawaiian Owl (*Asio flammeus sandwichensis*)
- Hawaiian Stilt (*Himantopus mexicanus knudseni*)
- O'ahu Creeper (*Paroreomyza maculata*)

### Terrestrial Plant(s):

- Koa haole (*Leucaena leucocephala* (Lam.) deWit)
- Pluchea (*Pluchea x fosbergii* Coop. and Gal.)
- Portia tree (*Thespesia populnea* (L.) Sol.)

### Aquatic Plant(s):

- Pickle-weed (*Batis maritima* L.)
- Hau (*Hibiscus tiliaceus* L.)
- Hairy fleabane (*Pluchea odorata* (L.) Cass.)

### Terrestrial Animal(s):

- Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)
- Cattle Egret (*Bubulcus ibis*)
- Common Myna (*Acridotheres tristis*)
- House Finch (*Carpodacus mexicanus*)
- Japanese White-eye (*Zosterops japonicus*)
- Northern Cardinal (*Cardinalis cardinalis*)
- Nutmeg Mannikin (*Lonchura punctulata*)
- Red-crested Cardinal (*Paroaria coronata*)
- Red-footed Booby (*Sula sula rubripes*)
- Red-tailed Tropicbird (*Phaethon rubricauda rothschildi*)
- Ring-necked Pheasant (*Phasianus colchicus*)
- Spotted Dove (*Streptopelia chinensis*)
- White-rumped Shama (*Copsychus malabaricus*)
- White-tailed Tropicbird (*Phaethon lepturus dorotheae*)
- Zebra Dove (*Geopelia striata*)
- Mongoose (*Herpestes auropunctatus*)

### Aquatic Animal(s):

- Bonefish (*Albula vulpes*)
- Ladyfish (*Elops hawaiiensis* Regan)
- Saddle Wrasse (*Thalassoma duperrey*)
- Belted Wrasse (*Stethojulis balteata*)
- Big Eye (*Priacanthus cruentatus*)
- Damselfish (*Abudefduf abdominalis*)
- Whitespot Goatfish (*Parupeneus porphyreus*)

## Kualoa Fish Pond--Continued

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Black-branded Goatfish (*Parupeneus multifasciatus*)  
 Silver Perch (*Kuhlia sandvicensis*)  
 Milkfish (*Chanos chanos (Forsk.)*)  
 Threadfin (*Polydactylus sexfilis*)  
 Striped Mullet (*Mugil cephalus L.*)  
 Anchovy (*Stolephorus purpureus Fowler*)  
 White Goatfish (*Mulloidides flavolineatus*)  
 Short-lined Cardinal Fish (*Foa brachygramma*)  
 Bluespine Unicornfish (*Naso unicornis*)  
 Hawaiian Surgeon (*Acanthurus dussumieri*)

### Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
 Osprey (*Pandion haliaetus*)  
 Ruddy Turnstone (*Arenaria interpres*)  
 Sanderling (*Calidris alba*)  
 Wandering Tattler (*Heteroscelus incanus*)

### Freshwater Origin:

1. Stream runoff
2. Springs

### Comments:

Old aerial photos which show accretion of material on the north side of groins constructed along the coast, suggest a southerly littoral transport. Old beach ridges suggest an incremental growth and it appears Kualoa peninsula is a dynamic sand spit building up south into Kane'ohē Bay (U.S. Army Corps of Engineers 1977).

### References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
- Towill, R.M., Corp. 1979. Environmental Impact Statement for the Kahalu'u wastewater treatment and disposal system. Prepared for the Department of Public Works, City and County of Honolulu, Hawaii. 124 p. plus app.
- U.S. Army Corps of Engineers, Engineer District, Honolulu. 1977. Detailed project report, beach erosion control and Final Environmental Statement for Kualoa regional park, O'ahu, Hawaii. 78 p. plus app.

### **Appendix E.3 System-Wide Characteristics of Ecologically Sensitive Habitats, Aquifers of Windward Sector, Koolaupoko System**

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**Aquifer System:** Koolaupoko (03)

**Aquifer Sector:** Windward (06)

**Island:** O'ahu (3)

**Water Wells in Aquifer System (Div. of Water and Land Development 1984):**

Disposal	5	Domestic	6	Industrial	-
Irrigation	5	Lost	-	Municipal	14
Observation	1	Other	-	Recharge	-
Sealed	5	Unused	19	Unknown	3

**(Department of Health 1987):**

Drinking	1
Other	-

**Total Number of Injection Wells:** 5

**Water Wells or Sampling Sites Once Contaminated with DBCP, EDB or TCP (Water Resources Research Center 1985):**

None

**Potential Pollutant Sources and Pollutants (see Fig. 2):**

**Source:** City and County of Honolulu (NPDES 20150)  
**Pollutants:** Municipal wastes from Kane'ohu STP  
**Discharge:** 3.92 mgd

**Source:** Agriculture and Ranching Activities  
**Pollutants:** Nitrates, Phosphates and Fecal Coliform  
**Discharge:** Non-point Source

**Source:** Stormwater Runoff  
**Pollutants:** Nitrogen and Phosphorus  
**Discharge:** Non-point Source

**Source:** Likelike Highway  
**Pollutants:** Runoff  
**Discharge:** Non-point Source

**Source:** Landfill Runoff  
**Pollutants:** Leachate  
**Discharge:** Non-point Source

**Source:** Residential Cesspools  
**Pollutants:** Fecal coliform  
**Discharge:** Non-point Source



### Appendix E.3.1 Habitat Description of Ho'omaluhia Park

Site:	Ho'omaluhia Park	Lat.:	21°23'30"
Island:	O'ahu	Long.:	157°48'25"
Sector:	Windward, 06	El.:	200-240 ft
System:	Koolaupoko (03)	Approx. Area/Length:	31.5 acres

#### Site Description:

A man-made lake near Kane'ohē was constructed as part of a U.S. Army Corps of Engineers flood control project. It is used by coots, gallinules and koloa. Ho'omaluhia Park is operated as an environmental education center.

Sensitivity Rating:		Aa12wm3f
Main Water Source:	A	Groundwater
Habitat:	a	Natural
Endangered Species:	1	Observed
Wetland Status:	2w	Wildlife Protected
Wetland Avifauna:	m	Migratory Fowl
Other Value:	3f	Sediment Trap
Habitat Code:		1-1b-3-4-4-3-1-1
Water Source:	1	Groundwater
Habitat Origin/Development:	1b	Natural/Altered
Ecological Character:	3	Endangered Species + Migratory Birds
Present Activities:	4	Recreation
Social Significance:	4	Historic Not Registered + Wildlife Protected
Physical Significance:	3	Sediment Trap + Flood Control
Wetland Type:	1	Pond
Water Quality:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:		30603212
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	2	High Level
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	2	Dike
Status Code:		11111
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High

**Ho'omaluhia Park--Continued**

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## U.S. Fish &amp; Wildlife Service Wetland Code:

Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent/ Dike-Impounded  
(POWHh)

## Geology:

1. Coastal plain sediments overlying dike complex
2. Shallow sediments; underlying dike complex, poorly permeable

## Soil Conservation Service, U.S. Dept. of Agriculture 1975:

HnB (Hanalei silty clay, Typic Fluvaquents)  
2-6% slopes

KHME (Kaneohe silty clay loam)  
15-30% slopes

LoB (Lolekaa silty clay, Humoxic Tropohumults)  
3-8% slopes

LoE (Lolekaa silty clay, Humoxic Tropohumults)  
25-40% slopes

LoF (Lolekaa silty clay, Humoxic Tropohumults)  
40-70% slopes

## Terrestrial Threatened or Endangered Plant(s):

No inventory available

## Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Duck (*Anas wyvilliana*)  
Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)

## Terrestrial Plant(s):

No inventory available

## Aquatic Plant(s):

No inventory available

## Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
Cattle Egret (*Bubulcus ibis*)

## Aquatic Animal(s):

No inventory available



**Ho'omaluhia Park--Continued**

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**Migratory Animal(s):**

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
Mallard (*Anas platyrhynchos*)

**Freshwater Origin:**

1. Stream runoff
2. Springs and dike waters

**Comments:****References:**

- Department of Land and Natural Resources. 1984. Statewide waterbird marking, movement, and disease study. Project no. W-18-R-9, Job no. R-III-F. 5 p.
- U.S. Fish and Wildlife Service. 1985. Recovery plan for the Hawaiian Waterbirds. Prepared for U.S. Fish and Wildlife Service, Portland, Oregon. 99 p.



### Appendix E.3.2 Habitat Description of He'eia

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Site:	He'eia	Lat.:	21°26'10"
Island:	O'ahu	Long.:	157°49'05"
Sector:	Windward, 06	El.:	0-40 ft
System:	Koolaupoko (03)	Approx. Area/Length:	391.6 acres

#### Site Description:

This coastal wetland is characterized by two species of mangroves, American and, less commonly, the Oriental (Elliott and Hall 1977). Dense growths up to 1.5 m (4 to 5 ft) tall are visible on both sides of the small bridge spanning He'eia Stream. The rapid growth of mangroves at the stream outlet restricts water flow and forms smaller ponds which communicate with the ocean through a channel at its border. Increasing silt loads in He'eia Stream as a result of urban development in the Kane'ohe watershed, have reduced the open water in the upper marshland to a fraction of its original size creating meadowland traps. These filter silt from stream flow and store periodic flood waters. To this extent the meadowland performs an important function to protect water quality in the bay. The reduced amount of open water meadowland is due to the overall reduction in water table in the Kane'ohe area and the 40% reduction in He'eia Stream flow is a result of diversion. The remaining open water in the meadowland ranged in depth from about 15 cm (6 in.) to 1 m (3 ft) and increases to more than 1.5 m (5 ft) after rains. The lands are used for cattle grazing. This activity has further increased the turbidity of the water. Various grasses, pluchea, and other shrubs have invaded the meadowland as the accumulation of silt has accelerated. A large landfill at the edge of the meadow-land has further degraded the habitat through runoff into the marsh.

Sensitivity Rating:	Aa12m3fh
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Other Value:	3f Sediment Trap
Other Value:	h Historical Value

Habitat Code:	1-1c-3-1b-1b-4-4-4
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	1b Agriculture Livestock
Social Significance:	1b Historic Not Registered
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	4 Marsh
Water Quality:	4 Combination

**He'eia--Continued**

---

Aquifer Code:		30603212
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	2	High Level
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	2	Dike
Status Code:		11111
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High

**U.S. Fish & Wildlife Service Wetland Code:**

Estuarine/Intertidal/Forested/Broad-Leaved Evergreen/Tidal Regular (E2FO3N)

Marine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal (M1OWL)

Palustrine/Emergent/Persistent/Non-Tidal Seasonal (PEM1C)

Palustrine/Emergent/Persistent/Non-Tidal Semipermanent (PEM1F)

Palustrine/Emergent/Persistent/Tidal Artificial/Non-Tidal  
Semipermanent/Dike-Impounded (PEM1KFh)

**Geology:**

1. Coastal plain sediments on Koolau dike complex
2. Shallow sediments; underlying dike complex poorly permeable

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

HnA (Hanalei silty clay, Typic Fluvaquents)  
0-2% slopes

HnB (Hanalei silty clay, Typic Fluvaquents)  
2-6% slopes

HoB (Hanalei stony silty clay)  
2-6% slopes

LoB (Lolekaa silty clay, Humoxic Tropohumults)  
3-8% slopes

## He'eia--Continued

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LoD (Lolekaa silty clay, Humoxic Tropohumults)  
15-25% slopes

LoE (Lolekaa silty clay, Humoxic Tropohumults)  
25-40% slopes

LoF (Lolekaa silty clay, Humoxic Tropohumults)  
40-70% slopes

MZ (Marsh)

Terrestrial Threatened or Endangered Plant(s):  
No inventory available

Terrestrial Threatened or Endangered Animal(s):  
Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Duck (*Anas wyvilliana*)  
Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
Hawaiian Owl (*Asio flammeus sandwichensis*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)  
O'ahu Creeper (*Paroreomyza maculata*)

Terrestrial Plant(s):  
Broomsedge (*Andropogon virginicus* L.)  
Octopus tree (*Brassaia actinophylla* Endl.)  
Partridge pea (*Cassia leschenaultiana* DC.)  
Common ironwood (*Casuarina equisetifolia* L.)  
Spanish clover (*Desmodium canum* (Gmel.) Schinz & Thellung)  
Spanish clover (*Desmodium intortum* (Mill.) Urban)  
Spanish clover (*Desmodium uncinatum* (Jacq.) DC.)  
Java plum (*Eugenia cuminii* (L.) Druce)  
Rose apple (*Eugenia jambos* L.)  
Impatiens (*Impatiens sultani* Hook. f.)  
Lantana (*Lantana camara* L.)  
Koa haole (*Leucaena leucocephala* (Lam.) deWit)  
Macaranga (*Macaranga grandifolia* (Blco.) Merr.)  
Molasses grass (*Melinis minutiflora* Beauv.)  
Basket grass (*Oplismenus hirtellus* (L.) Beauv.)  
Fevervine (*Paederia foetida* L.)  
Screw pine (*Pandanus odoratissimus* L. f.)  
Guinea grass (*Panicum maximum* Jacq.)  
Knottgrass (*Paspalum distichum* L.)  
Pluchea (*Pluchea x fosbergii* Coop. and Gal.)  
Common guava (*Psidium guajava* L.)

