Appendix A: Advisory Groups

Ala Wai Watershed Analysis Final Report

July 2003

Appendix A
Advisory Groups

Technical Advisory Group (TAG)

Ala Wai Watershed Association
City and County of Honolulu, Department of Environmental Services
City and County of Honolulu, Department of Parks and Recreation
Honolulu Board of Water Supply
State of Hawai‘i Department of Business, Economic Development, & Tourism, Office of State Planning
State of Hawai‘i Department of Health, Clean Water Branch
State of Hawai‘i Department of Health, Environmental Planning Office
State of Hawai‘i Department of Land and Natural Resources, Commission on Water Resources Management
State of Hawai‘i Department of Land and Natural Resources, Division of Aquatic Resources
State of Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife
State of Hawai‘i Department of Land and Natural Resources, Engineering Branch
State of Hawai‘i Department of Transportation, Highways Division
U.S. Army Corps of Engineers, Honolulu District
U.S. Fish and Wildlife Service
University of Hawai‘i, Department of Facilities Maintenance, Building and Grounds Management
University of Hawai‘i, Department of Oceanography
University of Hawai‘i, Environmental Center

Agency Study Group (ASG)

Ala Wai Watershed Association
City and County of Honolulu, Department of Environmental Services
City and County of Honolulu, Department of Facilities Maintenance
City and County of Honolulu, Department of Parks and Recreation
City and County of Honolulu, Department of Transportation Services
Honolulu Board of Water Supply
State of Hawai'i Department of Business, Economic Development, & Tourism, Office of State Planning
State of Hawai'i Department of Health, Clean Water Branch
State of Hawai'i Department of Health, Environmental Planning Office
State of Hawai'i Department of Land and Natural Resources, Commission on Water Resources Management
State of Hawai'i Department of Land and Natural Resources, Division of Aquatic Resources
State of Hawai'i Department of Land and Natural Resources, Division of Boating and Ocean Recreation
State of Hawai'i Department of Land and Natural Resources, Division of Forestry and Wildlife
State of Hawai'i Department of Land and Natural Resources, Engineering Branch
State of Hawai'i Department of Transportation, Highways Division
U.S. Army Corps of Engineers, Honolulu District
U.S. Department of Agriculture, Natural Resources Conservation Service
U.S. Environmental Protection Agency (EPA), Region IX, Pacific Island Office
U.S. EPA, Water Division, Nonpoint Source Program
U.S. Fish and Wildlife Service
U.S. Geological Survey
University of Hawai'i, Department of Facilities Maintenance, Building and Grounds Management
University of Hawai'i, Department of Oceanography
University of Hawai'i, Environmental Center
University of Hawai'i, Water Resources Research Center

Agencies and Organizations Interviewed

City and County of Honolulu, Department of Environmental Services
Ko'olau Mountains Watershed Partnership
State of Hawai'i Department of Land and Natural Resources, Division of Aquatic Resources
State of Hawai'i Department of Land and Natural Resources, Division of Forestry and Wildlife
State of Hawai'i Department of Transportation
University of Hawai'i, Department of Oceanography
University of Hawai'i, Environmental Center
U.S. Geological Survey

Appendix B: Agency Profiles and Watershed Programs

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Appendix B
Agency Profiles and Watershed Programs

There are a number of governmental agencies and non-governmental organizations that are engaged in watershed restoration programs in Hawai‘i and on a national level. Many of these entities have recognized the need to operate in partnerships and the practicality of sharing in costs and resources that would otherwise be too substantial for any one group. There are also agencies that participate in programs and projects that fund community groups directed toward watershed improvements. A selected listing of watershed related agencies and a description of their programs is provided below:

- **U.S. Environmental Protection Agency (EPA)**

The EPA provides federal leadership in environmental science, research, education, and assessment efforts. Working closely with other federal agencies, as well as state and local governments, the EPA develops and enforces regulations under existing environmental laws. The EPA is also responsible for researching and setting national standards for a variety of environmental programs and delegates the responsibility for issuing permits, monitoring, and enforcing compliance to individual states. Where national standards are not met, sanctions may be issued and/or steps might be taken to assist states in reaching the desired levels of environmental quality. The EPA also works with industries and all levels of government in a wide variety of voluntary pollution prevention programs and energy conservation efforts.

The EPA Office of Water is responsible for the Agency's water quality activities, including the development of national programs, technical policies, and regulations relating to drinking water, water quality, ground water, pollution source standards, and the protection of wetland, marine, and estuarine areas. The Office of Water administers, coordinates, oversees, or supports the following programs and legislation:

- Clean Water Act – administers the Act and oversees the State’s Nonpoint Source Pollution Management program as called for in Section 319.
- Section 6217, Coastal Zone Act Reauthorization Amendments (CZARA) – provides administrative guidance to states along with the National Oceanic and Atmospheric Administration (NOAA).
- Unified Watershed Assessment, Clean Water Action Plan - calls for all levels of government and the public to identify watersheds with the most critical water quality problems and to cooperatively focus resources and implement effective strategies to reach solutions to those

problems. The Watershed Initiative encourages watershed partnerships to protect and restore water resources.

- **Natural Resource Conservation Service (NRCS)**

The NRCS is a part of the United States Department of Agriculture and provides leadership in a partnership effort to help conserve, maintain, and improve natural resources and environment. The NRCS assists private land owners, local, state and federal agencies with conserving their soil, water, and other natural resources through technical assistance, cost-shares, and financial incentives. Participation is voluntary and is done mostly with local partners.

The authorized purposes for these NRCS-assisted watershed projects include: watershed protection, flood prevention, agricultural water management, water based recreation, fish and wildlife habitat improvement, ground water recharge, water quality management, and municipal and industrial water supply. However, program objectives have changed over time in response to legislative direction, environmental concerns, and changing social values. The objectives of many of the original projects were to reduce flooding, improve drainage, and increase irrigation efficiencies. In the 1960s, high priorities were placed on projects that provided jobs to combat poverty and encourage rural development; many of these projects involved establishing recreation areas. In recent years, projects have focused on land treatment measures to solve natural resource problems, such as substandard water quality and loss of wildlife habitat. Funding in fiscal year 1996 for program activities was $100 million (of which only $50 million is available for financial assistance).

The NRCS is founded upon an agency vision--"People in Partnership with a Healthy Land." Consistent with this vision, NRCS will administer its watershed program to support: "Local people leading a voluntary, coordinated, and integrated watershed approach to address natural and human resource conservation needs." As NRCS expands and strengthens its national watershed program, the Agency will be guided by key principles in assisting local communities to plan and implement their watershed projects. Within the NRCS is the Watershed Science Institute, whose mission is to incorporate ecological principles into natural resource conservation and accelerate the development and transfer of appropriate technology in response to comprehensive watershed needs and environmental sustainability at the watershed and landscape scales.

- National Conservation Program - national watershed program that assists states, local units of government, tribes, and other sponsoring organizations to address water-related and other natural resource issues, to conduct studies, to develop watershed plans, and to implement resource management systems. The program includes projects carried out under the Watershed Protection and Flood Prevention Act of 1954 (PL 83-566). Over 2,000 plans

covering 160 million acres of watersheds in every state, Puerto Rico, and the Pacific Basin have been completed or are underway. Land treatment measures have been applied to more than 30 million acres. More than 15,000 individual measures have been installed and have resulted in substantial contributions to environmental improvement, economic development, and social well-being.

- **U.S. Army Corps of Engineers (COE)**

The COE Civil Works programs include water resource development activities such as flood control, navigation, recreation, and infrastructure and environmental stewardship. The Corps has the authority to assist the states, local governments, and other non-federal entities in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources. The COE is authorized to carry out Civil Works water resources projects for navigation, flood damage reduction, ecosystem restoration, storm damage prevention, hydroelectric power, recreation, and water supply. This is accomplished through special project authorities and continuing project authorities. Additionally, the COE manages portions of the Clean Water and Rivers and Harbors Acts.

Planning and Engineering Technical Services

- Section 22, 1974 WRDA, Planning Assistance to States – provides technical and cost-share assistance to states, local governments, and other non-federal entities in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources.
- Section 206, 1960 FCA, Flood Plain Management Services – provides information, technical assistance, guidance, and financial funding to states and local communities to reduce flood damages.

Emergency Operations

- Public Law 84-99 (33USCA 701n), Flood fighting, Rehabilitation, and Other Disaster Relief Operations – allows for flood fighting, rescue operations, emergency relief work, and repair of approved local flood control projects and all COE constructed projects to local and state efforts.

Continuing Authorities Program provides for funding assistance toward addressing certain water resource problems.

- Section 14, 1946 Flood Control Act (PL 79-526), Emergency Bank Protection – provides for cost-share assistance to public entities for emergency stream bank and shoreline erosion protection to highways, bridge approaches, municipal water supply systems, sewage disposal plants, and other essential public works facilities endangered by floods or storms due to bank erosion.

- Section 103, 1962 River and Harbor Act (PL 87-874), Small Beach Protection Projects – provides cost-share assistance to projects that restore and protect coastal shores from erosion caused by natural wave and current action.
- Section 107, 1960 River and Harbor Act (PL), Small Navigation Projects – provides cost-share assistance to ensure safe and efficient use of small navigation projects.
- Section 111, 1968 River and Harbor Act (PL 90-483), Prevention and Mitigation of Shore Damage Caused by Existing Federal Navigation Works – provides cost-sharing assistance for investigation and construction of projects that prevent and mitigate shore damage attributable to federal navigation projects.
- Section 204(a), 1994 Water Resources Development Act, Beneficial Uses of Dredged Material – provides cost-sharing assistance for beneficial uses of material for construction, operation, or maintenance of an authorized navigation project.
- Section 205, 1948 Flood Control Act (PL 80-858), Small Flood Control Projects – provides cost-sharing for studies of small flood control projects for structural and non-structural solutions.
- Section 206, 1996 Water Resources Development Act (PL 104-303), Aquatic Ecosystem Restoration – provides cost-sharing assistance for aquatic ecosystem restoration and protection.
- Section 298, 1954 Flood Control Act (PL 83-780), Snagging and Clearing for Flood Control – provides for cost-sharing assistance for the removal of accumulated snags and other debris and for channel clearing amd straightening in navigable streams and tributaries.
- Section 1135, WRDA 1986 (PL 99-662), Environmental Restoration – provides cost-sharing assistance for modifying the structure or operation of a previous COE project to restore fish and wildlife habitat.

General Investigations are funded by specific appropriation to investigate water resource problems. Congressional authorization is required for construction.

- Section 209, 1962 FCA, Rivers and Harbors in Hawaii – authorizes surveys for flood control and associated purposes in harbors and rivers in Hawai‘i, with the purpose of determining the advisability of improvements.
- Section 216, 1970 FCA, Modification of Existing Corps Projects – authorizes review of previous COE projects due to significantly changed physical or economic conditions, and to recommend to Congress modifications to their structures or operations for the purpose of improving their function or environmental quality.

Section 404, Clean Water Act is managed by the COE and requires a proponent to obtain a permit for the discharge of dredged or fill material into U.S. waters.

Section 10, Rivers and Harbors Act of 1899 is managed by the COE and requires a proponent to obtain a permit to do any work in, over, or under a navigable water of the United States.

- **United State Geological Survey (USGS)**

  Congress created the USGS in 1879 as a bureau of the federal Department of the Interior. The mission of the USGS is to provide reliable and impartial scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life. The USGS has the principal responsibility within the federal government for providing hydrologic information and for appraising the nation's water resources. USGS operates offices in every state to conduct studies in cooperation with local and state governments, and with other federal agencies. A list of principal contacts in each state is available at the USGS website: *http://interactive2.usgs.gov/contact_us/index.asp*:

  The USGS achieves its mission by using funding from three distinctly different sources: (1) USGS Federal program funds, which provide 100 percent support for certain efforts; (2) Federal-State Cooperative program funds, which are a combination of federally appropriated funds (up to 50 percent) and funds from cooperating agencies at the state and local level; and (3) reimbursable funds, which are contributed by various partners without any federal match.

  Information for the following programs is available at the USGS website: *http://www.usgs.gov/programs.html*

  - Biological Informatics Program - develops and applies innovative information technologies and practices to the management of biological data, information, and knowledge.
  - Contaminant Biology Program - conducts research, assessments, and monitoring to provide information on the exposure, effects, and fate of deleterious substances in the environment.
  - Cooperative Research Units Program – a university-based partnership between the USGS, state natural resource agencies, host universities, and the Wildlife Management Institute to conduct research that addresses complex environmental issues. This program provides research, graduate education, and technical assistance.
  - Cooperative Water Program - monitors the quantity and quality of water in the nation's rivers and aquifers, assesses the sources and fate of contaminants in aquatic systems, develops tools to improve the application of hydrologic information, and ensures that its information and tools are available to all potential users.
  - Fisheries and Aquatic Resources – focuses research on the study of fishes, fisheries, aquatic invertebrates, and their

water-based or water-dependent habitats, with special attention to threatened and endangered species.