**He'eia--Continued**

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Christmas-berry tree (*Schinus terebinthifolius Raddi*)  
 Jamaica vervain (*Stachytarpheta jamaicensis (L.) Vahl*)  
 False kamani (*Terminalia catappa L.*)  
 Portia tree (*Thespesia populnea (L.) Sol.*)  
 Wedelia (*Wedelia trilobata (L.) Hitchc.*)  
 'Ape (*Xanthosoma sagittifolium (L.) Schott*)

**Aquatic Plant(s):**

Pickle-weed (*Batis maritima L.*)  
 California grass (*Brachiaria mutica (Forsk.) Stapf*)  
 Oriental mangrove (*Bruguiera gymnorhiza Lam.*)  
 Job's tears (*Coix lachryma-jobi L.*)  
 Day flower (*Commelina diffusa Burm. f.*)  
 Hau (*Hibiscus tiliaceus L.*)  
 Moon flower (*Ipomoea alba L.*)  
 Hairy fleabane (*Pluchea odorata (L.) Cass.*)  
 Red mangrove (*Rhizophora mangle L.*)

**Terrestrial Animal(s):**

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
 Cattle Egret (*Bubulcus ibis*)  
 Common Myna (*Acridotheres tristis*)  
 House Sparrow (*Passer domesticus*)  
 Northern Cardinal (*Cardinalis cardinalis*)  
 Nutmeg Mannikin (*Lonchura punctulata*)  
 Spotted Dove (*Streptopelia chinensis*)  
 Zebra Dove (*Geopelia striata*)  
 Mongoose (*Herpestes auropunctatus*)

**Aquatic Animal(s):**

Chinese Catfish (*Clarias fuscus*)  
 Green Swordtail (*Xiphophorus helleri (Heckel)*)  
 Guppy (*Poecilia reticulata Peters*)  
 Silver Perch (*Kuhlia sandvicensis*)  
 Mosquitofish (*Gambusia affinis (Baird and Girard)*)  
 Tilapia (*Tilapia mossambica*)  
 'O'opu (*Vitraria clarescens Jordan and Evermann*)  
 'O'opu 'alamo'o (*Lentipes concolor*)  
 'O'opu nakea (*Awaous stamineus*)  
 'O'opu naniha (*Awaous genivittatus*)  
 'O'opu nopili (*Sicydium stimsonii*)  
 Oriental Weatherfish (*Misgurnus anguillicaudatus (Cantor)*)  
 Pointed-tail Goby (*Oxyurichthys lonchotus (Jenkins)*)  
 Sailfin Molly (*Poecilia latipinna (Lesueur)*)

## He'eia--Continued

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Samoan Crab (*Scylla serrata*)  
 Shortfin Molly (*Poecilia mexicana*)  
 Slender Lizard Fish (*Saurida gracilis* (Quoy and Gaimard))

### Migratory Animal(s):

American Wigeon (*Anas americana*)  
 Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
 Mallard (*Anas platyrhynchos*)

### Freshwater Origin:

1. Runoff; from high level dike complex
2. Shallow alluvial sediment
3. Dike complex

### Comments:

He'eia is listed in the State of Hawaii Register of Historic Sites. Stream waters of He'eia are diverted in one area.

### References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
- Gray, Hong & Associates. 1986. Draft Supplemental Environmental Impact Statement for He'eia Kea Valley, He'eia, Koolaupoko, O'ahu. 99 p. plus app.
- Walsh, G.E. 1963. An ecological study of the He'eia mangrove swamp. PHD. thesis (Philosophy), University of Hawaii, Honolulu. 219 p.
- Towill, R.M., Corp. 1979. Environmental Impact Statement for the Kahalu'u wastewater treatment and disposal system. Prepared for the Department of Public Works, City and County of Honolulu, Hawaii. 124 p. plus app.
- Elliott, M.E. 1981. Wetlands and wetland vegetation of the Hawaiian Islands. Master thesis (Geography), University of Hawaii, Honolulu. 228 p.
- Elliott, M.E., and Hall, E.M. 1977. Wetlands and wetland vegetation of Hawaii. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 344 p.
- Timbol, A.S., and Maciolek, J.A. 1978. Stream channel modification in Hawaii. Part A: Statewide inventory of streams, habitat factors and associated biota. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 157 p.





### Appendix E.3.3 Habitat Description of Ioleka'a Stream

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Site:	Ioleka'a Stream	Lat.:	21°25'08"
Island:	O'ahu	Long.:	157°50'11"
Sector:	Windward, 06	El.:	160-1000 ft
System:	Koolaupoko (03)	Approx. Area/Length:	1 mile

#### Site Description:

Ioleka'a Stream is a tributary of He'eia Stream which originates in Ioleka'a Valley behind Haiku Plantations. This stream flows into He'eia Stream above Kahekili Highway. The drainage basin for this and Puolena Stream is 220 ha.

Rain in Kane'ohe results from cooling of warm moist air when the predominant northeast trade winds are deflected upward by the Koolau Range. Average annual rainfall ranges from about 1.3 m (50 in.) near the coast to about 2.5 m (100 in.) near the crest of the Koolau Range immediately inland of Ioleka'a Valley.

Sensitivity Rating:	Aa12m
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Habitat Code:	1-1c-2-5-5-4-2-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	2 Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	2 Stream
Water Quality:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:	30603212
Island:	3 O'ahu
Sector:	06 Windward
Aquifer System:	03 Koolaupoko
Aquifer Type (Hydrology):	2 High Level
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	2 Dike
Status Code:	11111
Development Stage:	1 Currently Used
Utility:	1 Drinking
Salinity:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )

**Ioleka'a Stream--Continued**

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Uniqueness: 1 Irreplaceable  
 Vulnerability to Contamination: 1 High

U.S. Fish & Wildlife Service Wetland Code:  
 Palustrine/Emergent/Persistent/Non-Tidal Seasonal (PEM1C)

**Geology:**

1. Coastal plain sediment on Koolau dike complex
2. Shallow sediments; underlying dike complex poorly permeable

Soil Conservation Service, U.S. Dept. of Agriculture 1975:  
 HoB (Hanalei stony silty clay)  
 2-6% slopes

Terrestrial Threatened or Endangered Plant(s):  
 No inventory available

Terrestrial Threatened or Endangered Animal(s):  
 Hawaiian Owl (*Asio flammeus sandwichensis*)

**Terrestrial Plant(s):**

- Candlenut tree (*Aleurites moluccana* (L.) Willd.)
- Ti (*Cordyline terminalis* (L.) Kunth)
- Mango (*Mangifera indica* L.)
- African tulip tree (*Spathodea campanulata* Beauv.)

**Aquatic Plant(s):**

- Job's tears (*Coix lachryma-jobi* L.)
- Hau (*Hibiscus tiliaceus* L.)

**Terrestrial Animal(s):**

- Japanese White-eye (*Zosterops japonicus*)
- Nutmeg Mannikin (*Lonchura punctulata*)
- Spotted Dove (*Streptopelia chinensis*)
- Zebra Dove (*Geopelia striata*)
- Mongoose (*Herpestes auropunctatus*)

**Aquatic Animal(s):**

- Tahitian Prawn (*Macrobrachium lar*)
- 'Opae-kala-'ole (*Atya bisulcata*)
- Chinese Catfish (*Clarias fuscus*)
- Crayfish (*Procambarus clarkii*)
- Electrid (*Eleotris sandwicensis* Vaillant and Sauvage)
- Green Swordtail (*Xiphophorus helleri* (Heckel))

**Ioleka'a Stream--Continued**

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Mosquitofish (*Gambusia affinis (Baird and Girard)*)

'O'opu nakea (*Awaous stamineus*)

Oriental Weatherfish (*Misgurnus anguillicaudatus (Cantor)*)

Shortfin Molly (*Poecilia mexicana*)

**Migratory Animal(s):**

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)

**Freshwater Origin:**

1. Runoff; from high level dike complex
2. Shallow alluvial sediment
3. Dike complex

**Comments:**

**References:**

Board of Water Supply. 1982. Environmental Impact Statement for Ioleka'a Well. City and County of Honolulu. 40 p. plus app.



### Appendix E.3.4 Habitat Description of Haiku Stream

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Site:	Haiku Stream	Lat.:	21°24'43"
Island:	O'ahu	Long.:	157°50'20"
Sector:	Windward, 06	El.:	200-1000 ft
System:	Koolaupoko (03)	Approx. Area/Length:	1 mile

#### Site Description:

This is a small tributary of Kea'ahala Stream which originates from Baskerville Spring near the pond at Haiku Gardens Restaurant off Haiku Road. The stream is unnamed, although sometimes referred to as "Haiku", a name also given to the segment of He'eia Stream above the confluence with Ioleka'a Stream. This stream is not shown on most maps of the area although it appears to be continuously flowing. The stream crosses under Kahekili Highway just south of Haiku Road and joins Kea'ahala Stream near the intersection of Kawa and Kahuhipa streets in Kane'ohe town.

Most rain in Kane'ohe results from cooling of warm moist air when the predominant northeast trade winds are deflected up by the Koolau Range. Average annual rainfall increases from about 1.3 m (50 in.) near the coast to 2.5 m (100 in.) near the crest of the Koolau Range immediately inland of Ioleka'a Valley.

Sensitivity Rating:		Aa1
Main Water Source:	A	Groundwater
Habitat:	a	Natural
Endangered Species:	1	Observed
Habitat Code:		1-1c-1-5-5-4-2-1
Water Source:	1	Groundwater
Habitat Origin/Development:	1c	Natural/Pristine + Altered
Ecological Character:	1	Endangered Species
Present Activities:	5	Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5	Neither Historic nor Wildlife Protected
Physical Significance:	4	Neither Sediment Trap nor Flood Control
Wetland Type:	2	Stream
Water Quality:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:		30603212
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	2	High Level
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	2	Dike

**Haiku Stream--Continued**

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Status Code:		11111
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High

## U.S. Fish &amp; Wildlife Service Wetland Code:

Palustrine/Emergent/Persistent/Non-Tidal Seasonal (PEM1C)

Palustrine/Forested/Broad-Leaved Evergreen/Non-Tidal Temporary (PFO3A)

## Geology:

1. Coastal plain sediment on Koolau dike complex
2. Shallow sediments; underlying dike complex poorly permeable

## Soil Conservation Service, U.S. Dept. of Agriculture 1975:

HnB (Hanalei silty clay, Typic Fluvaquents)

2-6% slopes

LoD (Lolekaa silty clay, Humoxic Tropohumults)

15-25% slopes

LoF (Lolekaa silty clay, Humoxic Tropohumults)

40-70% slopes

## Terrestrial Threatened or Endangered Plant(s):

No inventory available

## Terrestrial Threatened or Endangered Animal(s):

Hawaiian Owl (*Asio flammeus sandwichensis*)

## Terrestrial Plant(s):

Candlenut tree (*Aleurites moluccana* (L.) Willd.)  
 Ti (*Cordyline terminalis* (L.) Kunth)  
 Java plum (*Eugenia cuminii* (L.) Druce)  
 Koa haole (*Leucaena leucocephala* (Lam.) deWit)  
 Macaranga (*Macaranga grandifolia* (Blco.) Merr.)  
 Mango (*Mangifera indica* L.)  
 Molasses grass (*Melinis minutiflora* Beauv.)  
 Basket grass (*Oplismenus hirtellus* (L.) Beauv.)  
 Mamaki (*Pipturus albidus* (H. & A.) Gray)  
 Pluchea (*Pluchea x fosbergii* Coop. and Gal.)  
 Common guava (*Psidium guajava* L.)

## Haiku Stream--Continued

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Wedelia (*Wedelia trilobata* (L.) Hitchc.)  
 'Ape (*Xanthosoma sagittifolium* (L.) Schott)

### Aquatic Plant(s):

California grass (*Brachiaria mutica* (Forsk.) Stapf)  
 Job's tears (*Coix lachryma-jobi* L.)  
 Day flower (*Commelina diffusa* Burm. f.)  
 Hau (*Hibiscus tiliaceus* L.)  
 Hairy fleabane (*Pluchea odorata* (L.) Cass.)

### Terrestrial Animal(s):

No inventory available

### Aquatic Animal(s):

Chinese Catfish (*Clarias fuscus*)  
 Green Swordtail (*Xiphophorus helleri* (Heckel))  
 Guppy (*Poecilia reticulata* Peters)  
 Mosquitofish (*Gambusia affinis* (Baird and Girard))  
 'O'opu (*Vitraria clarescens* Jordan and Evermann)  
 'O'opu 'alamo'o (*Lentipes concolor*)  
 'O'opu nakea (*Awaous stamineus*)  
 'O'opu naniha (*Awaous genivittatus*)  
 'O'opu nopili (*Sicydium stimsonii*)  
 Oriental Weatherfish (*Misgurnus anguillicaudatus* (Cantor))  
 Shortfin Molly (*Poecilia mexicana*)

### Migratory Animal(s):

No inventory available

### Freshwater Origin:

1. Runoff; from high level dike complex
2. Shallow alluvial sediment
3. Dike complex

### Comments:

### References:

Taniguchi, Ltd., P.T. 1982. Revised Environmental Impact Statement for the deep well pump and construction of control building for Haiku Well at Haiku Valley, Koolaupoko, O'ahu. Board of Water Supply, City and County of Honolulu. 22 p. plus app.

**Haiku Stream--Continued**

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Chinn, S.S., Tateishi, G.A., and Yee, J.J.S. 1985. Water resources data/Hawaii and other Pacific areas/water year 1985/volume 1. U.S. Geological Survey Water-Data Report HI-85-1, prepared in cooperation with Division of Water and Land Development, Dept. of Land and Natural Resources, State of Hawaii, Honolulu. 302 p.



### Appendix E.3.5 Habitat Description of Baskerville Spring

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Site: Baskerville Spring	Lat.: 21°25'01"
Island: O'ahu	Long.: 157°49'05"
Sector: Windward, 06	El.: 160-200 ft
System: Koolaupoko (03)	Approx. Area/Length: N/A

#### Site Description:

Baskerville Spring is the water source for the Haiku Gardens pond. The spring originates in the southern face of the depression at Haiku Gardens then flows along the southern face eventually entering the pond. Haiku Gardens is a privately owned botanical garden that houses many tropical ornamental plants.

#### Sensitivity Rating:

	Aa2m
Main Water Source:	A Groundwater
Habitat:	a Natural
Wetland Avifauna:	2m Migratory Fowl

#### Habitat Code:

	1-1b-2-4-5-4-1-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1b Natural/Altered
Ecological Character:	2 Migratory Birds
Present Activities:	4 Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	1 Pond
Water Quality:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )

#### Aquifer Code:

	30603212
Island:	3 O'ahu
Sector:	06 Windward
Aquifer System:	03 Koolaupoko
Aquifer Type (Hydrology):	2 High Level
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	2 Dike

#### Status Code:

	11111
Development Stage:	1 Currently Used
Utility:	1 Drinking
Salinity:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1 Irreplaceable
Vulnerability to Contamination:	1 High

#### U.S. Fish & Wildlife Service Wetland Code:

Palustrine/Forested/Broad-Leaved Evergreen/Non-Tidal Temporary (PFO3A)

**Baskerville Spring--Continued**

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**Geology:**

1. Honolulu volcanic series
2. Late volcanics on sediments, which in turn cover Koolau dike complex

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

LoD (Lolekaa silty clay, Humoxic Tropohumults)  
15-25% slopes

**Terrestrial Threatened or Endangered Plant(s):**

No inventory available

**Terrestrial Threatened or Endangered Animal(s):**

No inventory available

**Terrestrial Plant(s):**

No inventory available

**Aquatic Plant(s):**

No inventory available

**Terrestrial Animal(s):**

No inventory available

**Aquatic Animal(s):**

No inventory available

**Migratory Animal(s):**

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)

**Freshwater Origin:**

1. High level perched
2. Honolulu volcanic series
3. Koolau dike complex; Honolulu volcanic series

**Comments:****References:**

Taniguchi, Ltd., P.T. 1982. Revised Environmental Impact Statement for the deep well pump and construction of control building for Haiku Well at Haiku Valley, Koolaupoko, O'ahu. Board of Water Supply, City and County of Honolulu. 22 p. plus app.

### Appendix E.3.6 Habitat Description of Waihe'e Stream

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Site:	Waihe'e Stream	Lat.:	21°26'55"
Island:	O'ahu	Long.:	157°52'05"
Sector:	Windward, 06	El.:	0-400 ft
System:	Koolaupoko (03)	Approx. Area/Length:	2 miles

#### Site Description:

Waihe'e Valley extends southwest 4 km (2.5 miles) into the Koolau Range from Kane'ohe Bay. The lower portion of the valley, extending 2.4 km (1.5 miles) to an altitude of about 60 m (200 ft), cuts across the dike complex of the main rift zone of the Koolau Range. The dike complex is characterized by numerous, closely spaced dikes. The upper part of the valley, above an elevation of 60 m, is in the marginal dike zone which borders the dike complex. The dikes are decidedly fewer and scattered in the marginal dike zone. The Waihe'e Tunnel, located near the western edge of the dike complex, extends southwest about 480 m (1,600 ft) into the marginal dike zone.

Waihe'e Stream discharges into nearby Kahalu'u Pond which is surrounded by urban lands and lies adjacent to Kamehameha Highway. Kahalu'u Pond is separated from the road by a small embankment covered with weedy vegetation including koa haole shrubs.

This area receives abundant rainfall as well as water from dike-confined springs and upland streams enabling the marsh to support low grasses and amaranthus in dry soil grading into great bulrush and California grass in waterlogged soil, marking the boundary on the southern side. The interior of the marsh is dominated by a dense stand of California grass, with occasional patches of arrowhead and kamole. The underlying soil is mucky, with 0.3 to 0.6 m (1-2 ft) of overlying water varying seasonally.

Sensitivity Rating:	Aa12t3f
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Use:	2t Traditional
Other Value:	3f Sediment Trap
Habitat Code:	1-1c-1-5-1b-3-2-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	1 Endangered Species
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	1b Historic Not Registered
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	2 Stream
Water Quality:	1 Fresh (<250 mg/l Cl <sup>-</sup> )

**Waihe'e Stream--Continued**

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Aquifer Code:		30603212
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	2	High Level
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	2	Dike
Status Code:		11111
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30603116
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30603122
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	2	Dike
Status Code:		11122
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	2	Replaceable
Vulnerability to Contamination:	2	Moderate

## Waihe'e Stream--Continued

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### U.S. Fish & Wildlife Service Wetland Code:

Estuarine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal/ Excavated  
(E1OWLx)

Marine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal (M1OWL)

Palustrine/Emergent/Persistent/Non-Tidal Seasonal (PEM1C)

Palustrine/Emergent/Persistent/Tidal Artificial/Non-Tidal  
Semipermanent/Dike-Impounded (PEM1KFh)

Riverine/Upper Perennial/Open Water-Unknown Bottom/Non-Tidal Permanent  
(R3OWH)

### Geology:

1. Coastal plain sediment on Koolau dike complex
2. Shallow sediments; underlying dike complex poorly permeable

### Soil Conservation Service, U.S. Dept. of Agriculture 1975:

HnA (Hanalei silty clay, Typic Fluvaquents)  
0-2% slopes

HnB (Hanalei silty clay, Typic Fluvaquents)  
2-6% slopes

Ph (Pearl Harbor clay, Typic Tropaquepts)

TR (Tropaquepts)

WpE (Waikane silty clay, Humoxic Tropohumults)  
25-40% slopes

WpF (Waikane silty clay, Humoxic Tropohumults)  
40-70% slopes

### Terrestrial Threatened or Endangered Plant(s):

No inventory available

### Terrestrial Threatened or Endangered Animal(s):

No inventory available

### Terrestrial Plant(s):

Spiny amaranth (*Amaranthus spinosus* L.)  
Hairy horseweed (*Bidens pilosa* L.)

## Waihe'e Stream--Continued

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Button weed (*Borreria laevis* (Lam.) Griseb.)  
 Common ironwood (*Casuarina equisetifolia* L.)  
 Asiatic pennywort (*Centella asiatica* (L.) Urban)  
 Coconut tree (*Cocos nucifera* L.)  
 Spanish clover (*Desmodium canum* (Gmel.) Schinz & Thellung)  
 Spanish clover (*Desmodium intortum* (Mill.) Urban)  
 Spanish clover (*Desmodium uncinatum* (Jacq.) DC.)  
 Large crabgrass (*Digitaria sanguinalis* (L.) Heist. in Scop.)  
 Oak fern (*Dryopteris dentata* (Forsk.) C. Chr.)  
 Flora's paint brush (*Emilia fosbergii* Nicolson)  
 Flora's paint brush (*Emilia sonchifolia* (L.) DC.)  
 Java plum (*Eugenia cuminii* (L.) Druce)  
 Indigo (*Indigofera anil* L.)  
 Indigo (*Indigofera suffruticosa* Mill.)  
 Indigo (*Indigofera tinctoria* L.)  
 Lions-ear (*Leonotis nepetaefolia* (L.) R. Br.)  
 Sensitive plant (*Mimosa pudica* L.)  
 Fevervine (*Paederia foetida* L.)  
 Passion flower (*Passiflora* sp.)  
 Strawberry guava (*Psidium cattleianum* Sabine)  
 Common guava (*Psidium guajava* L.)  
 Christmas-berry tree (*Schinus terebinthifolius* Raddi)  
 Malayan ground orchid (*Spathoglottis plicata* Bl.)  
 Nettle-leaved vervain (*Stachytarpheta urticaefolia* (Salisb.) Sims)

### Aquatic Plant(s):

California grass (*Brachiaria mutica* (Forsk.) Stapf)  
 Day flower (*Commelina diffusa* Burm. f.)  
 Hau (*Hibiscus tiliaceus* L.)  
 Primrose willow (*Ludwigia octovalvis* (Jacq.) Raven)  
 Red mangrove (*Rhizophora mangle* L.)  
 California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)  
 Great bulrush (*Scirpus validus* Vahl)  
 Arrowhead (*Sagittaria sagittaefolia* L.)

### Terrestrial Animal(s):

Cattle Egret (*Bubulcus ibis*)  
 Common Myna (*Acridotheres tristis*)  
 House Finch (*Carpodacus mexicanus*)  
 House Sparrow (*Passer domesticus*)  
 Japanese White-eye (*Zosterops japonicus*)  
 Red-crested Cardinal (*Paroaria coronata*)  
 Red-vented Bulbul (*Pycnonotus cafer*)  
 Spotted Dove (*Streptopelia chinensis*)

## Waihe'e Stream--Continued

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Zebra Dove (*Geopelia striata*)  
 House Mouse (*Mus musculus domesticus*)  
 Mongoose (*Herpestes auropunctatus*)  
 Norway Rat (*Rattus norvegicus*)  
 Roof Rat (*Rattus rattus*)

### Aquatic Animal(s):

Green Swordtail (*Xiphophorus helleri* (Heckel))  
 Guppy (*Poecilia reticulata* Peters)  
 Tilapia (*Tilapia mossambica*)  
 'O'opu (*Vitraria clarescens* Jordan and Evermann)  
 'O'opu 'alamo'o (*Lentipes concolor*)  
 'O'opu nakea (*Awaous stamineus*)  
 'O'opu naniha (*Awaous genivittatus*)  
 'O'opu nopili (*Sicydium stimsonii*)  
 Striped Mullet (*Mugil cephalus* L.)  
 Wrinkled Frog (*Rana rugosa*)

### Migratory Animal(s):

No inventory available

### Freshwater Origin:

1. Runoff; from high level dike complex
2. Shallow alluvial sediment
3. Dike complex

### Comments:

Waihe'e along with 'Ahuimanu Stream merges with Kahalu'u Stream which is diverted in two areas.

### References:

- Towill, R.M., Corp. 1979. Environmental Impact Statement for the Kahalu'u wastewater treatment and disposal system. Prepared for the Department of Public Works, City and County of Honolulu, Hawaii. 124 p. plus app.
- U.S. Geological Survey. 1965. Effects of water withdrawals by tunnels, Waihe'e Valley, O'ahu, Hawaii. In cooperation with State of Hawaii Department of Land and Natural Resources, Division of Water and Land Development.
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- Elliott, M.E. 1981. Wetlands and wetland vegetation of the Hawaiian Islands. Master thesis (Geography), University of Hawaii, Honolulu. 228 p.

**Waihe'e Stream--Continued**

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- Elliott, M.E., and Hall, E.M. 1977. Wetlands and wetland vegetation of Hawaii. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 344 p.
- Chinn, S.S., Tateishi, G.A., and Yee, J.J.S. 1985. Water resources data/Hawaii and other Pacific areas/water year 1985/volume 1. U.S. Geological Survey Water-Data Report HI-85-1, prepared in cooperation with Division of Water and Land Development, Dept. of Land and Natural Resources, State of Hawaii, Honolulu. 302 p.
- Timbol, A.S., and Maciolek, J.A. 1978. Stream channel modification in Hawaii. Part A: Statewide inventory of streams, habitat factors and associated biota. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 157 p.
- Soil Conservation Service. 1975. Final Environmental Impact Statement Kahalu'u watershed project. U.S. Department of Agriculture. 93 p. plus app.
- Hee & Associates, Inc. (William). 1980. Environmental Impact Statement for 42-inch waterline from Waihe'e booster station to intersection of Likelike Highway and Kamehameha Highway. 34 p. plus app.
- De Ausen, T.T. 1966. Coastline ecosystem in O'ahu, Hawaii. Master thesis (Botany), University of Hawaii, Honolulu. 114 p. plus app.



### Appendix E.3.7 Habitat Description of Kahalu'u Stream

Site:	Kahalu'u Stream	Lat.:	21°25'50"
Island:	O'ahu	Long.:	157°51'08"
Sector:	Windward, 06	El.:	0-1600 ft
System:	Koolaupoko (03)	Approx. Area/Length:	2.1 miles

#### Site Description:

The site is located directly adjacent to Kane'ohē Bay on coastal plains consisting of alluvial deposits. The site is nearly level, poorly drained, and predominantly overgrown by bulrush and to a lesser extent, California grass.

The Kahalu'u Fish Pond, a tidewater, man-made fishpond, is located along Kane'ohē Bay adjacent to the Kahalu'u Stream outlet. The fishpond is the smallest of three ancient ponds located on windward O'ahu, and one of only four examples of Hawaiian fishponds existing today on O'ahu. The pond wall forms a semicircle out from the shore, measuring some 366 m (1,200 ft) in length. It is built of large, stacked stones with a fill of smaller rock, soil, and rubble (USDA 1975).

Water in the pond is between 0.1 to 0.2 m (4-6 in.) deep, but there is a 0.3 to 0.6 m (1-2 ft) thick layer of mud and organic ooze on the bottom. The land is presently used for cattle grazing, and is exposed to considerable noise disturbance from the nearby Marine Corps Air Station.

Cattle, dogs, and mongoose are also present within the pond area. The shallow water supports a surprisingly high density of mosquitofish, crayfish, and gastropod mollusks. Hawaiian gallinules have been recorded at the site. The site holds additional water after heavy rains, enabling the area to support intermittently greater numbers of waterbirds; however, the neighboring human disturbance and accessibility of the site to a large number of people, predators, and cattle prevents the wetland from being of more than marginal significance to waterbirds (Shallenberger 1977).