- Geographic Analysis and Monitoring Program - conducts geographic assessments to improve the understanding of the rates, causes, and consequences of natural and human-induced processes that shape and change the landscape over time.
- Ground-Water Resources Program - provides unbiased scientific information and many tools used by federal, state, and local management and regulatory agencies to make important decisions about ground-water resources.
- Invasive Species Program – researches all significant groups of invasive organisms in terrestrial and aquatic ecosystems to combat invasive species in natural and semi-natural areas.
- Land Remote Sensing - collects, archives, and distributes satellite and aircraft information to provide repetitive coverage that makes it possible to monitor change.
- National Bridge Scour Program – measures the scour of streambeds at highway bridges.
- National Flood Frequency Program – uses estimates of the magnitude and frequency of flood-peak discharges and flood hydrographs for a variety of purposes, such as the design of bridges, culverts, and flood-control structures, and for the management and regulation of flood plains.
- National Research Program - conducts basic and problem-oriented hydrologic research in support of the mission of the USGS.
- National Streamflow Information Program – provides information on the quantity and timing of the stream flow.
- National Water Quality Assessment Program – develops long-term consistent and comparable information on streams, ground water, and aquatic ecosystems to support sound management and policy decisions.
- Status and Trends of Biological Resources Program – monitors and inventories Department of the Interior trust resources on Federal lands.
- Terrestrial, Freshwater, and Marine Ecosystems Program – conducts research to understand the factors which control ecosystem structure, function, condition, and the provision of goods and services.
- Toxic Substances Hydrology Program - provides objective scientific information to improve characterization and management of contaminated sites, to protect human and environmental health, and to reduce potential future contamination problems.
- State Water Resources Research Institute – a federal-state partnership that researches regional water problems, promotes technology transfer and the dissemination and application of research results, provides for the training of scientists and engineers through their participation in research, and provides for competitive grants to be awarded under the Water Resources Research Act.
- Stream Stats – provides stream flow statistics to the public Watershed and

River System Management Program - provides a data centered framework for water resources decision making.

- Wildlife and Terrestrial Ecosystems Program – research on waterfowl, songbirds, large mammals, terrestrial plants, amphibians, and their habitats that complement and support the conservation and management efforts of Federal and State wildlife agencies, non-governmental organizations, and international treaties.

Publications providing information about surface-water resources of the nation, including floods and droughts and other stream flow characteristics are available through Abstract Search and other USGS Publications and USGS Fact Sheets. The USGS collects, analyzes, archives, and disseminates data and information describing the surface-water resources of the nation. Historical daily stream flows and suspended-sediment data are available for many of the nation's rivers and streams. Real-time river stage and discharge data are available for more than 3,000 rivers and streams. The USGS operates a Hydraulics Laboratory for the testing of instruments and for hydraulic and sediment transport research. The Hydrologic Instrumentation Facility and the Federal Interagency Sedimentation Project develop, test, and distribute various measurement and sampling equipment.

o **U.S. Fish & Wildlife Service (USFWS)**

The U.S. Fish and Wildlife Service is the main federal agency dedicated to protecting wildlife and their habitat from the harmful effects of pollution, helping to create a healthy world for all living things. The USFWS coordinates and participates in numerous programs, partnerships, and grants, some of which include:

Environmental Quality Branch

- Environmental Contaminants Program - detecting toxic chemicals; addressing their effects; preventing harm to fish, wildlife, and their habitats; and removing toxic chemicals and restoring habitat when prevention is not possible.

Branch of Habitat Restoration

- Partners for Fish and Wildlife – voluntary partnership program to restore wetlands and other important fish and wildlife habitat on private property.
- Coastal Program - identifies important coastal resource problems and solutions, seeks partnerships to carry out on-the-ground conservation projects, and encourages public action in 15 of the nation's highest priority coastal areas.
- Coastal Wetlands Conservation Grant Program – provides grants to acquire, restore, and enhance wetlands in coastal states and trust territories

USFWS is also involved in Superfund sites by providing data and guidance to the EPA. The Endangered Species Branch designates “critical habitats” for listed

species, which regulates federal-related activities within these designations.

- **National Oceanic and Atmospheric Administration (NOAA)**

NOAA's mission is to describe and predict changes in the Earth's environment, and conserve and wisely manage the nation's coastal and marine resources. NOAA's interest in aquatic environments includes the land areas that drain into rivers, known as watersheds, as well as the rivers themselves. Because aquatic ecosystems are affected by so many different characteristics of the watershed, impact assessment and management can be significantly improved by using a method that shows the geographic relationship between measurements taken at specific places and the characteristics specific to that region.

- The NOAA - Coastal Protection and Restoration Division (CPRD) has developed an integrated assessment tool that combines a computer database and database-mapping programs. This approach allows scientists to analyze a variety of data (such as sediment contaminant concentrations, tissue data, aquatic species occurrence, and habitat characteristics) in combination with a watershed's features and land uses. This information is displayed on maps at various spatial scales, simplifying data presentation and improving our understanding of dynamic aquatic ecosystems. *Query Manager* is a software application used to access sediment chemistry, sediment toxicity, and tissue chemistry data from specific watershed projects. By downloading the associated program, MARPLOT, queried information then can be displayed on maps. Geographic Information Systems is utilized in watershed analysis and to create maps with data types such as sediment toxicity, fish surveys, land use, and aerial photographs. The National Marine Fisheries Service is under NOAA. The NOAA Fisheries strategic plan contains three goals: rebuild and maintain sustainable fisheries, promote the recovery of protected species, and protect and maintain the health of coastal marine habitats.

- **State of Hawai‘i Department of Health (DOH)**

The State of Hawai‘i Department of Health, Office of Environmental Management has under its direction the Clean Water Branch and Safe Drinking Water Branch. The Clean Water Branch (CWB) protects the public health of residents and tourists who utilize Hawaii’s coastal and inland water resources. The CWB also protects and restores inland and coastal waters for marine life and wildlife. This is accomplished through statewide coastal water surveillance and watershed-based environmental management through a combination of permit issuance, monitoring, enforcement, sponsorship of polluted runoff control projects, and public education. The mission of the Safe Drinking Water Branch of the Department of Health is to safeguard public health by protecting Hawaii’s drinking water sources (surface water and groundwater) from contamination and to ensure that

owners and operators of public water systems provide safe drinking water to the community. This mission is accomplished through the administration of the Safe Drinking Water Program, Underground Injection Control Program (UIC), Groundwater Protection Program (GWPP), and the Drinking Water State Revolving Fund (DWSRF). The Department of Health is the local implementing agency for several EPA initiatives.

- **Department of Land & Natural Resources (DLNR)**

There are various divisions within DLNR that are involved in watershed issues in the State of Hawai'i. The Division of Forestry and Wildlife (DOFAW) administers the State Watershed Protection and Management Program under Act 152, which works to protect and improve the condition of forests that benefit our water supply. The objectives of the program are to: 1) to help ensure water quality and quantity, 2) to prevent rapid run-off of storm flows and soil erosion, 3) to improve water infiltration into soil, and 4) to encourage forestry activities on private land. DLNR also administers the Landowner Incentive Program from the USFWS on the state level. The Division of Aquatic Resources manages the State's marine and freshwater resources through programs in commercial fisheries and resource enhancement; aquatic resources protection, enhancement and education; and recreational fisheries. Major program areas include projects to manage or enhance fisheries for long-term sustainability of the resources, protect and restore the aquatic environment, and protecting native and resident aquatic species and their habitat.

The Land Division is responsible for the management of State-owned lands, including submerged lands, rivers, streams, and canals that are not under the jurisdiction of other State Departments. The Engineering Branch of the Land Division administers the Water and Land Development, Flood Control and Dam Safety Programs. The Water and Land Development Program promotes economic development and enhances public welfare by developing water supplies and State lands. The Flood Control Program manages Hawaii's flood hazards, prevents loss of life, reduces property damage, and conserves and restores the natural and beneficial resources and functions of state rivers and coastal floodplains. The Dam Safety Program ensures the safety and integrity of dams in Hawai'i and protects people and property from the consequences of dam failures. The purpose is to provide for safe design, construction, operation and maintenance of dams to protect public safety.

The Commission on Water Resource Management (CWRM) administers the State Water Code, which was created by the 1987 Hawaii State Legislature. The Water Commission's general mission is to protect and enhance the water resources of the State of Hawaii through wise and responsible management. The Water Resource Management Division provides administrative, staff, and technical services in support of CWRM. The Water Resource Management Division's primary

responsibilities include basic data collection and resource assessment, water resource planning, regulation of water development and use, enforcement and technical support services, and protection of instream uses.

o City & County of Honolulu

Several departments within the Honolulu City and County government are involved in watershed issues, including the Departments of Planning and Permitting, Facilities Maintenance, and Design and Construction. The Department of Environmental Services (ENV) administers the Clean Water Program. This effort ensures that the City and County of Honolulu conforms to a set of Federal rules called the National Pollutant Discharge Elimination System (NPDES). These rules, part of the Federal Clean Water Act, are designed to protect ground and surface water. The NPDES regulations mandate cities with more than 250,000 residents to keep their municipal storm drains and sewer systems as free of pollution as possible. They also require the City and County to educate the public about the new law's requirements.

Day to day management of the storm water program falls under the Engineering Division of the City's Department of Environmental Services. The Division, in turn, reports to the State Department of Health and the Federal Environmental Protection Agency. As part of this program, the City and County will be testing and monitoring to determine the level of pollutants in our waters. DES monitors storm water discharges from drainage areas near residential and industrial areas. They issue water pollution control guidelines to the private sector, such as construction companies and industrial firms. New guidelines will also be given to managers of high-rise apartments, office buildings and hotels to ensure their residents and guests are complying with the new law. The City also oversees private connections to our storm sewer system. All new connections will be required to have a permit issued by the Engineering Division. Old connections will be inspected and those with effluent that violates water quality standards will be disconnected. Permits for old connections may have to be reissued to the current property owner with information on current activity.

Finally, the City is conducting a public education campaign on ways to reduce water pollution in residences and businesses. A website has been set up at the address: http://www.cleanwaterhonolulu.com/ to deliver the City's message.

o Honolulu Board of Water Supply

The Board of Water Supply is a semi-autonomous agency of the City and County of Honolulu. Its mission is to improve the quality of life of our community by providing world class water services statewide and throughout the Pacific. The BWS water management expertise and services will support the growth of Hawaii's economy, provide professional development opportunities for BWS staff and benefit our community by maintaining reasonable rates. With a total labor force of about 550 employees, the department services approximately 155,000 customers or about

900,000 people, with an average of 155 mgd of potable water and 10 mgd of recycled water per day, which makes it one of the 10 largest water utilities in the country.

BWS is assuming a leadership role in the environmental stewardship of Oahu's precious natural resources. BWS is forming community partnerships to protect our watersheds and are working with State and County agencies to effectively manage our water resources. BWS is also developing renewable water supplies, like recycled water, seawater desalination and deep ocean water supplies that will afford a foundation for sustainable economic development.

- **Non-Government Organizations**

There are also several non-governmental organizations that are involved in watershed restoration and management, including The Nature Conservancy (TNC). TNC is focused on providing fresh water for habitat needs, and recognizes the watershed approach. They have spearheaded the Freshwater Initiative, whose mission is to dramatically increase freshwater conservation in the United States and abroad through learning networks and promoting partnerships in watershed management

Ducks Unlimited conserves, restores, and manages wetlands and associated habitats for North America's waterfowl. These habitats also benefit other wildlife and people. Ducks Unlimited is a member of "Taking Wing," a private-public conservation partnership actively working on large-scale watershed restoration projects

The Center for Watershed Protection (CWP) is a non-profit 501(c)3 corporation that provides local governments, activists, and watershed organizations around the country with the technical tools for protecting some of the nation's most precious natural resources: our streams, lakes and rivers. The CWP has developed and disseminated a multi-disciplinary strategy for watershed protection that encompasses watershed planning, watershed restoration, storm water management, watershed research, better site design, education and outreach, and watershed training

New organizations are continuously being formed around the emerging practice of holistic watershed management.

- **Soil and Water Conservation Districts**

Soil and Water Conservation Districts are authorized under HRS Chapter 180 to coordinate resources to develop locally driven solutions to natural resource problems. DLNR oversees 16 Soil and Water Conservation Districts.

The South O‘ahu Soil and Water Conservation District includes the area from the ridge of the Ko‘olau Mountains to the sea between Makapu‘u and Pearl Harbor's Middle Loch. This District includes the Ala Wai watershed and specifically aims to provide "technical, financial, and educational resources, whatever their source and focus may be, and coordinate them so they meet the needs of the local community for conservation of soil, water and related resources."

o Watershed Partnerships

Partnerships that are organized with the intent of watershed improvement are a growing trend in environmental restoration across the country. There are several partnerships that have formed in the state of Hawai‘i that recognize the importance and magnitude of watershed health, especially on island ecosystems. Neighbor island partnerships include the East Moloka‘i Watershed Partnership, the West Maui Mountains Watershed Partnership, the East Maui Watershed Partnership and the Nāwiliwili Watershed Partnership. On O‘ahu, the Ko‘olau Mountains Watershed Partnership (KMWP) was formed in 1999 to collectively address the array of environmental and social issues facing the various watersheds in that mountain range. The KMWP developed a Management Plan in 2002 modeled after the East and West Maui Watershed Management Plans, but it is considered a unique document due to the specific biophysical and socio-cultural contexts. It seeks to balance the varied interests represented by each of the partnership’s unique members, with the goal of protecting the forested watershed areas within the Ko‘olau Range.