Sensitivity Rating:	Aa12tm3f
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Use:	2t Traditional
Wetland Avifauna:	m Migratory Fowl
Other Value:	3f Sediment Trap
Habitat Code:	1-1c-3-1b-1b-3-2-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	1b Agriculture Livestock
Social Significance:	1b Historic Not Registered
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	2 Stream
Water Quality:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )

**Kahalu'u Stream--Continued**

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Aquifer Code:		30603212
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	2	High Level
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	2	Dike
Status Code:		11111
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30603116
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30603122
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	2	Dike
Status Code:		11122
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	2	Replaceable
Vulnerability to Contamination:	2	Moderate

## Kahalu'u Stream--Continued

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### U.S. Fish & Wildlife Service Wetland Code:

Estuarine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal/ Excavated (E1OWLx)

Marine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal (M1OWL)

Palustrine/Emergent/Persistent/Non-Tidal Seasonal (PEM1C)

Palustrine/Emergent/Persistent/Tidal Artificial/Non-Tidal Semipermanent/Dike-Impounded (PEM1KFh)

Palustrine/Forested/Broad-Leaved Evergreen/Non-Tidal Temporary (PFO3A)

Riverine/Upper Perennial/Open Water-Unknown Bottom/Non-Tidal Permanent/Excavated (R3OWHx)

### Geology:

1. Coastal plain sediment on Koolau dike complex
2. Shallow sediments; underlying dike complex poorly permeable

### Soil Conservation Service, U.S. Dept. of Agriculture 1975:

HnA (Hanalei silty clay, Typic Fluvaquents)  
0-2% slopes

LoD (Lolekaa silty clay, Humoxic Tropohumults)  
15-25% slopes

LoF (Lolekaa silty clay, Humoxic Tropohumults)  
40-70% slopes

Ph (Pearl Harbor clay, Typic Tropaquepts)

TR (Tropaquepts)

### Terrestrial Threatened or Endangered Plant(s):

No inventory available

### Terrestrial Threatened or Endangered Animal(s):

Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)

### Terrestrial Plant(s):

Koa (*Acacia koa* Gray)

Candlenut tree (*Aleurites moluccana* (L.) Willd.)

Bermuda grass (*Cynodon dactylon* (L.) Pers.)

## Kahalu'u Stream--Continued

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Spanish clover (*Desmodium canum* (Gmel.) Schinz & Thellung)  
 Spanish clover (*Desmodium intortum* (Mill.) Urban)  
 Spanish clover (*Desmodium uncinatum* (Jacq.) DC.)  
 False staghorn fern (*Dicranopteris linearis* (Burm.) Underw.)  
 Pangola grass (*Digitaria decumbens* Stent)  
 Java plum (*Eugenia cuminii* (L.) Druce)  
 Lantana (*Lantana camara* L.)  
 Mango (*Mangifera indica* L.)  
 Screw pine (*Pandanus odoratissimus* L. f.)  
 Hilo grass (*Paspalum conjugatum* Berg.)  
 Kikuyu grass (*Pennisetum clandestinum* Hochst.)  
 Common guava (*Psidium guajava* L.)  
 Monkeypod (*Samanea saman* (Jacq.) Merr.)  
 Christmas-berry tree (*Schinus terebinthifolius* Raddi)

### Aquatic Plant(s):

California grass (*Brachiaria mutica* (Forsk.) Stapf)  
 Day flower (*Commelina diffusa* Burm. f.)  
 Hau (*Hibiscus tiliaceus* L.)  
 Primrose willow (*Ludwigia octovalvis* (Jacq.) Raven)  
 Red mangrove (*Rhizophora mangle* L.)  
 California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)  
 Great bulrush (*Scirpus validus* Vahl)

### Terrestrial Animal(s):

'Apapane (*Himatione sanguinea*)  
 Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
 Cattle Egret (*Bubulcus ibis*)  
 Common Barn-Owl (*Tyto alba*)  
 Common Myna (*Acridotheres tristis*)  
 House Finch (*Carpodacus mexicanus*)  
 House Sparrow (*Passer domesticus*)  
 Japanese White-eye (*Zosterops japonicus*)  
 Nutmeg Mannikin (*Lonchura punctulata*)  
 O'ahu 'amakihī (*Hemignathus virens chloris*)  
 O'ahu 'elepaio (*Chasiempis sandwichensis gayi*)  
 Red-crested Cardinal (*Paroaria coronata*)  
 Red-vented Bulbul (*Pycnonotus cafer*)  
 Ring-necked Pheasant (*Phasianus colchicus*)  
 Spotted Dove (*Streptopelia chinensis*)  
 Zebra Dove (*Geopelia striata*)  
 Hawaiian Rat (*Rattus exulans hawaiiensis*)  
 House Mouse (*Mus musculus domesticus*)  
 Mongoose (*Herpestes auropunctatus*)

## Kahalu'u Stream--Continued

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### Roof Rat (*Rattus rattus*)

#### Aquatic Animal(s):

American Bullfrog (*Rana catesbeiana*)  
 Crayfish (*Procambarus clarkii*)  
 Electric Eel (*Eleotris sandwicensis Vaillant and Sauvage*)  
 Giant Neotropical Toad (*Bufo marinus*)  
 Gold and Black Poison Frog (*Dendrobates adnatus*)  
 Green Swordtail (*Xiphophorus helleri (Heckel)*)  
 Guppy (*Poecilia reticulata Peters*)  
 Tilapia (*Tilapia mossambica*)  
 'O'opu (*Vitraria clarescens Jordan and Evermann*)  
 'O'opu 'alamo'o (*Lentipes concolor*)  
 'O'opu nakea (*Awaous stamineus*)  
 'O'opu naniha (*Awaous genivittatus*)  
 'O'opu nopili (*Sicydium stimsonii*)  
 Shortfin Molly (*Poecilia mexicana*)  
 Southern Platyfish (*Xiphophorus maculatus (Gunther)*)  
 Striped Mullet (*Mugil cephalus L.*)

#### Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)  
 Ruddy Turnstone (*Arenaria interpres*)

#### Freshwater Origin:

1. Runoff; from high level dike complex
2. Shallow alluvial sediment

#### Comments:

On 14 March 1973, the Kahalu'u Fish Pond was added to the National Register of Historic Places under the name of Kahouna Fish Pond (USDA 1975). Kahalu'u Stream is diverted in two areas; 14% of its channel length is altered.

#### References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.
- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepare for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
- Gray, Hong & Associates. 1982. Revised Environmental Impact Statement for the proposed Kahalu'u industrial project development. 252 p. plus app.

**Kahalu'u Stream--Continued**

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- Towill, R.M., Corp. 1979. Environmental Impact Statement for the Kahalu'u wastewater treatment and disposal system. Prepared for the Department of Public Works, City and County of Honolulu, Hawaii. 124 p. plus app.
- Board of Water Supply. 1980. Environmental Impact Statement Kahalu'u Well. City and County of Honolulu. 43 p.
- Nylen, A.R., and Nylen, R.H. 1984. Final Environmental Statement/Proposed Residences at: 47-395 Ahaolelo Road, Kahalu'u, O'ahu. 22 p. plus app.
- Chinn, S.S., Tateishi, G.A., and Yee, J.J.S. 1985. Water resources data/Hawaii and other Pacific areas/water year 1985/volume 1. U.S. Geological Survey Water-Data Report HI-85-1, prepared in cooperation with Division of Water and Land Development, Dept. of Land and Natural Resources, State of Hawaii, Honolulu. 302 p.
- Timbol, A.S., and Maciolek, J.A. 1978. Stream channel modification in Hawaii. Part A: Statewide inventory of streams, habitat factors and associated biota. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 157 p.
- Windward O'ahu Soil, Water Conservation District and City and County of Honolulu. 1969. Watershed work plan: Kahalu'u watershed (Wat Re-H 57 6B). 72 p. plus maps and illus.
- U.S. Department of Agriculture, Soil Conservation Service. 1975. Final Environmental Impact Statement Kahalu'u watershed project. 93 p. plus app.

### Appendix E.3.8 Habitat Description of 'Ahuimanu Stream

Site: 'Ahuimanu Stream	Lat.: 21°25'55"
Island: O'ahu	Long.: 157°50'42"
Sector: Windward, 06	El.: 0-1600 ft
System: Koolaupoko (03)	Approx. Area/Length: 1.9 miles

#### Site Description:

'Ahuimanu Stream is a tributary of Kahalu'u Stream, joining the latter about 885 m (0.5 mile) upstream of the Kamehameha Highway bridge and paralleling Kahekili Highway for an additional 0.4 mile. The drainage basin of 'Ahuimanu Stream is 144.5 ha (357 acres) (Park Engineering 1982). The stream bed has been modified and realigned so that, like Waihe'e and Kahalu'u streams, 'Ahuimanu Stream is now entirely on the west side of Kahekili Highway. Since the 1983 survey, the lower reach has been confined within a steep-sided, concrete culvert. A V-shaped notch in the bottom of this culvert extends upstream to a point just below the confluence with Waiola Stream.

Sensitivity Rating:	Aa2m
Main Water Source:	A Groundwater
Habitat:	a Natural
Wetland Avifauna:	2m Migratory Fowl
Habitat Code:	1-1c-3-5-5-4-2-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	2 Stream
Water Quality:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:	30603212
Island:	3 O'ahu
Sector:	06 Windward
Aquifer System:	03 Koolaupoko
Aquifer Type (Hydrology):	2 High Level
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	2 Dike
Status Code:	11111
Development Stage:	1 Currently Used
Utility:	1 Drinking
Salinity:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )

**'Ahuimanu Stream--Continued**

Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30603116
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30603122
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	2	Dike
Status Code:		11122
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	2	Replaceable
Vulnerability to Contamination:	2	Moderate
U.S. Fish & Wildlife Service Wetland Code:		
Estuarine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal/ Excavated (E1OWLx)		
Marine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal (M1OWL)		
Palustrine/Emergent/Persistent/Non-Tidal Seasonal (PEM1C)		
Palustrine/Emergent/Persistent/Tidal Artificial/Non-Tidal Semipermanent/Dike-Impounded (PEM1KFh)		



**'Ahuimanu Stream--Continued**

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Palustrine/Forested/Broad-Leaved Evergreen/Non-Tidal Temporary (PFO3A)

Riverine/Upper Perennial/Open Water-Unknown Bottom/Non-Tidal  
Permanent/Excavated (R3OWHx)

**Geology:**

1. Coastal plain sediment on Koolau dike complex
2. Shallow sediments; underlying dike complex poorly permeable

**Soil Conservation Service, U.S. Dept. of Agriculture 1975:**

HnA (Hanalei silty clay, Typic Fluvaquents)  
0-2% slopes

LoE (Lolekaa silty clay, Humoxic Tropohumults)  
25-40% slopes

LoF (Lolekaa silty clay, Humoxic Tropohumults)  
40-70% slopes

Ph (Pearl Harbor clay, Typic Tropaquepts)

TR (Tropaquepts)

**Terrestrial Threatened or Endangered Plant(s):**

No inventory available

**Terrestrial Threatened or Endangered Animal(s):**

No inventory available

**Terrestrial Plant(s):**

No inventory available

**Aquatic Plant(s):**

No inventory available

**Terrestrial Animal(s):**

Common Myna (*Acridotheres tristis*)  
House Finch (*Carpodacus mexicanus*)  
House Sparrow (*Passer domesticus*)  
Spotted Dove (*Streptopelia chinensis*)  
Zebra Dove (*Geopelia striata*)  
Mongoose (*Herpestes auropunctatus*)

**'Ahuimanu Stream--Continued**

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## Aquatic Animal(s):

Chinese Catfish (*Clarias fuscus*)  
 Green Swordtail (*Xiphophorus helleri* (Heckel))  
 Guppy (*Poecilia reticulata* Peters)  
 Mosquitofish (*Gambusia affinis* (Baird and Girard))  
 Tilapia (*Tilapia mossambica*)  
 'O'opu (*Vitraria clarescens* Jordan and Evermann)  
 'O'opu 'alamo'o (*Lentipes concolor*)  
 'O'opu nakea (*Awaous stamineus*)  
 'O'opu naniha (*Awaous genivittatus*)  
 'O'opu nopili (*Sicydium stimsonii*)  
 Oriental Weatherfish (*Misgurnus anguillicaudatus* (Cantor))  
 Shortfin Molly (*Poecilia mexicana*)  
 Striped Mullet (*Mugil cephalus* L.)  
 Top Minnow (*Poecilia vittata*)  
 Wrinkled Frog (*Rana rugosa*)

## Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica* (fulva))

## Freshwater Origin:

1. Runoff; from high level dike complex
2. Shallow alluvial sediment

## Comments:

'Ahuimanu along with Waihe'e Stream merges with Kahalu'u Stream which is diverted in two areas.

## References:

- Towill, R.M., Corp. 1979. Environmental Impact Statement for the Kahalu'u wastewater treatment and disposal system. Prepared for the Department of Public Works, City and County of Honolulu, Hawaii. 124 p. plus app.
- Timbol, A.S., and Maciolek, J.A. 1978. Stream channel modification in Hawaii. Part A: Statewide inventory of streams, habitat factors and associated biota. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 157 p.
- U.S. Department of Agriculture, Soil Conservation Service. 1975. Final Environmental Impact Statement Kahalu'u watershed project. 93 p. plus app.

### Appendix E.3.9 Habitat Description of Waiahole Stream

Site:	Waiahole Stream	Lat.:	21°28'31"
Island:	O'ahu	Long.:	157°53'10
Sector:	Windward, 06	El.:	0-600 ft
System:	Koolaupoko (03)	Approx. Area/Length:	2.8 miles

#### Site Description:

Waiahole Valley is located on the windward side of O'ahu. Its topography includes the near-vertical palis of the Koolau Range and the primary and secondary alluvial deposits of the valley floor. The rainfall pattern in the valley is orographic; the highest precipitation occurs near the top of the Koolau Range and decreases correspondingly with elevation. Waiahole Stream is a perennial stream about 3 miles long with a drainage basin of about 3.8 sq. miles (M & E Pacific 1985).

The basin drains northwesterly to Kane'ohe Bay and ranges in elevation from approximately 750 m (2,460 ft) to sea level, with agricultural uses and cattle grazing, as well as residential land uses, limited to elevations of less than 25 m (82 ft). No commercial or industrial developments are in the drainage basin. Waiahole Stream converges with Uwau tributary at 20 m (66 ft) elevation and Waianu at the 24 m (80 ft) elevation. Stream flow consists of a combination of direct runoff and groundwater flow from the Koolau dike complex. Some water is removed from the drainage basin above both Uwau tributary and Waiahole Stream and is transported via the Waiahole Ditch Tunnel to Leeward O'ahu.

Waiahole Stream is one of the few remaining unchannelized perennial streams on O'ahu. Values associated with stream fauna include use for scientific, educational, and food resources. Primary offstream uses include irrigation such as for wetland taro cultivation, domestic, and industrial uses (such as cooling).

Due to past land uses, the native ecosystem has been replaced by introduced flora and fauna species. A few native flora can be found in the forest reserve. Native fauna were dominant in the highest and lowest elevation stations in this unaltered perennial stream, however, native fishes were less abundant than exotics at all stations.

Sensitivity Rating:	Aa12m3fh
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Other Value:	3f Sediment Trap
Other Value:	h Historical Value
Habitat Code:	1-1c-1-1a-5-4-2-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	1 Endangered Species
Present Activities:	1a Agriculture Crops
Social Significance:	5 Neither Historic nor Wildlife Protected

**Waiahole Stream--Continued**


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Physical Significance:	4	Neither Sediment Trap nor Flood Control
Wetland Type:	2	Stream
Water Quality:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:		30603212
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	2	High Level
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	2	Dike
Status Code:		11111
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30603116
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30603122
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	2	Dike

**Waiahole Stream--Continued**

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Status Code: 11122  
 Development Stage: 1 Currently Used  
 Utility: 1 Drinking  
 Salinity: 1 Fresh (< 250 mg/l Cl<sup>-</sup>)  
 Uniqueness: 2 Replaceable  
 Vulnerability to Contamination: 2 Moderate

## U.S. Fish &amp; Wildlife Service Wetland Code:

Estuarine/Intertidal/Forested/Broad-Leaved Evergreen/Tidal Regular (E2FO3N)

Estuarine/Intertidal/Scrub-Shrub/Broad-Leaved Evergreen/ Tidal Regular (E2SS3N)

Palustrine/Emergent/Persistent/Tidal Artificial/Non-Tidal  
 Semipermanent/Dike-Impounded (PEM1KFh)

Palustrine/Forested/Broad-Leaved Evergreen/Non-Tidal Seasonal (PFO3C)

Palustrine/Open Water-Unknown Bottom/Non-Tidal Permanent/ Dike-Impounded  
 (POWHh)

## Geology:

1. coastal plain sediment on Koolau dike complex
2. Shallow sediments; underlying dike complex poorly permeable

## Soil Conservation Service, U.S. Dept. of Agriculture 1975:

HnA (Hanalei silty clay, Typic Fluvaquents)  
 0-2% slopes

Ph (Pearl Harbor clay, Typic Tropaquepts)

WpB (Waikane silty clay, Humoxic Tropohumults)  
 3-8% slopes

WpE (Waikane silty clay, Humoxic Tropohumults)  
 25-40% slopes

WpF (Waikane silty clay, Humoxic Tropohumults)  
 40-70% slopes

## Terrestrial Threatened or Endangered Plant(s):

No inventory available

## Terrestrial Threatened or Endangered Animal(s):

No inventory available

**Waiahole Stream--Continued**


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**Terrestrial Plant(s):**

- Koa (*Acacia koa* Gray)
- Candlenut tree (*Aleurites moluccana* (L.) Willd.)
- Bamboo (*Bambusa vulgaris* Schrad. ex Wendl.)
- Coconut tree (*Cocos nucifera* L.)
- False staghorn fern (*Dicranopteris linearis* (Burm.) Underw.)
- Java plum (*Eugenia cuminii* (L.) Druce)
- Hawaiian freycinetia (*Freycinetia arborea* Gaud.)
- Mango (*Mangifera indica* L.)
- Paper bark tree (*Melaleuca leucadendra* L.)
- Screw pine (*Pandanus odoratissimus* L. f.)
- Elephant grass (*Pennisetum purpureum* Schumach.)
- Papala kepau (*Pisonia umbellifera* (J.R. and G. Forst.) Seem)
- Christmas-berry tree (*Schinus terebinthifolius* Raddi)
- Lemon-scented gum (*Eucalyptus maculata* Hook.)
- Swamp mahogany (*Eucalyptus robusta* Sm.)

**Aquatic Plant(s):**

- Oriental mangrove (*Bruguiera gymnorhiza* Lam.)
- Hau (*Hibiscus tiliaceus* L.)
- Red mangrove (*Rhizophora mangle* L.)

**Terrestrial Animal(s):**

- Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)
- Cattle Egret (*Bubulcus ibis*)
- Common Barn-Owl (*Tyto alba*)
- Common Myna (*Acridotheres tristis*)
- House Finch (*Carpodacus mexicanus*)
- House Sparrow (*Passer domesticus*)
- Japanese White-eye (*Zosterops japonicus*)
- Nutmeg Mannikin (*Lonchura punctulata*)
- Red-crested Cardinal (*Paroaria coronata*)
- Spotted Dove (*Streptopelia chinensis*)
- White-tailed Tropicbird (*Phaethon lepturus dorotheae*)
- Zebra Dove (*Geopelia striata*)
- Hawaiian Rat (*Rattus exulans hawaiiensis*)
- House Mouse (*Mus musculus domesticus*)
- Mongoose (*Herpestes auropunctatus*)

**Aquatic Animal(s):**

- Chinese Catfish (*Clarias fuscus*)
- Electrid (*Eleotris sandwicensis* Vaillant and Sauvage)
- Giant Neotropical Toad (*Bufo marinus*)
- Green Swordtail (*Xiphophorus helleri* (Heckel))

## Waiahole Stream--Continued

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Guppy (*Poecilia reticulata* Peters)  
 Silver Perch (*Kuhlia sandvicensis*)  
 Mosquitofish (*Gambusia affinis* (Baird and Girard))  
 Tilapia (*Tilapia mossambica*)  
 'O'opu nakea (*Awaous stamineus*)  
 'O'opu naniha (*Awaous genivittatus*)  
 Oriental Weatherfish (*Misgurnus anguillicaudatus* (Cantor))  
 Shortfin Molly (*Poecilia mexicana*)  
 Southern Platyfish (*Xiphophorus maculatus* (Gunther))  
 Striped Mullet (*Mugil cephalus* L.)

### Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica* (fulva))  
 Ruddy Turnstone (*Arenaria interpres*)  
 Sanderling (*Calidris alba*)  
 Wandering Tattler (*Heteroscelus incanus*)

### Freshwater Origin:

1. Runoff; from high level dike complex
2. Shallow alluvial sediment

### Comments:

The primary instream value of Waiahole Stream and its tributaries has been its significance as a stream fauna habitat. Waiahole Stream and its tributaries were found to be among the best on O'ahu when the abundance of native fish and shrimp are used as criteria.

### References:

- Towill, R.M., Corp. 1979. Environmental Impact Statement for the Kahalu'u wastewater treatment and disposal system. Prepared for the Department of Public Works, City and County of Honolulu, Hawaii. 124 p. plus app.
- Norton, S.E., Timbol, A.S., and Parrish, J.D. 1978. Stream channel modification in Hawaii. Part B: Effect of channelization on the distribution and abundance of fauna in selected streams. Prepared for U.S. Fish and Wildlife Service, U.S. Department of the Interior. 47 p.
- M & E Pacific, Inc. 1985. Revised Environmental Impact Statement for the Waiahole Valley agricultural park and residential lots subdivision, Koolaupoko, O'ahu, Hawaii. 185 p. plus app.
- Environmental Communications, Inc. 1978. Environmental Impact Statement for the proposed Waikane residential subdivision, Waikane, Koolaupoko, O'ahu. 66 p.





### Appendix E.3.10 Habitat Description of Waikane Stream

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Site: Waikane Stream	Lat.: 21°30'39"
Island: O'ahu	Long.: 157°53'09"
Sector: Windward, 06	El.: 0-600 ft
System: Koolaupoko (03)	Approx. Area/Length: 2.6 miles

#### Site Description:

Waikane Stream flow is perennial and is relatively unmodified by structures or channelization. It is identified as one of the highest quality streams flowing into Kane'ohē Bay. It is a habitat for both endemic and exotic species of stream life and its mouth serves as a zone of passage for migratory aquatic life. A low area at the Kane'ohē-makai corner appears to be swamp-like. On survey, the site proved to be a combination of ephemerally flooded grassland and mangrove swamp. The swamp-like area at the mouth of Waikane Stream is dominated by California grass, with scattered patches of bulrush. Parts of the land are now used for cattle grazing.

Non-wetland bird species observed along the stream drainage and open grassland include sharma, melodious laughing-thrush, red-crested cardinal, spotted and barred doves, and Japanese white-eye. As many as a dozen cattle egrets were associated with the few cattle in the pasture land. Fishes and crustaceans in the stream drainage provide a regular source of food for black-crowned night-herons, but continual disturbance by cars on the highway and people from nearby houses probably inhibits greater use of the area (Shallenberger 1977).

Shortly after periods of stream flooding, the pasture land above the highway probably attracts greater numbers of herons and other waterbirds. The value of the area for waterbirds has surely declined in this century, as nearly 60% of the normal flow in Waikane Stream is diverted.

Sensitivity Rating:	Aa12m3f
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Other Value:	3f Sediment Trap
Habitat Code:	1-1c-3-5-5-3-2-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	2 Stream
Water Quality:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )

**Waikane Stream--Continued**

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Aquifer Code:		30603212
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	2	High Level
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	2	Dike
Status Code:		11111
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30603116
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30603122
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	03	Koolaupoko
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	2	Dike
Status Code:		11122
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	2	Replaceable
Vulnerability to Contamination:	2	Moderate

## Waikane Stream--Continued

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### U.S. Fish & Wildlife Service Wetland Code:

Palustrine/Emergent/Persistent/Non-Tidal Seasonal (PEM1C)

Palustrine/Forested/Broad-Leaved Evergreen/Non-Tidal Seasonal (PFO3C)

Upland [Non-Wetland] (U)

### Geology:

1. Marginal dike zone of Koolau volcanic series and coastal plain sediments
2. Water is held at high levels by dikes, generating the base flow of the stream; sediments act as caprock on Koolau aquifer

### Soil Conservation Service, U.S. Dept. of Agriculture 1975:

HnA (Hanalei silty clay, Typic Fluvaquents)  
0-2% slopes

MZ (Marsh)

Ph (Pearl Harbor clay, Typic Tropaquepts)

WpB (Waikane silty clay, Humoxic Tropohumults)  
3-8% slopes

WpE (Waikane silty clay, Humoxic Tropohumults)  
25-40% slopes

WpF (Waikane silty clay, Humoxic Tropohumults)  
40-70% slopes

### Terrestrial Threatened or Endangered Plant(s):

No inventory available

### Terrestrial Threatened or Endangered Animal(s):

No inventory available

### Terrestrial Plant(s):

- Molucca albizia (*Albizia falcataria* (L.) Fosb.)
- Candlenut tree (*Aleurites moluccana* (L.) Willd.)
- Casuarina (*Casuarina* sp.)
- Koster's curse (*Clidemia hirta* (L.) D. Don.)
- Coconut tree (*Cocos nucifera* L.)
- Ti (*Cordyline terminalis* (L.) Kunth)
- Rattle box (*Crotalaria incana* L.)
- Rattle box (*Crotalaria pallida* Wit.)

## Waikane Stream--Continued

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Flora's paint brush (*Emilia fosbergii* Nicolson)  
 Flora's paint brush (*Emilia sonchifolia* (L.) DC.)  
 Coral hibiscus (*Hibiscus schizopetalus* (Mast.) Hook. f.)  
 Sweet potato (*Ipomoea batatas* (L.) Lam.)  
 Mango (*Mangifera indica* L.)  
 Tree heliotrope (*Messerschmidia argentea* (L. f.) Johnston)  
 Banana (*Musa paradisiaca* L.)  
 Screw pine (*Pandanus odoratissimus* L. f.)  
 Passion flower (*Passiflora* sp.)  
 Plumeria (*Plumeria* sp.)  
 Common guava (*Psidium guajava* L.)  
 Sugar cane (*Saccharum officinarum* L.)  
 Christmas-berry tree (*Schinus terebinthifolius* Raddi)  
 Jamaica vervain (*Stachytarpheta jamaicensis* (L.) Vahl)  
 False kamani (*Terminalia catappa* L.)  
 Tree lobelia (*Rollandia crispa* Gaud.)

### Aquatic Plant(s):

California grass (*Brachiaria mutica* (Forsk.) Stapf)  
 Oriental mangrove (*Bruguiera gymnorhiza* Lam.)  
 Hau (*Hibiscus tiliaceus* L.)  
 Red mangrove (*Rhizophora mangle* L.)  
 California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)  
 Great bulrush (*Scirpus validus* Vahl)

### Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
 Cattle Egret (*Bubulcus ibis*)  
 Common Barn-Owl (*Tyto alba*)  
 Common Myna (*Acridotheres tristis*)  
 House Finch (*Carpodacus mexicanus*)  
 House Sparrow (*Passer domesticus*)  
 Japanese White-eye (*Zosterops japonicus*)  
 Japanese Quail (*Coturnis japonica*)  
 Melodious Laughing-thrush (*Garrulax canorus*)  
 Nutmeg Mannikin (*Lonchura punctulata*)  
 Red-crested Cardinal (*Paroaria coronata*)  
 Rock Dove (*Columba livia*)  
 Spotted Dove (*Streptopelia chinensis*)  
 White-rumped Shama (*Copsychus malabaricus*)  
 Zebra Dove (*Geopelia striata*)  
 Hawaiian Rat (*Rattus exulans hawaiiensis*)  
 Mongoose (*Herpestes auropunctatus*)  
 Roof Rat (*Rattus rattus*)

## Waikane Stream--Continued

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### Aquatic Animal(s):

Giant Neotropical Toad (*Bufo marinus*)

### Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)

Ruddy Turnstone (*Arenaria interpres*)

Sanderling (*Calidris alba*)

Wandering Tattler (*Heteroscelus incanus*)

### Freshwater Origin:

1. High level inland of coastal plain; basal in and beneath coastal plain
2. Marginal dike zone inland of coastal plain; sediments of coastal plain
3. Most groundwater originates from Koolau formation

### Comments:

Waikane Stream waters are diverted in two areas.