The concept of partnerships extends to agreements between government and community groups. With the reduction in size and budget of government agencies, more and more the success of government initiatives is through partnering with locally based community organizations. The key for involving community groups is to foster a sense of stewardship for the land on which they live, and to impress upon the importance of clean water in the environment. The initiation of non-profit organizations has occurred in several places in Hawai‘i, including in the West Honolulu Watershed region. These groups seek funding and the membership to carry out their organizational objectives from governmental agencies such as the EPA, NRCS, the Department of Health and the City and County. A community-based initiative actively involves the public and provides a long-term legacy in concert with educational programs to foster continued awareness and improvement in the watershed.

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Appendix C: Findings and Analysis

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Appendix C
Findings and Analysis

This section discusses the findings from the data search conducted for this analysis. Multiple avenues were pursued in order to be as comprehensive as possible. The first source of information included a data search of agency and university libraries for reports and other documents pertaining to the Ala Wai watershed and watershed management in general. To supplement this, the study team met with individuals from various agencies and organizations to obtain the most current information on the status of research, projects, and the future direction of management activities in the watershed. Additionally, an Agency Study Group was convened of various agencies and organizations with expertise in the issues pertaining to the Ala Wai watershed to provide input on the project as it developed.

The findings are organized by watershed topic, including water quality, erosion and sedimentation, flood control, public health and safety, biotic environment, and overall watershed. While most of the information for this analysis was drawn from the literature review, agencies and organizations provided valuable complementary information. Each watershed topic is discussed in terms of problems and issues, data gaps, and recommended actions

Problems and Issues

Each document discussed either a problem or a set of problems and issues within the Ala Wai Canal watershed. While most of the literature focused on the Ala Wai Canal itself, several documents specifically targeted streams or parts of streams, and some covered the entire watershed. Many documents discussed the same issues, which gave an indication of both the importance and the persistence of that issue. Discussions with agencies and organizations verified or updated the data presented in the literature.

Data Gaps

In addition to identifying known problems and issues in the watershed, data sources also recognized those areas where there was insufficient data. These "data gaps" identify types of information that should be collected in order to draw conclusions about the health and function of the watershed and/or to recommend actions for its improvement, maintenance, and/or restoration. Data gaps exist either because there has been no research or monitoring of that particular parameter, there is too little data or the data is too old due to little or reduced monitoring over the years.

Recommended Actions

Many of the documents researched recommended actions to address the problems and issues that were identified. Not all documents proposed actions, and several documents recommended similar or the same action. Actions were in the form

of proposed projects, ongoing programs, or recommendations for further research and monitoring. Meetings with those with expertise provided points of view on previously proposed projects and additional actions to consider. Those actions proposed by the literature and consultations were eventually developed into the recommended actions found in Section 4 of this report.

C.1 Water Quality

Most of the literature focused on water quality, with specific focus on the Ala Wai Canal. Documentation of poor water quality in the Canal itself exists from before 1970, illustrating the persistence of the watershed's problems.

C.1.1 Problems and Issues

Water quality may be described by physical, chemical, and biological parameters. Physical contaminants may be in the form of solids, unusual color or taste, plastics, debris, or heat.[92] A reconnaissance survey conducted for a 1992 Department of Land and Natural Resources (DLNR) report found considerable amounts of litter and organic debris such as plant wastes floating in the Ala Wai Canal or lying in its bed.[93] Most affected by litter and dumping were those areas in and around the Ala Wai and Mānoa-Pālolo Drainage Canals, bridges and stream crossings throughout the watershed, streamside "hangouts," fast food establishments, institutional sites, and remote sites.[94] The most plentiful man-made debris were aluminum cans, food containers, and cigarette butts, and were found in and around the Canal. Large items such as shopping carts, construction materials, household appliances, furniture, and automobile parts were found in the Canal and waterways as well.

Chemical water quality is affected by both organic and inorganic factors. Organic contaminants may include pesticides, oils, and other carbon-containing compounds.[95] Pesticide applications at institutions, residential areas, and along streams are suspected of leaching into the ground and surface water. Specifically, termiticides such as dieldrin have been found in fish in the Ala Wai Canal, and in 1990, the US Fish and Wildlife Service (USFWS) reported that Mānoa Stream had the highest concentrations of dieldrin, chlordane, and heptachlor among streams sampled throughout the nation.[96] Dieldrin and chlordane were heavily used as termiticides before deregistration in 1987 and 1988, respectively. Although dieldrin concentrations appear to be declining since its use has been discontinued, a 1992 report stated that concentrations still posed a significant health risk if fish from the Ala Wai Canal or Mānoa Stream were consumed for any length of time.[97] Biotic analyses

[92] Evensen, C. I. (2001 February 28). *Water Quality Monitoring and Watershed Basics.*
[93] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[94] Ibid.
[95] Evensen, C. I. (2001 February 28). *Water Quality Monitoring and Watershed Basics*.
[96] As cited in State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[97] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.

described in a 1992 report suggested that chlordane concentrations increased. However sediment analyses proved to be ambiguous, and the report could not be certain that chlordane concentrations had reached their peak.[98] Heptachlor contamination is likely from use of technical chlordane, of which it was a component. The calculated cancer risk for chlordane and heptachlor combined were in excess of EPA action levels.[99]

In addition to pesticide contamination, organic chemical pollution has also been suspected from leaking underground storage tanks (LUSTs) and runoff from service stations that may be contributing petroleum, automotive fluids, grease, and other chemicals to groundwater and streams through effluent flow or to storm drains via runoff.[100] This type of contamination may have been remedied since the 1992 report that identified these problems, especially due to the tightening of environmental regulations. However, improper disposal of household hazardous wastes may still be occurring. Improper disposal of these materials was cited as a likely cause of several reported fish kills and is suspected of being a long-term contributor of unmonitoried toxicants.[101]

Inorganic contaminants may include pH, salinity, and acidity, variations from ambient conditions, as well as excessive nutrient and metal concentrations.[102] The Ala Wai Canal has been identified by the State Department of Health (DOH) as a Water Quality Limited Segment for both Total Phosphorous (P) and Total Nitrogen (N).[103] A 1997 report found that N levels in the Canal were six times State Water Quality Standards (Standards), and P levels exceeded Standards by two times.[104] Nutrients are suspected of originating from urban lands, non-urban lands, groundwater, cesspools, and the Ala Wai Golf Course, although there is no conclusive research to substantiate these hypotheses.[105] Median levels of N have been found to be higher in Pālolo Stream than in either Makiki or Mānoa Streams, and median P levels have been found to be the highest in Pālolo Stream.[106] Poor circulation allows nutrients to persist in the Ala Wai Canal, therefore feeding algae and phytoplankton, whose numbers increase turbidity.[107]

Various metals such as Mercury, Cadmium, Zinc, and Arsenic have been found in the

[98] Ibid.
[99] Ibid.
[100] Ibid.
[101] Ibid.

[102] Evansen, Carl I. (2001). *Water Quality Monitoring and Watershed Basics*.
[103] State of Hawaii DOH Environmental Planning Office. (1993). *Revised Total Maximum Daily Load Estimates for Six Water Quality Limited Segments, Island of O'ahu, Hawaii*.
[104] State of Hawai'i DOH Clean Water Branch. (1997). *Water Quality Monitoring Report – May 1996-97 Ala Wai Canal Watershed Project*.
[105] State of Hawaii DOH Environmental Planning Office. (1993). *Revised Total Maximum Daily Load Estimates for Six Water Quality Limited Segments, Island of O'ahu, Hawaii* and State of Hawai'i DOH. (2001). *Total Maximum Daily Loads for Ala Wai Canal, Island of Oahu, Hawaii*.
[106] State of Hawai'i DOH Clean Water Branch. (1997). *Water Quality Monitoring Report – May 1996-97 Ala Wai Canal Watershed Project*.
[107] State of Hawaii OEQC. (1976). *Improvement of the Ala Wai Canal Final Report*.

biota and water of the watershed, but of these, only lead and Copper have been identified as potentially problematic.[108] According to a 1984 USFWS study, fish in Mānoa Stream had lead concentrations three times greater than levels in the other 110 streams sampled nationwide.[109] Additionally, the same study showed that Mānoa Stream had the second highest copper contamination of those streams studied.[110] Sources of lead include vehicle parts and gasoline; however, studies have shown that lead is decreasing in the environment, presumably due to the reduction of lead in gasoline in the late 1980's. Copper sources include vehicle traffic and parts, natural soils, and copper-based anti-fouling marine paints and pesticides.[111] Lead, copper and other vehicle-related metals are transported from streets and highways to streams and the Ala Wai Canal via storm sewers.[112] Ships and a vessel repair shop at the Ala Wai Harbor have been associated with marine anti-fouling agents that are brought into the Canal via tidal flux.[113]

Biological contaminants include pathogens and other toxic organisms. As early as 1969, high coliform counts were observed in the Ala Wai Harbor and in the Mānoa-Pālolo Drainage Canal.[114] Since then, fecal coliform levels in the streams and Canal and enterococcus levels in the Ala Wai Canal have been found to exceed state standards "virtually 100% of the time."[115] Although fecal coliform and enterococcus are used in water quality standards, enterococci and *Escherichia coli* have been found to naturally exist in streams and soil in Hawai'i, therefore suggesting that their presence may not be a reliable indicator of fecal contamination. *Clostridium perfringens* is another bacterium that may be a more reliable indicator of fecal contamination and was added as an indicator in 1998.[116] High levels of *C. perfringens* in the Pālolo sub-watershed was found to exceed normal background levels, especially in the lower portions of the Pūkele and Wai'ōma'o Streams and downstream of the Pālolo Housing area.[117]

Bacteria in the Ala Wai Canal have been found to be more concentrated in the upper portions of the water column. This is thought to be influenced by two factors: the location of the source at the surface and the increase in salinity with water depth.[118] Bacteria tend to die off as salinity increases.

[108] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[109] As cited in State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[110] Ibid.
[111] Ibid.
[112] C&C DTS. (1998). *Ala Wai Canal Dredging Conceptual Design and Environmental Assessment – Sources of Contamination/Potential Pollutants*.
[113] Ibid.
[114] As cited in Gonzales, F.I. (1971). *Descriptive Study of the Physical Oceanography of the Ala Wai Canal*.
[115] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[116] Natural Resources Defense Council. (2002, July). *Testing the Waters: A Guide to Water Quality at Vacation Beaches [Electronic version]*.
[117] State of Hawai'i DOH Clean Water Branch. (1997). *Water Quality Monitoring Report – May 1996-97 Ala Wai Canal Watershed Project*.
[118] Gonzales, F.I. (1971). *Descriptive Study of the Physical Oceanography of the Ala Wai Canal* and State of Hawaii DLNR DOWALD. (1992). *A*

Sources of *C. perfringens* could be sewer line leaks and cesspools in the residential areas of upper Pālolo Valley that may periodically discharge during high flow periods.[119] Other sources of bacteria may be domestic pet wastes and other animals such as pigeons in the watershed.[120] High bacteria counts at the Kapahulu end of the Canal may be from the storm drain there, although the ultimate source of bacteria is not known.[121]

Public access opportunities around streams in the Honolulu urban district are virtually non-existent. These streams have been channelized to convey storm water and are therefore not conducive to human interaction and enjoyment. This has resulted in an attitude of neglect towards urban streams, therefore facilitating their degradation by littering and dumping.[122] It also does not readily allow for cleanup and maintenance activities by volunteer civic organizations.

Pollution from the upper areas of the watershed, as well as a lack of routine maintenance and management of the Canal decrease the aesthetic beauty of the Canal and impede free passage by water craft during low tide. Additionally, anaerobic conditions cause smells, and recreational activities around the banks of the Canal are affected by the deteriorating condition of the existing Canal walls. Walls are reported to be in "fair" to "collapsed" condition due to continual sliding and settlement of the substrate.[123] This may make it dangerous to participate in recreational activities such as walking or jogging near the Canal.

Access to the Conservation District varies between the sub-watersheds. Makiki has the greatest concentration of trails, 13, and Mānoa has five trails; there are no public trails in Pālolo. Public access into the upper watershed brings with it some risk for natural hazards such as rock slides and flash flooding. The DLNR is currently studying these risks in order to implement the proper safety precautions.[124] A preliminary analysis covered only a small portion of the State's trails.

Conflicting uses are another concern in the upper watershed. Some activities such as dirt biking may cause erosion. Pig hunting requires the maintenance of a pig population. Additionally, hunting is not considered the most efficient way to eliminate pigs from an area. Feral pig populations exacerbate erosion by uprooting plants and creating wallows. Both dirt biking and hunting may also be dangerous when conducted near passive recreation activities such as hiking.

Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii.

[119] State of Hawai'i DOH Clean Water Branch. (1997). *Water Quality Monitoring Report – May 1996-97 Ala Wai Canal Watershed Project*.

[120] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I*.

[121] Ibid.

[122] Ibid.

[123] State of Hawaii DLNR. (1999). *Evaluation of Seawalls, Ala Wai Canal Dredging Project, Honolulu, Oahu, Hawaii*.

[124] State of Hawaii DLNR Risk Assessment Working Group. (2001). *Hawai'i Trail Analysis: Survey and Risk Management Data Profile*.

An additional concern for the Conservation District is that heavy use increases the impact on the resources. Public access may cause erosion, opportunities for illegal dumping, and the introduction of noxious weeds.

C.1.2 Data Gaps

Monitoring data is limited. The USGS, DLNR Commission on Water Resources Management, and the City currently maintain eleven gauging stations, although other sites were previously maintained.[125] Inadequacies result from a lack of monitoring on a particular waterway, a lack of current information, or inconsistencies in sampling or reporting methodologies.[126]

Among information that is lacking for appropriate water quality determinations and corrective measures include adequate recording of the concentrations of pollutants in streams.[127] Specifically, there have been no recent sediment or water analysis for dieldrin concentrations.[128] However, the most frequently mentioned data gap in terms of water quality is not in measurements of contaminants, but in their sources. Suspected pesticide sources include residential lawn and garden pesticides and agency use along streams, but these sources are unconfirmed and there has been no research to confirm the contribution of LUSTs to groundwater pollution.[129] The USGS National Water Quality Assessment Program investigated nutrient, pesticide, and sediment loads, and biological parameters in streams throughout O‘ahu. Monitoring ended in 2001, but is expected to continue again on 2008.

Additionally, the relative concentrations of various sources of copper have not been determined, and contamination trends are inconclusive.[130] The sources of coliform bacteria have also not been investigated and it is unknown if the bacteria threaten humans or aquatic life.[131] The source of the high nitrates and fecal coliform bacteria at the Kapahulu end of the Canal has not been identified.[132]

Additionally, the impacts that humans have on the environment are not fully understood, especially on trails and at other recreational venues. Specific research is needed to address the impacts that public access has on streams, erosion, and alien species dispersal.[133]

C.1.3 Recommended Actions

Numerous actions were proposed to remedy the various water quality problems that exist

[125] USGS. Personal interview. (24 April 2003).
[126] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[127] UH Department of Oceanography. Personal Interview. (09 December 2002).
[128] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[129] Ibid.
[130] Ibid.
[131] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii* and State of Hawai‘i DOH Clean Water Branch. (1997). *Water Quality Monitoring Report – May 1996-97 Ala Wai Canal Watershed Project*.
[132] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[133] DLNR-DOFAW. Personal interview. (23 January 2003).

in the Ala Wai Canal and throughout the watershed. Recommendations addressed physical pollution, organic and inorganic chemical contaminants, biological pathogens, and general water quality throughout the watershed and in the Canal itself. The following actions were recommended to address physical pollution, specifically the streamside dumping.

Several preventive measures were recommended. Efforts to promote recycling included encouraging vendors to use returnable bottles, supporting a feasibility study on locating a reprocessing/recycling facility in Hawaii, and enhancing the County's recycling efforts to include curbside pickups.[134] Other preventive measures included education on litter control, enforcement of the County Litter Control Ordinance (Article 4, Chapter 29, ROH), requiring fast-food restaurants to provide trash bins in their parking lots, increasing fines and penalties for illegal dumping and abandoning automobiles, and increasing the County's "bulky item" pickup program to include automobiles for a small fee.[135] The C&C should also take measures to ensure appropriate rubbish disposal for low-rise residential and high-density residential areas.[136]

Most of the recommendations came from the 1992 reports produced by Edward K. Noda and Associates, Inc. Since then, the C&C has proposed an expanded recycling program that includes curbside pickup and the legislature has passed a "bottle bill" that promotes recycling by imposing a deposit on certain beverage cans and bottles, and refund the deposit upon return of the containers for recycling. An additional charge is applied to each container to support recycling operations.

In addition to preventive measures, several actions were recommended to remove physical litter, garbage, and debris from streams and waterways. These included enforcement of sections 29-4.5 and 29.4.7 of the Revised Ordinances of Honolulu (ROH), which mandate the removal of litter, to be paid for either by the person(s) responsible for littering or by the private owner whose property contains the litter.[137] Additional proposals included installing floating debris containment booms on tributaries to the Ala Wai Canal[138] and enforcement of the Stream Maintenance Ordinance § 41-26, ROH that mandates stream maintenance by the owner and removal of any material "that may interfere with the natural flow of water."[139] Volunteer-related options were organizing stream cleanup programs at the state and county level and expanding State litter

[134] Ibid.
[135] Ibid.
[136] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I.*
[137] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii.*
[138] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I.*
[139] Revised Ordinances of Honolulu, as cited by State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*

cleanup programs such as "Get the Drift and Bag it" and "Adopt-A-Stream."[140]

The Noda reports also recommended efforts to control construction and roadway related materials. These were to ensure proper disposal of all construction wastes in approved sites, to clean up existing asphalt and concrete wastes generated through road and path degeneration, and to improve and maintain roadways and bridges to keep deterioration to a minimum.[141]

Organic contaminants are those with carbon containing compounds such as pesticides and petroleum derivatives. While persistent termiticides such as dieldrin and chlordane have been banned, other pesticides are being used and may be getting into our ground and surface water. Recommendations for preventing pesticide contamination included replacing herbicide use near streams or in areas with direct runoff access to streams with manual clearing, adopting non-pesticide alternatives, banning or restricting persistent and mobile pesticides, requiring BMPs for pesticide use, and educating the public on BMPs and their proper use.[142]

Household hazardous wastes such as cleaners and solvents are also organic contaminants. Various actions were proposed to reduce pollution from these sources: increase public education about the environmental effects, laws, and penalties of dumping toxic materials and how to access waste collection programs, enhance "Amnesty Day" programs that allow for the penalty-free submission of toxic materials, develop a program for periodic curb-side toxic waste collection, require retailers of toxic household materials to be drop-off and/or recycle centers for unused portions and wastes, and the systematic monitoring of streams and storm drains to determine the impacts of the urban disposal of toxic materials.[143] The ENV is currently surveying large institutions and other entities to detect pollutant discharge violations.[144]

Industrial hazardous materials may also contribute to organic chemical pollution. Agencies and private interests have been working to carry out the recommendations by the Noda report (1992) to identify and bring LUSTs and service stations into compliance with environmental regulations. Because of this, hazardous materials may not be as significant of a source of pollutants as they once were.

Two major inorganic chemical pollutants are nutrients and metals. A portion of the nutrient load is thought to come from urban and non-urban runoff, construction of roads and trails, groundwater inputs, fertilizer applications, cesspools, and boat wastes.[145] To address these potential sources, it was recommended that there be education on the

[140] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[141] Ibid.
[142] Ibid.
[143] Ibid.
[144] C&C ENV. Personal interview. (21 January 03).
[145] State of Hawaii DOH. (2001). *Total Maximum Daily Loads for Ala Wai Canal, Island of Oahu, Hawaii.*

appropriate BMPs for fertilizer use[146], improved management of fertilizer applications[147], conversion of cesspools to septic systems[148], storm water management practices including retention and filtering[149], and insurance that boat wastes are disposed of properly.[150] These efforts are ongoing but may not produce significant reductions in nutrient loads as most of the nutrients are suspected of coming from vegetation in the upper watershed.[151] Also, the previously mentioned recommendations would not address the notion that much of the nutrients in the Ala Wai Canal are thought to be regenerated within the Canal itself from bacterial action on dead phytoplankton.[152]

The main sources of metals in the waterways of the Ala Wai watershed include motor vehicles and boat paints. Recommendations to address the contribution of boat paints were to discourage and/or ban the use of anti-fouling and anti-rust paints containing heavy metals, require boat paints to be scraped in dry lock and wastes be disposed of properly, and perform light bottom dredging of harbor areas to collect paint peelings.[153] Some of these measures are already being implemented, therefore making boat-related contributions less of a concern.

Motor vehicles continue to be a source of metals that contaminate our waters and sediments. While leaded gasoline has been banned, vehicles still produce lead, copper, and other metal residues from wear on parts such as brake pads and tires. Proposed actions to address this source included quantifying the amount of pollution vehicles contribute and using BMPs such as storm drain filters and street sweeping.[154] The C&C ENV currently runs a street sweeping program that performs sweeping once a week and is investigating the effectiveness of various storm drain filters in reducing the amount of contaminants that reach the streams.[155]

Biological contaminants include bacteria and other toxic organisms. Feral animals in the upper watershed are suspected of contributing to fecal coliform concentrations. Recommended actions included research to determine the contribution feral animals make towards bacteria concentrations and feral animal eradication.[156]

[146] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[147] State of Hawaii DOH Environmental Planning Office. (1993). *Revised Total Maximum Daily Load Estimates for Six Water Quality Limited Segments, Island of O'ahu, Hawaii*.
[148] Ibid.
[149] State of Hawai'i DOH. (2001). *Total Maximum Daily Loads for Ala Wai Canal, Island of Oahu, Hawaii.*
[150] Ibid.
[151] Ibid.
[152] State of Hawaii OEQC. (1976). *Improvement of the Ala Wai Canal Final Report*.
[153] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[154] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I*.
[155] C&C ENV. Personal interview. (21 January 2003).
[156] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.

Another source of biological contaminants are animal wastes in the urban district, either from domestic pets or other wild animals such as pigeons and other birds. The Noda report (1992) produced several recommendations focusing on domestic pet wastes including research to determine the relative magnitude of domestic pet waste as a source of fecal coliform as compared to other animal sources, public education on pet wastes as sources of bacteria and nutrients and the need for proper waste disposal, and increased enforcement of Litter Control Ordinance, §29-4.4(a)(9) ROH, that mandates solid pet waste disposal.[157]

Additionally, the Noda (1992) report proposed studies regarding the Ala Wai Canal itself. The two large storm drains at the Kapahulu end of the Canal should be monitored for pollutants to determine if they are the source of nitrates and fecal coliform in that area, and the reports of staphylococcus and other skin infections thought to be attributed to contact with Ala Wai Canal waters should be verified.[158] A study done to evaluate the propensity for skin infections due to contact with Canal waters was done as a part of the 1998 Ala Wai Canal Watershed Water Quality Improvement Project. This study showed that canoe paddlers at the Ala Wai Canal suffered skin rashes much more frequently than a control group that paddled in another location. However, one of the contributors to the study recommended that the research be repeated due to a flaw in the methodology.[159]

Several actions were proposed to address multiple water quality concerns throughout the watershed. General stream improvement recommendations included planning and managing the forest and streams in the Conservation District, extending those management practices to streams in the Urban District and the Ala Wai Canal, and restoring streams.[160] Improving public access to streams, waterways and the upper watershed is a means by which management and maintenance goals could be achieved.[161] A 1998 study suggested that access not only puts people in the natural resource therefore building appreciation, it also allows for volunteers and work crews to perform maintenance tasks.[162]

Aesthetics, safety, and impacts on the environment should be considered when improving public access. Stream beautification, especially highly modified streams in Urban District, should be considered as a means to increase appreciation for the environment.[163]

Access to streams in the Urban District is fairly poor, and generally limited to the Ala Wai Canal. In the 1970's, the University of Hawai'i developed a linear park concept that

[157] Ibid.
[158] Ibid.
[159] Dashiell, Eugene P., AICP. Personal communications.
[160] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I.*
[161] Ibid.
[162] Ibid.
[163] Ibid.

centered on Mānoa Stream.[164] This concept incorporated pedestrian and bike trails, access points, redevelopment of neighboring properties, and secondary trails. Actions should be mindful of liability and security issues that result from public access.[165]

The Ala Wai Canal itself is generally accessible, with a few exceptions near the Mānoa-Pālolo Drainage Canal and the Ala Wai Golf Course. However, the walls of the Ala Wai Canal are deteriorating, therefore creating a potential hazard to recreationists and maintenance crews. Studies to stabilize these Canal walls should occur.[166]

Public access to the Conservation District in Makiki and Mānoa is currently provided through a network of trails. Efforts to improve access in Pālolo might be investigated.[167] Maintenance and safety precautions should first occur on existing trails, including completing a hazard analysis for existing trails and developing hazard minimization actions.[168] This might include actions that optimize the watershed experience for each user group by separating those actions that may conflict with each other such as dirt biking and hiking.

Impacts on the environment caused by public access into the watershed should be monitored. Research into optimal trail materials and technologies that minimize impacts and increase safety and enjoyment of the resource could lead to more effective management of trail resources.[169]

A difficulty that impedes proper maintenance of the watershed is the way management is organized. Multiple agencies are responsible for various portions of the watershed, either by geographic or operational delineation. Additionally, private property owners are responsible for maintaining their particular section of stream. This leads to a fractured approach to watershed management and maintenance. A regional approach to watershed management should be implemented that is overseen by an entity that coordinates issues throughout the watershed in a holistic manner and is coupled with updated agency capabilities and programs.[170]

Water quality in the Ala Wai Canal may be seen as an accumulation of the conditions throughout the entire watershed. The effectiveness of a seawater flushing system has been evaluated several times to improve the water quality in the Canal.[171] Studies

[164] University of Hawaii Manoa Campus. (1978). *Urban Design: Manoa Stream Park*.
[165] DLNR-DOFAW. Personal interview. (23 January 2003).
[166] State of Hawaii DLNR. (1999). *Evaluation of Seawalls, Ala Wai Canal Dredging Project, Honolulu, Oahu, Hawaii*.
[167] Dashiell, Eugene P. Dashiell, AICP. Personal communications.
[168] State of Hawaii DLNR Risk Assessment Working Group. (2001). *Hawai'i Trail Analysis: Survey and Risk Management Data Profile*.
[169] DLNR-DOFAW. Personal interview. (23 Janary 2003).
[170] Ibid.
[171] Various documents including State of Hawaii OEQC. (1976). *Improvement of the Ala Wai Canal Final Report*. Laws, E., et. al. (1993). Hypereutrophication of the Ala Wai Canal: Prospects for Cleanup. State of Hawaii DLNR DOWALD. (1992). *Ala Wai Canal Improvement, Honolulu, Oahu, Hawaii, Feasibility Report*. & State of Hawaii DLNR DOWALD. (1993). *Environmental Assessment and Negative*

showed that a flushing system using clear salt water at the Kapahulu end of the Canal would have no significant adverse impact on sedimentation processes in the Canal or Harbor, while reducing coliform counts and nitrogen, thereby reducing phytoplankton growth and reducing turbidity.[172]

A major difficulty in determining pollution levels, sources, and remedial actions is that monitoring data is deficient. Monitoring data is needed to evaluate projects and programs in the watershed and to evaluate BMPs. An ideal monitoring situation might include nine stations: two in Makiki, three in Mānoa, three in Pālolo, and one at Kaimukī High School.[173]

C.2 Erosion/Sedimentation/ Contaminated Sediments

Erosion and sedimentation issues were other frequently discussed topics in the Ala Wai Watershed. This is likely due to the visibility of stream bank erosion and the accumulation of sediments in the Mānoa-Pālolo and Ala Wai Canals.

C.2.1 Problems and Issues

The amount of sediment accumulating in the Ala Wai Canal has been estimated at 8,000 - 10,500 yards^3/year.[174] The DLNR estimated that three-fourths of this sediment originates naturally in the upper watershed through the erosion of soils[175] that has likely increased in recent years due to human influences. Native Hawaiian forests are believed to not only hold the soil, but to also dissipate the force of raindrops through a multi-story canopy, thus reducing the erosive potential of the water that falls to the ground.[176] Rain then infiltrates into the soil and feeds our groundwater aquifer. Human-introduced flora, however, tend to out-compete native vegetation. This creates a single-story monoculture that is suspected of being inferior in breaking the force of rainwater.[177] This leads to less infiltration and more surface runoff.

Alien fauna are also of concern in the upper watershed. Feral ungulates, pigs in particular, destroy young plants, thereby eliminating the under story, overturn established plants, and create wallows. These actions expose soils and make the conservation areas more susceptible to erosion.

Some urban activities, such as construction sites with exposed soils, also contribute to sediments in streams and the Canals.[178] Sediment may also come from eroding stream banks that encroach into private property and is a concern for landowners whose structures may be threatened.

Declaration for the Ala Wai Canal Improvement, Honolulu, Oahu, Hawaii.

[172] State of Hawaii OEQC. (1976). *Improvement of the Ala Wai Canal Final Report*.

[173] UH Mānoa Department of Oceanography. Personal interview. (09 December 2002).

[174] C&C DTS & DDC. (1998). *Ala Wai Canal Dredging Final Environmental Assessment*.

[175] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I*.

[176] Honolulu Board of Water Supply *Water for Life: The History and Future of Water on O'ahu*.

[177] Ibid.

[178] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.

Specific sites of erosion have been recorded at Mānoa Stream. In the lower Woodlawn area, urban development adjacent to the stream is suspected of altering the natural drainage way, therefore accelerating erosion. At Mānoa Valley District Park, steep slopes create unstable banks.[179] Other areas include Kanahā Stream near Roosevelt High School, Makiki Stream makai of South King Street, Pūkele and Wai'ōma'o Stream, and much of the Mānoa-Pālolo Drainage Canal.[180] Sedimentation was only mentioned as a problem in one area other than in the Mānoa-Pālolo Drainage and the Ala Wai Canals. Water velocities slow below the Woodlawn Bridge of Mānoa Stream due to a moderate gradient in that area and deposit sediment here.[181]

While much of the sediment in the Ala Wai Canal is transported from the upper watershed, some sediment is also produced in the Canal itself. The Ala Wai is one of the most productive bodies of water in the world.[182] A 1976 report concluded that because the sediments in the Canal are 69% organic, that they may be the result of biological activity on the canal, primarily excessive phytoplankton production in the surface layers.[183]

Sediments contribute to turbidity and siltation in receiving waters and often create poor habitat conditions for aquatic and marine life. The large amounts of sediment that accumulate in the Ala Wai Canal make regular dredging necessary. Dredging is currently ongoing; it began in August of 2002 and is expected to be completed in mid to late 2003. An estimated 170,000 cubic yards of sediment is expected to be removed from the Ala Wai and Mānoa-Pālolo Drainage Canals at a cost of $7.4 million.[184] Although dredging has been recommended approximately every 10 years, the previous dredging occurred in 1978-1979.[185] Part of the delay in dredging is the large cost and multiple permits required, as well as the addressing of impacts to the community that result from restricting access to portions of the highly used recreational venue.

Another difficulty in dredging has been the sediment testing and disposal alternatives required for a portion of the dredge spoils that are considered too contaminated to be placed at the South O'ahu Ocean Dredge Material Disposal Site approximately 3.8 miles seaward of Sand Island. As a result of the current dredging operation, about 1,800 cubic yards of sediment at the Kapahulu end of the Canal will be disposed of on land at

[179] State of Hawaii DLNR DOWALD. (1995). *A Study to Alleviate Flooding of Manoa Stream (East Manoa Road Woodlawn Drive) Island of Oahu* & C&C DDC. (2000). *Draft Environmental Assessment: Ala Wai Canal Watershed Project, Manoa Valley District Park Streambank Improvements, Honolulu, Oahu, Hawaii*.

[180] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I*.

[181] C&C DFM. (1999). *Mānoa Stream Maintenance Plan: Kahaloa Drive to Woodlawn Drive*.

[182] As cited in State of Hawaii OEQC. (1976). *Improvement of the Ala Wai Canal Final Report*.

[183] State of Hawaii OEQC. (1976). *Improvement of the Ala Wai Canal Final Report.*

[184] Leone, Diana. (2000, August 4). Dredging the Ala Wai Canal.

[185] State of Hawaii DLNR DOWALD. (1992). *A Maintenance Plan for the Ala Wai Canal, Honolulu, Oahu, Hawaii*.

the Airport Reef Runway due to its inability to meet EPA standards for ocean disposal. Land disposal is typically more costly than ocean disposal and generates additional environmental concerns from the general public. Sediment disposal operations follow EPA guidelines, although they were designed for mainland sites and may not apply to conditions in Hawai'i.[186]

Contaminated sediments also pose health risks by exposing water users to heavy metals, pesticides, and other chemicals. Aquatic and marine life may also absorb contaminants into their tissue and become a hazard for fishers. In 1998, a fish consumption risk assessment done for the Ala Wai Canal Watershed Water Quality Improvement Project concluded that the health risk due to lead was considerable for children who consumed more than eight meals per month of whole fish from the Ala Wai Canal.[187]

Sediment contamination is likely caused by the erosion of soils that are contaminated by pesticides and other chemicals in the urban area.[188] Termiticides such as dieldrin and chlordane were applied in residential areas until they were discontinued in the late 1980's. Construction sites with existing or previous structures may expose soils contaminated with these chemicals and lead to erosion that contributes contaminated sediments.[189] Heavy metals such as lead and copper are suspected to result from automobile brake pads and other parts due to continual wear.[190] Approximately 250,000 vehicles pass through the watershed daily, and their residues are transported to streams and receiving waters via storm drains.[191]

Storm drains have been linked to site-specific sediment contamination within the Ala Wai Canal. The Kapahulu end of the Canal has been found to have high levels of lead, chlordane, and polycyclic aromatic hydrocarbons and a site near the midway point of the Canal on the mauka side across from Kalanimoku Street had high levels of polycyclic aromatic hydrocarbons.[192]

One additional source of contaminants may be boating operations at the mouth of the Ala Wai Canal. Bottom paint from vessels serviced at the Ala Wai Marine Boatyard is suspected of contributing organic tin to the sediments, and petroleum by-products are likely from boating operations at the Ala

[186] UH Mānoa Department of Oceanography. Personal interview. (09 December 2002).
[187] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan – Volume II Technical Appendices*.
[188] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii* and C&C DTS & DDC. (1998). *Ala Wai Canal Dredging Final Environmental Assessment*.
[189] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[190] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I*.
[191] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I* and C&C DTS. (1998). *Ala Wai Canal Dredging Conceptual Design and Environmental Assessment – Sources of Contamination/Potential Pollutants*.
[192] State of Hawaii DLNR. (1999). *Ala Wai Canal Dredging Final Design and Permitting Dredge Sediment Characterization Tier III Field and Data Report Volume II: Appendices*.

Wai Harbor.[193] Marine anti-fouling agent residuals from vessel repair facilities are suspected of contributing other contaminants to sediments.[194]

C.2.2 Data Gaps

The effect of land use on sediment type and quantity has not yet been determined.[195] A study on the proportion of sediment that originates from conservation areas, urban areas, and construction areas would allow for a better understanding of the effect of land use on erosion. Specifically, the sediment yield from each watershed is unknown, but would allow planners to focus on watershed-specific measures.[196] The magnitude of the impact that feral animals have on erosion is also undetermined[197], and suspended sediment loading data is necessary to generate sediment rating curves.

There is also no research to confirm the source of pesticides and metals in sediments currently thought to be from construction sites, lawns, gardens, and residential and commercial sites via runoff.[198] The amount of vehicle-generated contaminants, such as lead, needs to be quantified so we may better understand the magnitude of this problem.[199]

C.2.3 Recommended Actions

Several actions have been recommended to improve the erosion and sedimentation problems in the watershed. Sediment reduction possibilities include on-site measures, where erosion is occurring, and off-site measures, generally in downstream areas. On-site actions include those that are focused on the Conservation District, as most of the sediment that is transported downstream is suspected of originating there. Research is recommended to determine the total quantity of sediment coming from the upper watershed and its relative proportion of the sediment load from the entire watershed.[200] The ENV is currently monitoring sediment load in the streams to determine the sediment load contribution from various land uses.[201]

Physical actions in the Conservation District include the management of invasive species.[202] This includes the reduction of

[193] C&C DTS. (1997). *Ala Wai Canal Dredging Conceptual Design and Environmental Assessment Dredge Sediment Characterization Tier II Field Trip Report #2 & Tier II Laboratory and Data Report #2* and C&C DTS & DDC. 1998. *Ala Wai Canal Dredging Final Environmental Assessment*.

[194] C&C DTS. (1998). *Ala Wai Canal Dredging Conceptual Design and Environmental Assessment – Sources of Contamination/Potential Pollutants.*

[195] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii* and State of Hawaii DLNR DOWALD. (1980). *Statewide Silt Basin Investigation, State of Hawaii*.

[196] State of Hawaii DLNR DOWALD. (1980). *Statewide Silt Basin Investigation, State of Hawaii.*

[197] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.

[198] Ibid.

[199] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii* and State of Hawaii DLNR DOWALD. (1980). *Statewide Silt Basin Investigation, State of Hawaii*.

[200] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.

[201] C&C ENV. Personal interview. (21 January 2003).

[202] State of Hawai'i DOH. (2001). *Total Maximum Daily Loads for Ala Wai Canal, Island of Oahu, Hawaii*.

feral pig populations that increase erosion by destroying the under story and uprooting plants. Another aspect of alien species management is the restoration of native forest, which has been taken over by predominantly alien ground cover. Once those erosion inducing factors are removed, reforestation and stabilization of areas with exposed soils should take place.[203]

The Ko'olau Mountains Watershed Partnership (KMWP) has recognized that restoration efforts in the Ala Wai watershed may not be as productive as in less impacted areas; therefore, they focus their efforts in this area to threat control and mitigation.[204] Accordingly, the KMWP is initiating their Ala Wai Mauka Restoration Project that is funded by the State Department of Health.[205] This project will include pig hunting coupled with native species out-planting and project monitoring.