### References:

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**Waikane Stream--Continued**

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#### Appendix E.4 System-Wide Characteristics of Ecologically Sensitive Habitats, Aquifers of Windward Sector, Waimanalo System

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Aquifer System: Waimanalo (04)

Aquifer Sector: Windward (06)

- Island: O'ahu (3)

Water Wells in Aquifer System (Div. of Water and Land Development 1984):

Disposal	12	Domestic	2	Industrial	4
Irrigation	4	Lost	2	Municipal	5
Observation	10	Other	4	Recharge	-
Sealed	3	Unused	18	Unknown	1

(Department of Health 1987):

Drinking	1
Other	-

Total Number of Injection Wells: 7

Water Wells or Sampling Sites Once Contaminated with DBCP, EDB or TCP  
(Water Resources Research Center 1985):

None

Potential Pollutant Sources and Pollutants (see Fig. 2):

Source: Foremost Farms (NPDES 311)

Pollutants: Agricultural wastes

Discharge: Emergency (0)

Source: Ameron HC&D (NPDES 20796)

Pollutants: Industrial wastes from Kapaa Quarry, Kailua

Discharge: 27,000 gpd

Source: U.S. Navy PACNAVENCOM (NPDES 110078)

Pollutants: Domestic wastes from KMCAS STP, Mokapu Peninsula

Discharge: 1.5 mgd

Source: C & C of Honolulu, Maunawili Park WTP (NPDES 20028)

Pollutants: Municipal wastes including suspended solids, nitrogen,  
phosphorous, and fecal coliforms

Discharge: 140,000 gpd

Source: C & C of Honolulu, Maunawili Estates WTP (NPDES 20036)

Pollutants: Municipal wastes including suspended solids, nitrogen,  
phosphorous, and fecal coliforms

Discharge: 95,000 gpd

**Waimanalo--Continued**

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- Source: C & C of Honolulu, Pohakupu WTP (NPDES 20010)  
Pollutants: Municipal wastes including suspended solids, nitrogen, phosphorous, and fecal coliforms  
Discharge: 426,000 gpd
- Source: C & C of Honolulu, Kailua WTP (NPDES 20141)  
Pollutants: Municipal wastes including suspended solids  
Discharge: 4.69 mgd
- Source: Bellows Air Force Station, 15th Air Base Wing (UO 1354)  
Pollutants: Untreated sewage  
Discharge: 17,000 gpd
- Source: Sea Life Park (UO 1219)  
Pollutants: Untreated aquacultural wastewater and secondary treated sewage  
Discharge: 10.8 mgd and 1,500 gpd, respectively
- Source: Sea Life Park (UO 1267)  
Pollutants: Primary treated sewage  
Discharge: 45,000 gpd
- Source: The Oceanic Institute (UO 1325)  
Pollutants: Untreated aquacultural wastewater and secondary treated sewage  
Discharge: 80,000 and 1,100 gpd, respectively
- Source: Waimanalo Waste Treatment Plant (UO 1259)  
Pollutants: Secondary treated sewage  
Discharge: 504,000 gpd
- Source: Kawainui Residential Subdivision, Windward, O'ahu, Hawaii  
Pollutants: Stormwater runoff  
Discharge: Non-point Source
- Source: Kapaa Quarry Stream  
Pollutants: PCB as Aroclor 1260, Oxychlorane, CIS-Nonachlor and Trans-nonachlor detected 09/07/82  
Discharge: Non-point Source
- Source: Landfill  
Pollutants: Leachate may contain pesticides, heavy metals or other contaminants  
Discharge: Non-point Source



**Waimanalo--Continued**

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Source: Pasture Grazing  
Pollutants: Fecal coliform  
Discharge: Non-point Source

Source: Stormwater Runoff  
Pollutants: Petroleum products, heavy metals, and fine sediments  
Discharge: Non-point Source

Source: Former Landfill near the H-3 Entrance to KMCAS  
Pollutants: Leachate from landfill  
No significant leaching has been recorded  
Discharge: Non-point Source



### Appendix E.4.1 Habitat Description of Kawainui Marsh

Site:	Kawainui Marsh	Lat.:	21°24'00"
Island:	O'ahu	Long.:	157°45'30"
Sector:	Windward, 06	El.:	20-40 ft
System:	Waimanalo (04)	Approx. Area/Length:	818.6 acres

#### Site Description:

Kawainui Marsh is located on the northeast, windward coast of O'ahu. It encompasses an area of about 324 ha (800 acres) and is situated between the foothills of the Koolau mountain range and the urbanized areas of Kailua (U.S. Army Corps of Engineers 1981).

The marsh area is relatively flat with -0.3 to 12 + m (-1 to 40 + ft) elevation. Two freshwater streams empty into the marsh, Maunawili (7.8 mgd) and Kahanaiki (1.0 mgd). Both flow in a northerly direction from the Pali area. Several natural freshwater springs along the western slopes also feed the marsh. Other sources include runoff and discharge from a quarry, sanitary landfill, auto disposal yards, residential developments, pastures, and sewage treatment plants (Smith 1978).

The boundary of the marsh and the extent of pond waters varies with rainfall between wet and dry seasons. Small areas of open water remain in the center of the marsh. Drier portions of the marsh are used for cattle grazing. Kawainui is the largest remaining inland freshwater marsh in Hawaii (Smith 1978).

The vegetative cover is dominated by two vegetation types (1) California grass and (2) a community of bulrush and native sawgrass with minor amounts of other plant species. A turnover rate of 455 days was estimated for vegetation in the marsh (Smith 1978).

A number of species of wildlife are known to live in or feed in the marsh; species of fish, crustaceans, birds, insects and even turtles have been reported from the area (U.S. Army Corps of Engineers 1981).

Sensitivity Rating:	Aa12m3fh
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Other Value:	3f Sediment Trap
Other Value:	h Historical Value

Habitat Code:	1-1c-3-1b-1b-3-4-1
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	1b Agriculture Livestock
Social Significance:	1b Historic Not Registered
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	4 Marsh

**Kawainui Marsh--Continued**

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Water Quality:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Aquifer Code:		30604116
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	04	Waimanalo
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	1	Unconfined
Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30604122
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	04	Waimanalo
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	2	Dike
Status Code:		11113
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	3	Low
U.S. Fish & Wildlife Service Wetland Code:		
Palustrine/Emergent/Persistent/Non-Tidal Seasonal (PEM1C)		
Palustrine/Emergent/Persistent/Non-Tidal Semipermanent (PEM1F)		
Palustrine/Open Water-Unknown Bottom/Non-Tidal Semipermanent (POWF)		
Geology:		
1. Alluvial sediments between calcareous sediments toward the coast and Koolau caldera rocks inland		
2. Sediment rocks on calderal complex		

## Kawainui Marsh--Continued

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Soil Conservation Service, U.S. Dept. of Agriculture 1975:

AeE (Alaeloa silty clay, Orthoxic Tropohumults)

15-35% slopes

HnA (Hanalei silty clay, Typic Fluvaquents)

0-2% slopes

KlaB (Kawaihapai stony clay loam, Cumulic Haplustolls)

2-6% slopes

MZ (Marsh)

Ph (Pearl Harbor clay, Typic Trophaquepts)

Terrestrial Threatened or Endangered Plant(s):

No inventory available

Terrestrial Threatened or Endangered Animal(s):

Hawaiian Coot (*Fulica americana alai*)

Hawaiian Duck (*Anas wyvilliana*)

Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)

Hawaiian Owl (*Asio flammeus sandwichensis*)

Hawaiian Stilt (*Himantopus mexicanus knudseni*)

Terrestrial Plant(s):

Hairy abutilon (*Abutilon molle* Sweet)

Ageratum (*Ageratum conyzoides* L.)

Candlenut tree (*Aleurites moluccana* (L.) Willd.)

Spiny amaranth (*Amaranthus spinosus* L.)

Norfolk Island pine (*Araucaria heterophylla* (Salisb.) Franco)

Breadfruit (*Artocarpus altilis* (Parkins.) Fosb.)

Chinese violet (*Asystasia gangetica* (L.) T. Anders.)

Hairy horseweed (*Bidens pilosa* L.)

Octopus tree (*Brassaia actinophylla* Endl.)

Dog tail (*Buddleja asiatica* Lour.)

Maunaloa (*Dioclea violacea* Mart.)

Red pepper (*Capsicum frutescens* L.)

Papaya (*Carica papaya* L.)

Mexican fire plant (*Cassia bicapsularis* L.)

Pink shower (*Cassia grandis* L. f.)

Kolomona (*Cassia surattensis* Burm. f.)

Common ironwood (*Casuarina equisetifolia* L.)

Nettle leaf goosefoot (*Chenopodium murale* L.)

Swollen finger grass (*Chloris inflata* Link)

## Kawainui Marsh--Continued

- Fragrant clerodendrum (*Clerodendrum philippinum* Schau.)  
 Coconut tree (*Cocos nucifera* L.)  
 Ti (*Cordyline terminalis* (L.) Kunth)  
 Rattle box (*Crotalaria incana* L.)  
 Rattle box (*Crotalaria pallida* Wit.)  
 Taro patch fern (*Cyclosorus interruptus* (Willd.) H. Ito)  
 Bermuda grass (*Cynodon dactylon* (L.) Pers.)  
 Umbrella plant (*Cyperus alternifolius* L.)  
 Kyllinga (*Cyperus brevifolius* (Rottb.) Hassk.)  
 Kyllinga (*Cyperus kyllinga* Endl.)  
 Beach wiregrass (*Dactyloctenium aegyptium* (L.) Willd.)  
 Royal poinciana (*Delonix regia* (Bojer) Raf.)  
 Slender mimosa (*Desmanthus virgatus* (L.) Willd.)  
 Spanish clover (*Desmodium canum* (Gmel.) Schinz & Thellung)  
 Spanish clover (*Desmodium intortum* (Mill.) Urban)  
 Spanish clover (*Desmodium uncinatum* (Jacq.) DC.)  
 Flora's paint brush (*Emilia fosbergii* Nicolson)  
 Flora's paint brush (*Emilia sonchifolia* (L.) DC.)  
 Java plum (*Eugenia cuminii* (L.) Druce)  
 Hairy spurge (*Euphorbia hirta* L.)  
 Rubber plant (*Ficus elastica* Roxb.)  
 Koa haole (*Leucaena leucocephala* (Lam.) deWit)  
 Cherry tomato (*Lycopersicon esculentum* Mill.)  
 Mango (*Mangifera indica* L.)  
 Paper bark tree (*Melaleuca leucadendra* L.)  
 Wood rose (*Merremia tuberosa* (L.) Rendle)  
 East Indian polypody (*Microsorium scolopendria* (Burm.) Copel.)  
 Bitter melon (*Momordica charantia* L.)  
 Sea bean (*Mucuna gigantea* (Willd.) DC.)  
 Banana (*Musa paradisiaca* L.)  
 Common oleander (*Nerium oleander* L.)  
 Egyptian lotus (*Nymphaea lotus* L.)  
 Yellow wood-sorrel (*Oxalis corniculata* L.)  
 Pink wood-sorrel (*Oxalis martiana* Zucc.)  
 Screw pine (*Pandanus odoratissimus* L. f.)  
 Guinea grass (*Panicum maximum* Jacq.)  
 Hilo grass (*Paspalum conjugatum* Berg.)  
 Dallis grass (*Paspalum dilatatum* Poir.)  
 Knottgrass (*Paspalum distichum* L.)  
 Yellow liliko'i (*Passiflora edulis* f. *flavicarpa* Deg.)  
 Scarlet fruited passion flower (*Passiflora foetida* L.)  
 Passion flower (*Passiflora* sp.)  
 White passion flower (*Passiflora subpeltata* Ortega)  
 Elephant grass (*Pennisetum purpureum* Schumach.)

## Kawainui Marsh--Continued

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Wild bean (*Phaseolus lathyroides* L.)  
 Gold and silver feras (*Pityrogramma* sp.)  
 Broad-leaved plantain (*Plantago major* L.)  
 Shrubby fleabane (*Pluchea symphytifolia* L. (Mill.) Gillis)  
 Pluchea (*Pluchea x fosbergii* Coop. and Gal.)  
 Plumeria (*Plumeria* sp.)  
 Common guava (*Psidium guajava* L.)  
 Castor bean (*Ricinus communis* L.)  
 Sugar cane (*Saccharum officinarum* L.)  
 Monkeypod (*Samanea saman* (Jacq.) Merr.)  
 Christmas-berry tree (*Schinus terebinthifolius* Raddi)  
 Palm grass (*Setaria palmifolia* (Koen.) Stapf)  
 Sida (*Sida acuta* var. *carpinifolia* Brum. f.)  
 'Ilima (*Sida fallax* Walp.)  
 Cuba jute (*Sida rhombifolia* L.)  
 Prickly sida (*Sida spinosa* L.)  
 Siegesbeckia (*Siegesbeckia orientalis* L.)  
 Black nightshade (*Solanum nigrum* L.)  
 Apple of Sodom (*Solanum sodomaeum* L.)  
 Sow thistle (*Sonchus oleraceus* L.)  
 Johnson grass (*Sorghum halepense* (L.) Pers.)  
 African tulip tree (*Spathodea campanulata* Beauv.)  
 False vervain (*Stachytarpheta cayennensis* (L. C. Rich.) Vahl.)  
 Nettle-leaved vervain (*Stachytarpheta urticaefolia* (Salisb.) Sims)  
 Nodeweed (*Synedrella nodiflora* (L.) Gaertn.)  
 False kamani (*Terminalia catappa* L.)  
 Sourgrass (*Trichachne insularis* (L.) Nees)  
 Sacramento bur (*Triumfetta rhomboidea* Jacq.)  
 Cattail (*Typha latifolia* L.)  
 Golden crown-beard (*Verbesina encelioides* (Cav.) Benth. and Hook.)  
 Wedelia (*Wedelia trilobata* (L.) Hitchc.)  
 Wandering Jew (*Zebrina pendula* Schnizl.)  
 Morning-glory (*Ipomoea congesta* R. Br.)