Due to the large area covered by the Conservation District and the number of potential factors that affect soil erosion there, it was recommended that a detailed soil erosion reduction management plan and species inventory be prepared.[206] This could include the development and requirement of BMPs for activities and actions in the Conservation District.[207] The KMWP is currently looking to partner with the DLNR DOFAW to prepare a master plan for controlling feral ungulates in the natural areas.[208]

Other on-site erosion control measures are focused on construction sites within the Urban District. Recommended actions include improving and enhancing grading permit regulations and permit enforcement, requiring contractors to be tested and licensed for the use of BMPs for erosion control techniques, and requiring the use of BMPs.[209] Research and monitoring is also recommended to determine the magnitude of sediment loads attributable to construction sites relative to background levels.[210] This research will enable managers to assess the effectiveness of various control measures and BMPs. These measures will collectively reduce the amount of sediment coming from areas exposed during construction.

Development adjacent to streams is also considered a factor in accelerating erosion. Recommended actions to address this include prohibiting encroachment into the flood plain and considering the sediment carrying capacity or settling characteristics of the channels when deciding on

[203] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[204] Ko'olau Mountains Watershed Partnership. Personal interview. (06 February 2003).
[205] Ibid.
[206] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I*.
[207] State of Hawaii DLNR DOWALD. (1980). *Statewide Silt Basin Investigation, State of Hawaii*.
[208] Ko'olau Mountains Watershed Partnership. Personal interview. (06 February 2003).
[209] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[210] Ibid.

encroachments into the Canal or Harbor.[211] This may be difficult to implement because the watershed is already highly developed. This policy may be useful in very long term planning to remove future redevelopment from stream and channel banks.

Various off-site measures were also recommended for reducing and disposing of the sediment that ultimately accumulates in the Ala Wai Canal. These traps are small impoundments that allow sediment to settle out of runoff water, therefore protecting the stream or other waterway from heavy sediment loads. Sediment traps have been recommended at the foot of the Conservation District to catch a substantial portion of the sediments before they reach the lower watershed, at areas downstream of construction sites to trap sediments from those sources, and in the Mānoa-Pālolo Drainage Canal (MPDC) to collect sediments before they reach the Ala Wai Canal.[212] Another option is to over dredge the MPDC so it will accumulate sediment.[213] This area could be dredged more frequently, therefore reducing the dredging frequency of the Ala Wai Canal.

For the sediment that does end up in the Ala Wai Canal, regular dredging should occur.[214] The recommended dredging frequency is every ten years, although the last dredging occurred in 1978-1979, a period of 24 years. This delay was in part a result of the lack of a readily available fund for regular maintenance and the lengthy permitting process required. To prevent this delay from occurring again, a maintenance dredging fund should be established for the Ala Wai and Mānoa-Pālolo Drainage Canals.[215] Additionally, general permits for recurring maintenance dredging should be prepared by the respective authorities to reduce delays and costs.[216]

In addition to the quantity of sediment that is generated in the watershed, soil contamination is another problem. Several measures have been recommended to not only reduce soil contamination, but also to manage soil once it becomes contaminated. These actions are general and do not specifically target contamination sources in the Ala Wai watershed.

Soil contamination is thought to occur from excessive pesticide applications and automotive residues.[217] Suggested actions to reduce soil contamination from pesticides include public education on the BMPs appropriate for land use management and fertilizer and pesticide applications, banning

[211] State of Hawaii DLNR DOWALD. (1980). *Statewide Silt Basin Investigation, State of Hawaii*.
[212] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[213] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I*.
[214] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[215] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I*.
[216] Ibid.
[217] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.

the use of persistent or mobile pesticides, requiring testing and licensing of professional fertilizer and pesticide applicators for proper use of BMPs, and requiring BMPs for fertilizer and pesticide applications.[218]

Automobile residues from the wear on parts, such as brake pads, and from exhaust is believed to be transported from our roadways through storm drains and into streams and other waterways.[219] Proposed measures to reduce this source of contamination include improving automobile maintenance and education for automobile owners; reducing environmentally unsafe vehicles by requiring new inspections that include such considerations as exhaust emissions, oil leaks, wheel alignment, excessive wear of tires, ball joints, brake pads/shoes, brake discs/drums, an corroding rusting body and mechanical parts; encouraging mass transit and transportation alternatives; enhancing insurance laws to keep uninsured vehicles off the roads; and reducing the amount of metal used in vehicle parts, such as brake pads or tires.[220]

In combination with efforts to reduce soil contamination, some actions were suggested to control contaminated sediment and prevent it from reaching the waterways. Some previously developed lands have contaminated soils from earlier pesticide applications and can erode when soils are exposed during redevelopment. Therefore, it is recommended that soils on previously developed sites be tested for pesticides or other site-specific contaminants. If contaminants are found, the soil should treated, removed, and/or contained, depending on the types of contaminants and the level of contamination found.[221]

Sweeping of highways, roads, parking lots, and mall areas has been recommended to collect road contaminants.[222] A study conducted by the ENV has found that street sweeping is effective in picking up medium- to large-sized road residues, and moderately effective in controlling oil, grease, and heavy metals.[223] The ENV currently conducts street sweeping in the Ala Wai watershed on a weekly basis.

If contaminated sediment does move off-site, sediment filters in storm drains could remove contaminants. The ENV is currently investigating the effectiveness of various storm drain filter devices in removing pollutants from urban road runoff.[224]

Sediment disposal after dredging is sometimes problematic, depending on the

[218] Ibid.
[219] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I.*
[220] Ibid.
[221] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[222] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii* and State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I.*
[223] C&C ENV. (1999). *Storm Drain and Street Cleaning Effectiveness Report, City and County of Honolulu Municipal Separate Storm Sewer system NPDES Permit No. HI0021229).*
[224] C&C ENV. Personal interview. 21 January 2003.

level of sediment contamination. The EPA guidelines that are used for sediment disposal are based on U.S. mainland sites and may not apply to Hawai'i. Disposal standards and guidelines should be established specifically for sediments and disposal locations in Hawai'i.[225]

Sediment loading research would allow for better management decisions regarding erosion minimization, contamination control, and sediment disposal. Studies on the proportion of sediment from different land uses would be helpful. The ENV is currently monitoring sediment load to determine the amount of sediment generated from the Conservation District versus the Urban District.[226] Other studies could be targeted at determining the impact that feral animals have on erosion[227] and the effect that shallow-rooted plant species have on slope stability and soil creep.[228]

Additional research should focus on contaminated sediment and sources of contamination. Studies should be conducted to confirm the source of pesticides and metals in sediments currently thought to be from construction sites, lawns, gardens, and residential and commercial sites.[229] The amount of vehicle-generated contaminants, such as lead, also should be quantified so we may better understand the magnitude of this problem.[230] The UHM Department of Oceanography is currently studying dissolved metals in the watershed[231] and the ENV is conducting some monitoring of nutrients, chloride, heavy metals, total dissolved solids, and total suspended solids at Mānoa Stream, Kānewai Field, Waihī Stream, and Waiakeakua Stream.[232]

C.3 Flooding

Flooding is a great concern for the Ala Wai Watershed due to dense development throughout the urban area and the economic importance of Waikīkī. While flooding problems have been reported several times in various locations throughout the watershed, most occurred many years ago.

C.3.1 Problems and Issues

The greatest flooding issue is at the Canal itself where a 1991 report concluded that dredging would be required in order to accommodate even the 50-year flood,[233] although it was concluded that maintenance dredging would not significantly improve the flood carrying capacity.[234] A storm in December of 1967 caused the Ala Wai Canal to overflow its banks onto Ala Wai Boulevard near the confluence with the

[225] UH Mānoa Department of Oceanography. Personal interview. 09 December 2002.
[226] C&C ENV. Personal interview. 21 January 2003.
[227] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii*.
[228] Comments from the ASG. (26 November 2002).
[229] Ibid.
[230] State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii* and State of Hawaii DLNR DOWALD. (1980). *Statewide Silt Basin Investigation, State of Hawaii*.
[231] UH Mānoa Department of Oceanography. Personal interview. 09 December 2002.
[232] C&C ENV. Personal interview. 21 January 2003.
[233] Lum W. & Cox, R. (1991) *The Ala Wai Canal – from Wetlands to World Famous Waikiki*.
[234] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I*.

Mānoa-Pālolo Drainage Canal and flood that area with over 2 feet of water.[235] That same storm flooded Ala Wai Elementary School on the mauka bank with 6-12 inches of water and created damage estimated at $10,000.[236]

In 1994, a report by Ed Noda & Associates, Inc. concluded that the Canal has only marginal capacity to handle a 10-year or more frequent flood flow and that it could definitely not handle the 100-year event flood flow due to inadequate capacity.[237] The section of Canal from the Ala Moana Boulevard Bridge to the Kalākaua Boulevard Bridge is approximately 100 feet narrower than the upstream sections of the Canal, therefore restricting flow.[238] City drainage standards in the urban area recommend a capacity for accommodating a "100-year storm" event.[239] In addition to flooding due to storm conditions, the Ala Wai Canal could potentially suffer flooding from tsunami and hurricane storm waves as well.[240]

Flood problems in the Makiki Drainage basin include the overflow of Makiki Ditch and Kanahā Stream, despite some existing improvements.[241] Makiki Stream has especially experienced flooding and overflow of the existing drainage channel in the areas downstream of King Street due to inadequate capacity of the channel (500-1500 feet^3/second) to accommodate flows from the entire drainage area (5600 feet^3/second).[242] Approximately 110 properties may potentially be affected by flooding, including Lunalilo Elementary School and Washington Intermediate School. The Fern Street area is subject to a flood recurrence interval of only 1.1 years.[243]

Mānoa Stream experiences some flooding occurrences as well due to the inadequate capacity of the natural stream channel to accommodate flood flows. Several restrictive bridge crossings and flatter terrain in the Woodlawn area further slow stream flows in this area,[244] and development along the stream has altered the natural drainage way, although only 900 feet of the stream itself is improved.[245]

There have been more than 12 major floods of Mānoa Stream over the past century, and

[235] State of Hawaii DLNR DOWALD. (1968). *Post Flood Report Storm of 17-18 December 1967 Islands of Kaua'i and O'ahu*.
[236] Ibid.
[237] State of Hawaii DLNR DOWALD. (1994). *Ala Wai Canal Improvement Project Storm Water Capacity Study, Honolulu, Oahu, Hawaii.*
[238] State of Hawaii DLNR. (1977). *Preliminary Engineering Report for Dredging Ala Wai Canal, Island of Oahu*.
[239] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I*.
[240] Ibid.
[241] State of Hawaii DLNR DOWALD. (1984). *Flood Control and Flood Water Conservation in Hawaii Volume II: General Flood Control Plan for Hawaii*.
[242] C&C. 1975. *Engineering Report of Alternative Structural Schemes for Makiki Stream Flood Control Unit I at Honolulu, Oahu, Hawaii*.
[243] C&C Department of Public Works. (1975). *Final Environmental Impact Statement for Makiki Stream Flood Control, Unit I Improvement South King Street to Ala Wai Canal, Honolulu*.
[244] State of Hawaii DLNR DOWALD. (1995). *A Study to Alleviate Flooding of Manoa Stream (East Manoa Road Woodlawn Drive) Island of Oahu.*
[245] State of Hawaii DLNR DOWALD. (1984). *Flood Control and Flood Water Conservation in Hawaii Volume II: General Flood Control Plan for Hawaii*.

at least one life was taken.[246] A flood in November of 1965 flooded residential homes in the vicinity of Kānewai and Koali Road when Mānoa Stream overtopped and part of the stream bank collapsed due to undercutting caused by floodwaters.[247] A December 1992 flood also caused Mānoa Stream to overtop its banks and flood Woodlawn Drive.[248] More recently, Mānoa Stream flooded mauka of Mānoa Marketplace in January of 2002 after 2.5 inches of rain was recorded at Lyon Arboretum in three hours.[249]

Pālolo Stream has been reported to have experienced major flooding eight times in the past century, claiming six lives.[250] While most of the stream within the urbanized area is improved, damages still occur. Mudslides caused by a flood in November of 1965 covered part of Myrtle Street and damaged three homes.[251] During a flood in 1967, landslides, debris, road damages, and erosion occurred in Pālolo Valley.[252] According to a COE report, "Asphalt pavements on Lai Road were washed out by hillside runoff. At the uppermost portion of the Valley, a landslide covered the roadway and dumped large trees into the stream, isolating several families. In lower Pālolo, erosion toppled retaining walls and moved several homes from their foundations."[253]

C.3.2 Data Gaps

No data gaps were specifically cited in the literature.