### Aquatic Plant(s):

California grass (*Brachiaria mutica* (Forsk.) Stapf)  
 Native sawgrass (*Cladium leptostachyum* Nees & Meyen)  
 Taro (*Colocasia esculenta* (L.) Schott)  
 Day flower (*Commelina diffusa* Burm. f.)  
 False daisy (*Eclipta alba* (L.) Hassk.)  
 Water hyacinth (*Eichhornia crassipes* (Mart.) Solms)  
 Spike sedge (*Eleocharis obtusa* (Willd.) Schult.)  
 White ginger (*Hedychium coronarium* Koenig)  
 Hau (*Hibiscus tiliaceus* L.)

### Kawainui Marsh--Continued

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Native pink hibiscus (*Hibiscus youngianus* Gaud.)  
 Moon flower (*Ipomoea alba* L.)  
 Lesser duckweed (*Lemna minor* L.)  
 Cordate monochoria (*Monochoria vaginalis* (Burm.) Presl)  
 Water lily (*Nymphaea* sp.)  
 Indian pluchea (*Pluchea indica* (L.) Less.)  
 Hairy fleabane (*Pluchea odorata* (L.) Cass.)  
 Arrowhead (*Sagittaria sagittaeifolia* L.)  
 California bulrush (*Scirpus californicus* (C.A. Meyer) Steud.)  
 Great bulrush (*Scirpus validus* Vahl)

#### Terrestrial Animal(s):

Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
 Cattle Egret (*Bubulcus ibis*)  
 Common Myna (*Acridotheres tristis*)  
 Great Frigatebird (*Fregata minor palmerstoni*)  
 House Finch (*Carpodacus mexicanus*)  
 House Sparrow (*Passer domesticus*)  
 Japanese White-eye (*Zosterops japonicus*)  
 Japanese Quail (*Coturnis japonica*)  
 Melodious Laughing-thrush (*Garrulax canorus*)  
 Northern Cardinal (*Cardinalis cardinalis*)  
 Nutmeg Mannikin (*Lonchura punctulata*)  
 Red-billed Leiothrix (*Leiothrix lutea*)  
 Red-crested Cardinal (*Paroaria coronata*)  
 Red-vented Bulbul (*Pycnonotus cafer*)  
 Rock Dove (*Columba livia*)  
 Spotted Dove (*Streptopelia chinensis*)  
 White-rumped Shama (*Copsychus malabaricus*)  
 Zebra Dove (*Geopelia striata*)  
 Mongoose (*Herpestes auropunctatus*)

#### Aquatic Animal(s):

Barracuda (*Sphyraena barracuda* (Walbaum))  
 Chinese Catfish (*Clarias fuscus*)  
 Common Carp (*Cyprinus carpio* (Linnaeus))  
 Electrid (*Eleotris sandwicensis* Vaillant and Sauvage)  
 Green Swordtail (*Xiphophorus helleri* (Heckel))  
 Giant Neotropical Toad (*Bufo marinus*)  
 Guppy (*Poecilia reticulata* Peters)  
 Silver Perch (*Kuhlia sandwicensis*)  
 Milkfish (*Chanos chanos* (Forsk.)  
 Mosquitofish (*Gambusia affinis* (Baird and Girard))  
 Tilapia (*Tilapia mossambica*)



## Kawainui Marsh--Continued

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'O'opu nakea (*Awaous stamineus*)  
 'O'opu naniha (*Awaous genivittatus*)  
 Pointed-tail Goby (*Oxyurichthys lonchotus* (Jenkins))  
 Sailfin Molly (*Poecilia latipinna* (Lesueur))  
 Shortfin Molly (*Poecilia mexicana*)  
 Slender Lizard Fish (*Saurida gracilis* (Quoy and Gaimard))  
 Smallmouth Bass (*Micropterus dolomieu* Lacepede)  
 Striped Mullet (*Mugil cephalus* L.)  
 Top Minnow (*Poecilia vittata*)  
 Wrinkled Frog (*Rana rugosa*)

### Migratory Animal(s):

American Wigeon (*Anas americana*)  
 Canada Goose (*Branta canadensis*)  
 Common Snipe (*Gallinago gallinago*)  
 Emperor Goose (*Chen canagica*)  
 Green-winged Teal (*Anas crecca*)  
 Lesser Golden-Plover (*Pluvialis dominica* (fulva))  
 Lesser Scaup (*Aythya affinis*)  
 Long-billed Dowitcher (*Limnodromus scolopaceus*)  
 Mallard (*Anas platyrhynchos*)  
 Northern Pintail (*Anas acuta*)  
 Northern Shoveler (*Anas clypeata*)  
 Redhead (*Aythya americana*)  
 Ring-necked Duck (*Aythya collaris*)  
 Ruddy Turnstone (*Arenaria interpres*)  
 Sanderling (*Calidris alba*)  
 Wandering Tattler (*Heteroscelus incanus*)

### Freshwater Origin:

1. Runoff from high level groundwater; surface runoff
2. Sediments
3. Koolau rift zone

### Comments:

The vegetation of Kawainui Marsh provides a large biological processing system for incoming nutrients, a sink for sediments from incoming streams, runoff, and sewage treatment plant effluent, a food resource and refuge for wildlife, and a flood control mechanism for much of Kailua.

### References:

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**Kawainui Marsh--Continued**

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## Appendix E.4.2 Habitat Description of Kaelepulu Pond

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Site:	Kaelepulu Pond	Lat.:	21°23'00"
Island:	O'ahu	Long.:	157°44'23"
Sector:	Windward, 06	El.:	20-40 ft
System:	Waimanalo (04)	Approx. Area/Length:	87.5 acres

### Site Description:

Kaelepulu Pond, now called "Enchanted Lake", was once more than 81 ha (200 acres) in size with associated marshland increasing the overall habitat to more than 162 ha (400 acres). Development of the surrounding lands began more than 20 years ago with partial draining of the pond. For a few years, water levels fluctuated with rainfall and surface runoff, but eventually the deposition of fill shrank the pond to a fraction of its original size. The pond is now encircled with housing and shores of the pond, including the drainage canal to the ocean, are a combination of rock walls and steep dirt ledges. Much of the original vegetative cover along the canal shores is now gone, or replaced with ornamental plants and small shrubs. The water in the pond and canal is often quite turbid.

The vegetative cover is characterized by great bulrush, seashore paspalum, and scattered thickets of American mangrove along the edges of the pond waters. Inland these grade into dense growths of California grass and occasionally honohono grass.

Sensitivity Rating:	Aa12m3f
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Other Value:	3f Sediment Trap
Habitat Code:	1-1b-3-5-5-3-1-2
Water Source:	1 Groundwater
Habitat Origin/Development:	1b Natural/Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	1 Pond
Water Quality:	2 Brackish (250-15,000 mg/l Cl <sup>-</sup> )
Aquifer Code:	30604116
Island:	3 O'ahu
Sector:	06 Windward
Aquifer System:	04 Waimanalo
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined

**Kaelepulu Pond--Continued**

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Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30604122
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	04	Waimanalo
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	2	Dike
Status Code:		11113
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	3	Low
U.S. Fish & Wildlife Service Wetland Code:		
Lacustrine/Limnetic/Open Water-Unknown Bottom/Non-Tidal Permanent (L1OWH)		
Palustrine/Emergent/Persistent/Non-Tidal Semipermanent (PEM1F)		
Palustrine/Scrub-Shrub/Broad-Leaved Evergreen/Non-Tidal Semipermanent [Emergent/Persistent/Non-Tidal Semipermanent] (PSS3/EM1F)		
Geology:		
1. Alluvial sediments between calcareous sediments toward the coast and Koolau caldera rocks inland		
2. Sediment rock on caldera complex		
Soil Conservation Service, U.S. Dept. of Agriculture 1975:		
FL (Fill Land mixed)		
HnA (Hanalei silty clay, Typic Fluvaquents)		
0-2% slopes		

## Kaelepulu Pond--Continued

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PYD (Papaa clay, Udic Chromusterts)  
6-20% slopes

Terrestrial Threatened or Endangered Plant(s):  
No inventory available

Terrestrial Threatened or Endangered Animal(s):  
Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Duck (*Anas wyvilliana*)  
Hawaiian Gallinule (*Gallinula chloropus sandvicensis*)  
Hawaiian Owl (*Asio flammeus sandwichensis*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)

Terrestrial Plant(s):  
Koa haole (*Leucaena leucocephala* (Lam.) deWit)  
Pluchea (*Pluchea x fosbergii* Coop. and Gal.)  
Mesquite (*Prosopis pallida* (Humb. and Bonpl. ex Willd.) HBK.)  
Common guava (*Psidium guajava* L.)

Aquatic Plant(s):  
California grass (*Brachiaria mutica* (Forsk.) Stapf)  
Oriental mangrove (*Bruguiera gymnorrhiza* Lam.)  
Day flower (*Commelina diffusa* Burm. f.)  
Hau (*Hibiscus tiliaceus* L.)  
Seashore paspalum (*Paspalum vaginatum* Sw.)  
Hairy fleabane (*Pluchea odorata* (L.) Cass.)  
Red mangrove (*Rhizophora mangle* L.)

Terrestrial Animal(s):  
Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)  
Cattle Egret (*Bubulcus ibis*)  
Common Myna (*Acridotheres tristis*)  
Great Frigatebird (*Fregata minor palmerstoni*)  
House Finch (*Carpodacus mexicanus*)  
House Sparrow (*Passer domesticus*)  
Japanese White-eye (*Zosterops japonicus*)  
Melodious Laughing-thrush (*Garrulax canorus*)  
Northern Cardinal (*Cardinalis cardinalis*)  
Red-crested Cardinal (*Paroaria coronata*)  
Red-vented Bulbul (*Pycnonotus cafer*)  
Spotted Dove (*Streptopelia chinensis*)  
White-rumped Shama (*Copsychus malabaricus*)  
Zebra Dove (*Geopelia striata*)  
Mongoose (*Herpestes auropunctatus*)

**Kaelepulu Pond--Continued**

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## Aquatic Animal(s):

Striped Mullet (*Mugil cephalus L.*)

## Migratory Animal(s):

American Wigeon (*Anas americana*)

Canada Goose (*Branta canadensis*)

Green-winged Teal (*Anas crecca*)

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)

Lesser Scaup (*Aythya affinis*)

Mallard (*Anas platyrhynchos*)

Northern Pintail (*Anas acuta*)

Northern Shoveler (*Anas clypeata*)

Pectoral Sandpiper (*Calidris melanotos*)

Ruddy Duck (*Oxyura jamaicensis*)

Ruddy Turnstone (*Arenaria interpres*)

Sanderling (*Calidris alba*)

Semipalmated Plover (*Charadrius semipalmatus*)

Wandering Tattler (*Heteroscelus incanus*)

## Freshwater Origin:

1. Runoff from high level groundwater; surface runoff
2. Sediments
3. Koolau rift zone

## Comments:

## References:

- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol I. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 131 p.
- Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.
- Elliott, M.E. 1981. Wetlands and wetland vegetation of the Hawaiian Islands. Master thesis (Geography), University of Hawaii, Honolulu. 228 p.
- Cox, D.C., and Gordon, L.C. Jr. 1970. Estuarine pollution in the State of Hawaii. Technical report no. 31, Water Resources Research Center, University of Hawaii, Honolulu. 151 p.

### Appendix E.4.3 Habitat Description of Nuupia Pond Complex

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Site:	Nuupia Pond Complex	Lat.:	21°26'10"
Island:	O'ahu	Long.:	157°45'00"
Sector:	Windward, 06	El.:	0-20 ft
System:	Waimanalo (04)	Approx. Area/Length:	440.3 acres

#### Site Description:

Nuupia Pond is a Federal Wildlife Reserve located within the Kane'ohē Marine Corps Air Station on O'ahu's Mokapu Peninsula. The eight shallow mixohaline ponds forming the Nuupia Pond complex occupy a shallow basin (or basins) on the lowlying emerged reef formation. The basin is a consolidated stone formation with a generally smooth surface, but having numerous potholes of various sizes. The water levels and salinity vary with rainfall and tidal fluctuations. The walls between the ponds consist of coral-fill material that forms a well-compacted berm of sufficient width to support a roadway.

Around the pond are numerous mudflats and pickleweed salt marshes. The rare and endangered Hawaiian stilt uses these areas as nesting and feeding grounds. Nuupia Pond is one of Hawaii's most important habitats for this species of bird.