C.3.3 Recommended Actions

Recommended actions addressed specific flood problem locations in Makiki, Mānoa, Pālolo, the Ala Wai Canal, and the watershed in general. Those proposals that examined the entire watershed included flood plain zoning, which would establish encroachment zones in the potential tsunami inundation areas and regulate the use of any undeveloped areas in the flood plain.[254] Additionally, flood fighting sub-units should be organized to stress the techniques of proper preparation and clean-up procedures.[255] A storm water master plan that runs from the mountains to the ocean would ensure that projects are not piecemeal and will not conflict with each other.[256]

There is a high potential for damages if the Ala Wai Canal floods, due to the close proximity of such dense developments as Waikīkī, McCully, and Kapahulu. A recommendation to reduce the flood potential of the Canal is to combine

[246] Ibid.
[247] Committee on Hydrology. (2001). *Ala Wai Canal, Honolulu, Hawai'i.*
[248] State of Hawaii DLNR DOWALD. (1995). *A Study to Alleviate Flooding of Manoa Stream (East Manoa Road Woodlawn Drive) Island of Oahu.*
[249] Altonn, Helen. (2002, January 29). Rains cause havoc, flood alerts.
[250] State of Hawaii DLNR DOWALD. (1984). *Flood Control and Flood Water Conservation in Hawaii Volume II: General Flood Control Plan for Hawaii.*
[251] Committee on Hydrology. (2001). *Ala Wai Canal, Honolulu, Hawai'i.*
[252] State of Hawaii DNR DOWALD. (1968). *Post Flood report Storm of 17-18 December 1967 Islands of Kaua'i and O'ahu.*
[253] U.S. COE. (1992). *Urban Flood Control Study Honolulu, Hawaii Final Reconnaissance Report Main Report.*
[254] State of Hawaii DLNR DOWALD. (1983). *Flood Control and Flood Water Conservation in Hawaii Volume I: Floods and Flood Control.*
[255] Ibid.
[256] Study Team. November 2002.

dredging with short walls along top of the Canal banks to increase flood capacity.[257] Additionally, the state should conduct more refined analyses of alternatives, with special attention paid to new floodwalls and a combination of dredging, new floodwalls, and levees.[258] Other options should also be investigated, such as reconstructing bridge openings and widening the area downstream of the McCully Bridge.[259]

In addition to structural modifications, other measures, such as a bridge blockage sensitivity analysis of floating debris in the Canal, was suggested.[260] All existing storm sewers should also be identified and their functionality verified.[261]

Some recommendations addressed flood control measures that did not involve physical action on the Canal itself. The Ala Wai Watershed Analysis Team proposed a study to determine the feasibility of diverting flood flows over a small portion of the Ala Wai Golf Course that would be reconfigured to serve as a temporary storm water detention basin. The COE and DLNR are currently investigating flood control actions for the Ala Wai Canal.[262]

Most of the flooding associated with Makiki Stream has been in the areas makai of King Street. To address this, modifications to the existing channel were designed in the 1970's but were never constructed. These designs included channel and box culvert alterations, bridge reconstructions, storm drain and utility line adjustments, street and private property adjustments and restorations, maintenance road construction, and studies to realign the stream.[263]

Additionally, modifications were recommended for the section of stream above King Street, including construction of a box culvert from King Street to Wilder Avenue, a concrete channel for Makiki Ditch from Wilder Avenue to Pensacola Street, and channel modifications above Wilder Avenue.[264] The DLNR began channel improvements on Makiki Ditch above Wilder Avenue in 1984.[265]

Flooding associated with Mānoa Stream are related to the inadequate capacity of the natural stream channel to accommodate flood flows.[266] One area where specific problems occur is near the Woodlawn Bridge. To address this, the DLNR

[257] State of Hawaii Department of Land and Natural Resources Division of Water and Land Development. (1994). *Ala Wai Canal Improvement Project Computer Modeling Study of Effects of a Proposed Submerged Dam on the Canal Water Quality*.
[258] State of Hawaii DLNR Land Division. (2001). *Planning Assistance to States Study Report, Ala Wai Flood Study, Island of O'ahu, Honolulu, Hawai'i*.
[259] Dashiell, Eugene P., AICP. Personal communications.
[260] Committee on Hydrology. (2001). *Ala Wai Canal, Honolulu, Hawai'i*.
[261] Ibid.
[262] DLNR, Engineering Division. Personal communications.
[263] Ibid.
[264] State of Hawaii DLNR DOWALD. (1983). *Flood Control and Flood Water Conservation in Hawaii Volume I: Floods and Flood Control*.
[265] Ibid.
[266] Department of the Army Pacific Ocean Division, COE. (1977). *Flood Hazard Study: Manoa Stream Basin Honolulu, Hawaii*.

proposed widening and deepening both the upstream and downstream approaches to the Woodlawn Bridge and designing the channel for the 100-year storm by increasing capacity to between 10,700 and 11,400 cfs.[267] As interim measures, crm walls to protect the embankments and a stream maintenance program were recommended.[268]

In addition to the Woodlawn area, the City recommended reinforced concrete channel modifications for the area above Lowrey Avenue and from Pawaina Street to Nipo Street.[269]

A 1995 DLNR study recommended the development of a linear park between the East Mānoa Road Bridge and the Woodlawn Drive Bridge.[270] This would allow for access for stream maintenance and prevent encroachment of development too close to the stream banks, which could alter drainage patterns. Additionally, a linear park would prevent development within the flood zone associated with Mānoa Stream. The University of Hawai'i also proposed a linear park for Mānoa Stream, although it was not for flood control purposes.[271]

Much of Pālolo Stream within the Urban District is modified. However, there are some indications of isolated flooding events in the lower reaches of the stream before its confluence with Mānoa Stream. To address this and associated erosion problems, it was recommended that a reinforced concrete channel be built from St. Louis Drive to Keanu Street.[272]

C.4 Public Health and Safety

The Ala Wai Canal Watershed is heavily used for recreational purposes, not only for activities in the Canal itself, but also for other activities in its mauka regions such as hiking and hunting. The tourist center of Waikīkī and its location in urban Honolulu make the recreational demand on the Ala Wai Canal one of the highest in the state.[273] The watershed provides for eight of nine recreational opportunities identified by the Hawai'i Stream Assessment and was ranked "Outstanding" by the Regional Committee on Recreational Resources.[274] However, recreational activities are affected by the condition of the watershed, often in the form of poor water quality. This causes potential health and safety risks to users of the Ala Wai Canal and watershed.[275]

[267] State of Hawaii DLNR DOWALD. (1995). *A Study to Alleviate Flooding of Manoa Stream (East Manoa Road Woodlawn Drive) Island of Oahu*.
[268] Ibid.
[269] State of Hawaii DLNR DOWALD. (1983). *Flood Control and Flood Water Conservation in Hawaii Volume I: Floods and Flood Control.*
[270] State of Hawaii DLNR DOWALD. (1995). *A Study to Alleviate Flooding of Manoa Stream (East Manoa Road Woodlawn Drive) Island of Oahu*.
[271] University of Hawaii at Manoa. (1978). *Urban Design: Manoa Stream Park*.
[272] State of Hawaii DLNR DOWALD. (1983). *Flood Control and Flood Water Conservation in Hawaii Volume I: Floods and Flood Control*.
[273] C&C DTS & DDC. (1998). *Ala Wai Canal Dredging Final Environmental Assessment*.
[274] State of Hawaii DLNR CWRM. (1990). *Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii's Stream Resources*.
[275] State of Hawaii Department of Land and Natural Resources Division of Water and Land Development. (1992). *Ala Wai Canal Improvement, Honolulu, Oahu, Hawaii, Executive Summary.*

C.4.1 Problems and Issues

The federal Clean Water Act of 1972 established the objective of eliminating the discharge of all pollutants by 1985. An interim goal was to make waters fishable and swimmable by 1983. While these deadlines have passed, local, state, and federal agencies are still striving to attain these objectives.

People sometimes discharge wastes, such as paints, into storm drains because they do not realize that their wastes wind up in streams and the Ala Wai Canal. The DOH and ENV provide warnings of these and other spills to recreational users. However, sometimes those warnings do not reach the users in a timely manner.

In 1993, a report concluded that water quality in the Ala Wai Canal was not acceptable for water-based recreational activities due to poor circulation and water flow.[276] An eight-week survey of canoe paddlers found "constant and recurring skin rashes among crews of paddlers at three different locations on the Ala Wai Canal," and a lower occurrence of skin problems in a control group.[277] However, the methodology of this study should be updated to provide a more appropriate control group.[278] Bacteria concentrations are not likely from human sewage contamination; instead, animals from both the conservation and urban districts are suspected of contributing bacteria.[279]

Leptospirosis is a bacterial disease whose symptoms may include fever, headache, chills, muscle aches, vomiting, diarrhea, and others, with severe cases resulting in death. While recent "hot spots" have included Maunawili, Kapena Falls, and Nu'uanu Stream, leptospirosis may be found in waters throughout the state.[280] Diagnoses of leptospirosis are difficult due to the wide range of symptoms that may occur, their similarity with the symptoms of other illnesses such as the flu, and the possibility of initial tests returning negative results. Clean Water Act objectives of "fishable and swimmable" waterways will not be met until this leptospirosis is eradicated or a cure or inoculation is developed.

Poor water quality also affects fish and other organisms in the water. Fish in streams and the Ala Wai Canal were found to be contaminated with pesticides and heavy metals, and a 1999 risk assessment showed that eating eight meals per month of whole fish from the Ala Wai Canal could cause unacceptable risk of lead poisoning in a child.[281] Despite this, a study done in 1997

[276] State of Hawaii DLNR DOWALD. (1993). *Environmental Assessment and Negative Declaration for the Ala Wai Canal Improvement, Honolulu, Oahu, Hawaii*.

[277] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I*.

[278] Dashiell, Eugene P., AICP. Personal communications.

[279] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I*.

[280] Helen Altonn. (2000, September 25). Leptospirosis Cases Dwindle, but Isles Rank First in Nation.

[281] U.S. COE, Honolulu Engineer District. (1999). *Ecosystem Restoration Ala Wai Canal Watershed, Honolulu, Hawai'i.*

concluded that 45% of Ala Wai Canal fishers consumed their catch.[282]

C.4.2 Data Gaps

There is no research to confirm or deny reports of staphylococcus and other skin infections attributed to contact with Ala Wai Canal waters. This makes it difficult to assess the actual health risk associated with participating in recreational activities in and around the Ala Wai Canal and to develop precautionary measures.

C.4.3 Recommended Actions

Recommendations that address health and safety focused primarily on the Ala Wai Canal, as it is a very heavily used recreational venue. There is a suspicion that contact with Ala Wai Canal waters increases the occurrence of skin rashes and infections.[283] Studies should be conducted to confirm or deny reports of staphylococcus and other skin infections. A previous study was conducted as a part of the 1998 Ala Wai Canal Watershed Water Quality Improvement Project, but since then, the methodology has been updated to produce more reliable results.[284] In the meantime, those who participate in recreational water sports in the Canal, such as canoe paddlers, should bathe with soap and water before and after practicing to reduce bacteria and virus counts on the skin.[285] To help facilitate this, the City and State should provide adequate showers, changing areas, and toilet facilities.[286]

Another biological contaminant of concern is leptospirosis in the streams. While leptospirosis has been reported on the four major islands, it is still difficult to detect. Leptospirosis eradication, treatment, and inoculation should be pursued, as well as rat eradication, as they act as vectors of the bacteria.[287]

Recreational fishing occurs in the Ala Wai Canal, but some fishermen also consume their catches, despite several studies that have found health risks involved in consuming organisms caught in the Canal. A 1998 study recommended that the DOH test fish in the Canal every five years for lead, dieldrin, chlordane, and other contaminants to monitor trends in concentrations.[288] The DOH already posts signs warning against ingesting organisms from the Canal.[289]

Additional warnings of sewage or other spills should immediately be given in a consistent, clear, and ubiquitous way. The DOH and ENV should be proactive in providing warnings along the Canal to paddlers and other water recreationists to

[282] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I.*
[283] Ibid.
[284] Dashiell, Eugene P. Dashiell, AICP. Personal communications.
[285] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I.*
[286] Ibid.
[287] Dashiell, Eugene P. Dashiell, AICP. Personal comunications.
[288] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I.*
[289] Warnings were recommended by State of Hawaii DLNR DOWALD. (1992). *A Management Plan for the Ala Wai Canal Watershed, Honolulu, Oahu, Hawaii.*

reduce the risk those people may expose themselves to after a spill.[290]

C.5 Biotic Environment

Resource data is very sparse for the biotic environment in general. There is little information on aquatic habitat statewide, and because data on specific streams in the Ala Wai Watershed were not available, general references to stream biota and aquatic habitat were used.

C.5.1 Problems and Issues

The upper watershed is a component of the Honolulu Watershed Forest Reserve and is includes such alien vegetation as *Miconia* and fountain grass.[291] Alien plants tend to out-compete native species and create a single storied monoculture that may increase erosion, infiltration, and groundwater recharge.[292] Some alien plants, such as *Miconia*, also have shallow root systems that are less effective in stabilizing soil than native species with deeper roots.[293]

Also of concern are alien animals, such as rats, that prey upon native birds. Additionally, the Conservation District of the Ala Wai Watershed supports a dense feral pig (*Sus scrofa*) population that has been present in the Koʻolau Mountains for approximately 165 years.[294] Pigs decimate the under story by eating young plants and overturning established plants, therefore increasing soil erosion. Pigs also create wallows where pools of water form, creating a breeding ground for mosquitoes that may be vectors for avian diseases, such as malaria. This problem is very difficult to control due to the pervasiveness of the pigs throughout the Conservation District.