Sensitivity Rating:	Ba12wtm3f
Main Water Source:	B Not Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Status:	2w Wildlife Protected
Wetland Use:	t Traditional
Wetland Avifauna:	m Migratory Fowl
Other Value:	3f Sediment Trap
Habitat Code:	2-1b-3-5-4-3-1-3
Water Source:	2 Other
Habitat Origin/Development:	1b Natural/Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	5 Neither Agriculture, Aquaculture, nor Recreation
Social Significance:	4 Historic Not Registered + Wildlife Protected
Physical Significance:	3 Sediment Trap + Flood Control
Wetland Type:	1 Pond
Water Quality:	3 Marine (> 15,000 mg/l Cl <sup>-</sup> )
Aquifer Code:	30604116
Island:	3 O'ahu
Sector:	06 Windward
Aquifer System:	04 Waimanalo
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined

**Nuupia Pond Complex--Continued**

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Aquifer Type (Geology):	6	Sedimentary
Status Code:		12211
Development Stage:	1	Currently Used
Utility:	2	Ecologically Important
Salinity:	2	Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	1	High
Aquifer Code:		30604122
Island:	3	O'ahu
Sector:	06	Windward
Aquifer System:	04	Waimanalo
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	2	Dike
Status Code:		11113
Development Stage:	1	Currently Used
Utility:	1	Drinking
Salinity:	1	Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1	Irreplaceable
Vulnerability to Contamination:	3	Low
U.S. Fish & Wildlife Service Wetland Code:		
		Estuarine/Intertidal/Emergent/Persistent/Tidal Irregular [Tidal Unknown/Tidal Temporary Tidal/Euhaline/Tidal Irregular] (E2EM1/US2 P)
		Estuarine/Intertidal/Scrub-Shrub/Broad-Leaved Evergreen/ Tidal Regular (E2SS3N)
		Estuarine/Intertidal/Unknown/Temporary Tidal/Euhaline/Tidal Irregular (E2US2P)
Geology:		
		1. Tuff of Honolulu volcanic series
		2. Tuff is poorly permeable, making tight bottom
Soil Conservation Service, U.S. Dept. of Agriculture 1975:		
		JcC (Jaucas sand, saline, Typic Ustipsammments)
		0-12% slopes
		KmbA (Keaau clay, saline, Typic Trophaquepts)
		0-2% slopes



## Nuupia Pond Complex--Continued

MnC (Mamala stony silty clay loam, Trypic Tropofolists)  
0-12% slopes

Terrestrial Threatened or Endangered Plant(s):  
No inventory available

Terrestrial Threatened or Endangered Animal(s):  
Hawaiian Coot (*Fulica americana alai*)  
Hawaiian Duck (*Anas wyvilliana*)  
Hawaiian Gallinule (*Gallinula chloropus sandwicensis*)  
Hawaiian Owl (*Asio flammeus sandwichensis*)  
Hawaiian Stilt (*Himantopus mexicanus knudseni*)

Terrestrial Plant(s):  
Perfume plant (*Acacia farnesiana* (L.) Willd.)  
Spiny amaranth (*Amaranthus spinosus* L.)  
Scarlet pimpernel (*Anagallis arvensis* L.)  
Wilder grass (*Andropogon aristatus* Poir.)  
Mexican creeper (*Antigonon leptopus* H. and A.)  
Chinese violet (*Asystasia gangetica* (L.) T. Anders.)  
Australian salt bush (*Atriplex semibaccata* R. Br.)  
Water hyssop (*Bacopa monnieri* (L.) Pennell)  
Hairy horseweed (*Bidens pilosa* L.)  
Spiderling (*Boerhavia diffusa* Heimerl.)  
Common ironwood (*Casuarina equisetifolia* L.)  
Sandbur (*Cenchrus echinatus* L.)  
Lamb's quarters (*Chenopodium album* L.)  
Star grass (*Chloris divaricata* R. Br.)  
Swollen finger grass (*Chloris inflata* Link)  
Sea grape (*Coccoloba uvifera* (L.) Jacq.)  
Rattle box (*Crotalaria incana* L.)  
Bermuda grass (*Cynodon dactylon* (L.) Pers.)  
Nut grass (*Cyperus rotundus* L.)  
Beach wiregrass (*Dactyloctenium aegyptium* (L.) Willd.)  
Spanish clover (*Desmodium canum* (Gmel.) Schinz & Thellung)  
Spanish clover (*Desmodium intortum* (Mill.) Urban)  
Spanish clover (*Desmodium uncinatum* (Jacq.) DC.)  
Flora's paint brush (*Emilia fosbergii* Nicolson)  
Flora's paint brush (*Emilia sonchifolia* (L.) DC.)  
Beach spurge (*Euphorbia degeneri* var. *degeneri* Sherff)  
Graceful spurge (*Euphorbia glomerifera* (Millsp.) L. C. Wheeler)  
Nena (*Heliotropium anomalum* var. *argenteum* Gray)  
Seaside heliotrope (*Heliotropium curassavicum* L.)  
Indigo (*Indigofera anil* L.)

## Nuupia Pond Complex--Continued

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Indigo (*Indigofera suffruticosa* Mill.)  
 Indigo (*Indigofera tinctoria* L.)  
 Lantana (*Lantana camara* L.)  
 Koa haole (*Leucaena leucocephala* (Lam.) deWit)  
 Bur clover (*Medicago polymorpha* L.)  
 Yellow sweet clover (*Melilotus indica* (L.) All.)  
 Hairy morning-glory (*Merremia aegyptia* (L.) Urban)  
 Tree heliotrope (*Messerschmidia argentea* (L. f.) Johnston)  
 Sensitive plant (*Mimosa pudica* L.)  
 Guinea grass (*Panicum maximum* Jacq.)  
 Hilo grass (*Paspalum conjugatum* Berg.)  
 Scarlet fruited passion flower (*Passiflora foetida* L.)  
 Buffel grass (*Pennisetum ciliare* (L.) Link)  
 Kikuyu grass (*Pennisetum clandestinum* Hochst.)  
 Mesquite (*Prosopis pallida* (Humb. and Bonpl. ex Willd.) HBK.)  
 Natal grass (*Rhynchelytrum repens* (Willd.) C. E. Hubb.)  
 Beach naupaka (*Scaevola taccada* (Gaertn.) Roxb.)  
 Christmas-berry tree (*Schinus terebinthifolius* Raddi)  
 Sida (*Sida acuta* var. *carpinifolia* Brum. f.)  
 'Ilima (*Sida fallax* Walp.)  
 Black nightshade (*Solanum nigrum* L.)  
 Sow thistle (*Sonchus oleraceus* L.)  
 Johnson grass (*Sorghum halepense* (L.) Pers.)  
 Salt marsh sand spurry (*Spergularia marina* (L.) Griseb)  
 False vervain (*Stachytarpheta cayennensis* (L. C. Rich.) Vahl)  
 Portia tree (*Thespesia populnea* (L.) Sol.)  
 Sourgrass (*Trichachne insularis* (L.) Nees)  
 Coat buttons (*Tridax procumbens* L.)  
 Golden crown-beard (*Verbesina encelioides* (Cav.) Benth. and Hook.)  
 Ironweed (*Vernonia cinerea* (L.) Less.)  
 Beach pea (*Vigna marina* (Burm.) Merr.)

### Aquatic Plant(s):

Pickle-weed (*Batis maritima* L.)  
 California grass (*Brachiaria mutica* (Forsk.) Stapf)  
 Marsh Cyperus (*Cyperus javanicus* Houtt.)  
 Hau (*Hibiscus tiliaceus* L.)  
 Indian pluchea (*Pluchea indica* (L.) Less.)  
 Hairy fleabane (*Pluchea odorata* (L.) Cass.)  
 Red mangrove (*Rhizophora mangle* L.)  
 Sea tassel (*Ruppia maritima* L.)  
 Sea purslane (*Sesuvium portulacastrum* L.)

## Nuupia Pond Complex--Continued

### Terrestrial Animal(s):

- Black Noddy (*Anous minutus melanogenys*)
- Black-crowned Night-Heron (*Nycticorax nycticorax hoactli*)
- Cattle Egret (*Bubulcus ibis*)
- Common Myna (*Acridotheres tristis*)
- Great Frigatebird (*Fregata minor palmerstoni*)
- House Finch (*Carpodacus mexicanus*)
- House Sparrow (*Passer domesticus*)
- Japanese White-eye (*Zosterops japonicus*)
- Northern Cardinal (*Cardinalis cardinalis*)
- Nutmeg Mannikin (*Lonchura punctulata*)
- Red-crested Cardinal (*Paroaria coronata*)
- Red-vented Bulbul (*Pycnonotus cafer*)
- Rock Dove (*Columba livia*)
- Spotted Dove (*Streptopelia chinensis*)
- Zebra Dove (*Geopelia striata*)
- Mongoose (*Herpestes auropunctatus*)

### Aquatic Animal(s):

- Barracuda (*Sphyraena barracuda* (Walbaum))
- Silver Perch (*Kuhlia sandvicensis*)
- Milkfish (*Chanos chanos* (Forsk.)
- Mosquitofish (*Gambusia affinis* (Baird and Girard))
- Tilapia (*Tilapia mossambica*)
- Sailfin Molly (*Poecilia latipinna* (Lesueur))
- Striped Mullet (*Mugil cephalus* L.)
- Top Minnow (*Poecilia vittata*)

### Migratory Animal(s):

- Brant (*Branta bernicla*)
- Bufflehead (*Bucephala albeola*)
- Canada Goose (*Branta canadensis*)
- Hooded Merganser (*Lophodytes cucullatus*)
- Laughing Gull (*Larus atricilla*)
- Least Tern (*Sterna antillarum*)
- Lesser Golden-Plover (*Pluvialis dominica (fulva)*)
- Lesser Scaup (*Aythya affinis*)
- Mallard (*Anas platyrhynchos*)
- Northern Pintail (*Anas acuta*)
- Osprey (*Pandion haliaetus*)
- Ring-billed Gull (*Larus delawarensis*)
- Ruddy Turnstone (*Arenaria interpres*)
- Sanderling (*Calidris alba*)
- Wandering Tattler (*Heteroscelus incanus*)

**Nuupia Pond Complex--Continued**

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## Freshwater Origin:

## 1. Runoff

## Comments:

The U.S. Marine Corps Air Station has established the Nuupia ponds as a Wildlife Management Area (Drigot 1983).

## References:

Shallenberger, R.J. 1977. An ornithological survey of Hawaii wetlands. Vol II. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 278 p.

Elliott, M.E. 1981. Wetlands and wetland vegetation of the Hawaiian Islands. Master thesis (Geography), University of Hawaii, Honolulu. 228 p.

Elliott, M.E., and Hall, E.M. 1977. Wetlands and wetland vegetation of Hawaii. Prepared for the U.S. Army Corps of Engineers, Engineer District, Honolulu. 344 p.

#### Appendix E.4.4 Habitat Description of Bellows Air Force Station

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Site:	Bellows Air Force Station	Lat.:	21°21'53"
Island:	O'ahu	Long.:	157°43'08"
Sector:	Windward, 06	El.:	0-20 ft
System:	Waimanalo (04)	Approx. Area/Length:	4.1 acres

#### Site Description:

The Bellows Air Force Station has ditches, streams, and wetland areas which provide limited habitat for coots, gallinules, and stilts. Presently, much of the habitat area is used for weekend camping and military exercises.

Sensitivity Rating:	Aa12m
Main Water Source:	A Groundwater
Habitat:	a Natural
Endangered Species:	1 Observed
Wetland Avifauna:	2m Migratory Fowl
Habitat Code:	1-1c-3-4-5-4-2-4
Water Source:	1 Groundwater
Habitat Origin/Development:	1c Natural/Pristine + Altered
Ecological Character:	3 Endangered Species + Migratory Birds
Present Activities:	4 Recreation
Social Significance:	5 Neither Historic nor Wildlife Protected
Physical Significance:	4 Neither Sediment Trap nor Flood Control
Wetland Type:	2 Stream
Water Quality:	4 Combination
Aquifer Code:	30604116
Island:	3 O'ahu
Sector:	06 Windward
Aquifer System:	04 Waimanalo
Aquifer Type (Hydrology):	1 Basal
Aquifer Type (Hydrology):	1 Unconfined
Aquifer Type (Geology):	6 Sedimentary
Status Code:	12211
Development Stage:	1 Currently Used
Utility:	2 Ecologically Important
Salinity:	2 Low (250-1,000 mg/l Cl <sup>-</sup> )
Uniqueness:	1 Irreplaceable
Vulnerability to Contamination:	1 High
Aquifer Code:	30604122
Island:	3 O'ahu
Sector:	06 Windward

**Bellows Air Force Station--Continued**

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Aquifer System:	04	Waimanalo
Aquifer Type (Hydrology):	1	Basal
Aquifer Type (Hydrology):	2	Confined
Aquifer Type (Geology):	2	Dike

Status Code:	11113
Development Stage:	1 Currently Used
Utility:	1 Drinking
Salinity:	1 Fresh (< 250 mg/l Cl <sup>-</sup> )
Uniqueness:	1 Irreplaceable
Vulnerability to Contamination:	3 Low

## U.S. Fish &amp; Wildlife Service Wetland Code:

Estuarine/Subtidal/Open Water-Unknown Bottom/Tidal Subtidal/ Excavated  
(E1OWLx)

Estuarine/Intertidal/Emergent/Persistent/Tidal Regular (E2EM1N)

Estuarine/Intertidal/Forested/Broad-Leaved Evergreen/Tidal Regular (E2FO3N)

## Geology:

1. Limestone and calcareous sediments
2. Highly permeable

## Soil Conservation Service, U.S. Dept. of Agriculture 1975:

HeA (Hale'iwa silty clay, Typic Haplustolls)  
0-2% slopes

JaC (Jaucas sand, Typic Ustipsamments)  
0-15% slopes

## Terrestrial Threatened or Endangered Plant(s):

No inventory available

## Terrestrial Threatened or Endangered Animal(s):

Hawaiian Stilt (*Himantopus mexicanus knudseni*)

## Terrestrial Plant(s):

No inventory available

## Aquatic Plant(s):

Pickle-weed (*Batis maritima* L.)

**Bellows Air Force Station--Continued**

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## Terrestrial Animal(s):

No inventory available

## Aquatic Animal(s):

No inventory available

## Migratory Animal(s):

Lesser Golden-Plover (*Pluvialis dominica (fulva)*)

## Freshwater Origin:

1. Basal
2. Limestone and calcareous sediment
3. Recharge on limestone and sand locally; alluvium further inland; Koolau volcanic rock beyond coastal plain

## Comments:

## References:

U.S. Fish and Wildlife Service. 1985. Recovery plan for the Hawaiian Waterbirds. Prepared for U.S. Fish and Wildlife Service, Portland, Oregon. 99p.