"Hawaii's Native and Exotic Freshwater Animals," written by DLNR DAR biologists, describes the habitat and lifestyle of the aquatic fish and invertebrate species found in Hawaiʻi streams. Most native stream species such as the *oʻopu* favor clear, well-oxygenated water and streambeds with boulders, cobbles and gravel bottoms.[295] However, stream habitat has been altered over the years by human activities such as channelization. Channelization has been man's attempt to protect lives and property that have developed too close to streams. Increased flows, or freshets, during heavy rainfall periods are contained by these concrete structures whose purpose is to convey storm water as quickly as possible to the ocean. While channelization serves this purpose very well, it also eliminates habitat for native species. Not only do these modifications remove runs, riffles, and pools from the streambed, it also eliminates trees and other riparian vegetation that shade the

[290] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I.*
[291] Michael J. Leech, Oahu Invasive Species Committee. Email communication. (12 May 2003).
[292] Honolulu Board of Water Supply. *Water for Life: The History and Future of Water on Oʻahu*.
[293] Ibid.
[294] Koʻolau Mountains Watershed Partnership. (2002). *Koʻolau Mountains Watershed Partnership Management Plan*.
[295] State of Hawaii DLNR CWRM. (1990). *Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii's Stream Resources*.

stream and provide food.[296] Additionally, because the base flow of the stream is spread out over a wider channel, flows are shallower, slower, and warmer than conditions that native species favor.[297] Anecdotal evidence suggests that man-made structures have increased water temperatures and algal blooms and that alien species, such as channel catfish, have been moving upstream.[298]

Reduced flow is another problem for our streams. This may result from excessive groundwater pumping and stream diversions for such things as irrigation.[299] Channel hardening may also restrict groundwater from seeping into streams, thereby supplementing their flow. Reduced stream flows may result in habitat loss, warmer water temperatures, and lower dissolved oxygen levels.[300] The minimum stream flow required to sustain beneficial in-stream uses has not been determined for the Ala Wai System.

A 1975 study of the Ala Wai Canal biota found "a profuse and varied zooplankton fauna," five species of crustaceans, and twenty-one species of fish, eleven of which are considered of recreational importance.[301] However, a 1999 study concluded that the "muddy and contaminated substrate, coupled with the nutrient-rich and poorly circulated waters of the Canal, have created a less diverse ecosystem than that which was established prior to the 1960's. The degradation of water quality has favored alien species capable of surviving in a low dissolved oxygen, high sediment, aquatic environment. Live coral are non-existent, and reef fish, which normally should (and previously did) exist in abundance in both their juvenile and adult forms, do not thrive. Similarly, native migratory stream species, such as the native gobies and shrimp, which once utilized the Ala Wai Canal as part of their life-cycle and migratory pathway from the ocean to the mountains, are significantly reduced in abundance and diversity.[302]

Water pollution, as discussed earlier in this section, also affects stream, estuarine, and near-shore biota as well. Silt from excess runoff may smother benthic organisms and alter their habitat. Chemical pollutants, such as pesticides and other toxic materials, may result in fish kills when experienced in high enough concentrations. In lower quantities, these substances may accumulate in tissue and build up in higher and higher concentrations up the food chain; however, the effect of this long-term bio-accumulation of substances is not known.[303]

Nutrients may also have detrimental effects on the biology of a watershed. Excess nutrients may cause algal blooms that reduce oxygen in the water and increase turbidity,

[296] Yamamoto, M. N. & Tagawa, A. W. (2000). *Hawaii's Native and Exotic Freshwater Animals*.
[297] Ibid.
[298] UH Mānoa Department of Oceanography. Personal interview. 09 December 2002.
[299] Yamamoto, M. N. & Tagawa, A. W. (2000). *Hawaii's Native and Exotic Freshwater Animals*.
[300] Ibid.
[301] Miller, J. N. (1975). *Ecological Studies of the Biota of the Ala Wai Canal*.
[302] U.S. COE, Honolulu Engineer District. (1999). *Ecosystem Restoration Ala Wai Canal Watershed, Honolulu, Hawai'i*.
[303] Yamamoto, M. N. & Tagawa, A. W. (2000). *Hawaii's Native and Exotic Freshwater Animals*.

therefore reducing the depth at which sunlight penetrates into the water. Biological contaminants include pathogens and parasitic organisms that may infect *o'opu* and other native species.

Introduced species are a problem for native ecosystems for several reasons. Exotic species not only compete with natives for resources, such as food and habitat, they may also prey upon natives and some, like the Green Swordtail (*Xiphophorus helleri*), may transmit parasites that are known to infect *o'opu*.[304] Aliens also tend to thrive in human-modified aquatic and marine environments that have slow-moving, shallow water. Some introduced species, such as tilapia (*Oreochromis/Sarotherodon spp.*), also do well in sluggish, oxygen-poor environments while others, such as the Chinese Catfish or Puntat (*Clarias fuscus*), can actually breathe air, allowing them to out-compete native species that prefer cooler, fast-moving, oxygen-rich water.

C.5.2 Data Gaps

Management of the biotic resources of the watershed is difficult due to the lack of information on the plants, animals, and relationships between them and the physical habitat. Not only is it difficult to account for all of the variables that may be affecting a species or process, it may be very costly to conduct proper monitoring activities. Additionally, it may take years, decades, or longer to adequately assess some natural processes, which may also change over time.

Basic watershed research is needed to determine exactly what the problems are, and what their extent is. For example, while the Analysis team suspects that alien species are inferior to natives in stabilizing soils and promoting infiltration and stream flow, the functional differences between alien and native forests are not fully understood.[305] If alien species are as damaging to the environment as believed, studies to determine the effect that alien species controls have on water quality, forest health, sedimentation, and other qualities and functions would allow resource managers to determine the level of control that is the most cost effective in reaching our water quality objectives.[306] Other basic research needs include vegetative cover mapping, hydrology, and other data that would allow researchers to determine "normal" or baseline conditions for native forests, therefore making it possible to assess the severity of degradation caused by specific impacts.[307]

In some cases, specific data would be useful in developing improved management strategies for the undeveloped areas. Strong evidence on the destructiveness of feral pigs already exists, but additional data on their migratory movement and the level of disturbance they create would help in designing management efforts.[308] Other specific data could be useful in managing endangered 'elepaio and other native bird populations. It would be useful to quantify

[304] Ibid.

[305] DLNR-DOFAW. Personal interview. 23 January 03.
[306] Ibid.
[307] Ibid.
[308] Ibid.

forest types and the affinity of ‘elepaio and other native birds for the different types.[309] Additionally, further research into native bird biology, such as why some species are able to adapt to non-native forest, is needed.[310]

The biggest difficulty in managing Hawaii’s aquatic resources is that there is very little data. Little information exists on the “biology, larval life history, and genetic structure” of native amphidromous species, therefore making it difficult to develop management policies and practices.[311] Additionally, the effects of pollution on aquatic and marine biota are unknown, especially the long-term effects of continual exposure to particular contaminants.[312]

There is also little information on aquatic habitat, and no determination of the significance of estuaries and embayments to stream fauna.[313] The lack of data on aquatic habitat may be preventing the determination of minimum low flow standards that take into account habitat needs.[314]

C.5.3 Recommended Actions

Several actions were recommended to address the problems, issues, and data gaps related to the biotic resources of the watershed. The Ala Wai Watershed is highly impacted by development and alien species. Therefore, restorative efforts are difficult and costly, making threat control and mitigation more realistic.[315]

Actions should seek to reestablish natural watershed functions, such as habitat provision and sediment filtering, that may have been displaced, degraded, or eliminated.[316] Projects could be designed to accommodate multiple functions such as storm water retention and habitat for water birds, which are very adaptable and would likely make use of new habitat if it were available.[317] The urban areas are of greater concern than the undeveloped area due to their highly modified condition.

The KMWP received funds to implement the Ala Wai Watershed Mauka Restoration Project that will focus on reducing the feral pig population and invasive plant species, out-planting native plant species, monitoring the impacts of the project, and raising public awareness of watershed values and management.[318] Hunting was selected over fencing as a means to control pig populations due to the high cost that would be incurred by constructing and maintaining fence lines around such a large area.[319] The

[309] Ibid.
[310] Ibid.
[311] As cited in State of Hawaii DLNR CWRM. (1990). *Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii’s Stream Resources*.
[312] Yamamoto, M. N. & Tagawa, A. W. (2000). *Hawaii’s Native and Exotic Freshwater Animals*.
[313] State of Hawaii DLNR CWRM. (1990). *Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii’s Stream Resources*.
[314] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I*.
[315] Ko‘olau Mountains Watershed Partnership Personal interview. (06 February 2003).
[316] DLNR-DOFAW. Personal interview. (23 January 2003).
[317] Ibid.
[318] Ko‘olau Mountains Watershed Partnership. (2002). *Ko‘olau Mountains Watershed Partnership Management Plan*.
[319] Ko‘olau Mountains Watershed Partnership. Personal interview. (06 February 2003).

DLNR DOFAW conducted a hunting test project in response to pig activity that was impacting the trails and residences in Makiki. The project was successful in removing pigs and demonstrating the ability of hunting to occur near residential areas.[320] The KMWP project will expand on this hunting test project. These efforts to control pigs, remove invasive weeds, and reintroduce native species should be continued, even after this project is completed.

Predator control has been found to effectively increase native bird nesting success.[321] Rat control efforts should continue in an effort to rebuild native bird populations.

There is little information on stream biota and their habitat. Additional research is needed to better understand habitat needs and how to maintain, reestablish, or accommodate those needs. Stream low flow standards for habitat should be re-evaluated as a part of this effort.[322]

Streams have been highly modified in the Urban District and have also been invaded by alien species. Existing modifications have eliminated native species habitat and created conditions such as warm temperatures and very low stream flows. Aquatic habitat should be considered when designing stream modifications for flood control or bank stabilization. There are currently no guidelines to direct engineers in designing stream modifications that are sensitive to native species habitat.[323] Features that may be included are low-flow channels, unlined bottoms, meanders, pools, riffles, and maintenance.[324]

Stream bioassessments should be conducted to monitor bio-indicators of stream quality health such as *o'opu*[325] and to monitor the invasion of alien species.[326] A species inventory may also allow for the identification of habitat restoration actions.[327] The ENV has already completed stream bioassessments for Hālawa and Moanalua Streams.[328] Bioassessment protocol may follow these examples, or be modified to better suit streams in the Ala Wai watershed.

C.6 Overall Watershed

Overall watershed issues are those that have multiple purposes and/or jurisdictions. These topics deal mainly with maintenance and research needs on watershed functions and dynamics.

C.6.1 Problems and Issues

Management and maintenance of the streams and waterways in the Ala Wai

[320] DLNR-DOFAW. Personal interview. (23January 2003).
[321] Ibid.
[322] Dashiell, Eugene P., AICP. Personal communications.
[323] DLNR-DAR. Personal interview. (27February 2003).
[324] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I.*
[325] Ibid.
[326] Agency Study Group. Personal consultation. (23 November 2003).
[327] Ibid.
[328] C&C ENV. Personal interview. (21 January 2003).

Watershed is difficult due to the numerous public and private entities that have jurisdiction over different geographic locations. Public maintenance jurisdiction of the canals and streams lie with the DLNR, ENV, and DPR. Urban streams also present the difficulty of private ownership of stream banks and, in some cases, to the middle of the stream itself.[329] This prevents state agencies from planning holistically for stream bank maintenance, debris removal, and erosion and flood control.

C.6.2 Data Gaps

There is a lack of information on watersheds in Hawai‘i. While many processes are being investigated, most research has been done on the U.S. mainland and may not be applicable to Hawai‘i where watersheds are typically shorter, steeper, and have smaller drainages.[330] Therefore, watershed quality is poorly identified in Hawai‘i[331] and site specific data is sorely lacking. Specific data needs include tributary stream discharge rates[332] and the sources and proportions of many pollutants.[333] Data deficiencies are the result of data collected at widely different times, old data, and inconsistencies in reporting.[334]

C.6.3 Recommended Actions

Multiple agency and private owner jurisdiction over stream courses creates inconsistent and inadequate maintenance conditions. Stream corridor preservation would provide for multiple functions, including maintenance, flood control, bank stabilization, and habitat protection. Possible methods may include obtaining stream easements from private owners and consolidating agency jurisdiction.[335]

Data on watersheds in Hawai‘i is incomplete, largely due to the large scale of issues and area, the interconnectedness of processes and organisms, the long time-frame required to observe changes, and the expense in research. A watershed should be designated to provide a venue for researching issues that will help to shape management decisions. A partnership could be convened to organize and administer research activities. The Ala Wai Watershed could provide such a venue in that it includes several research entities such as the University of Hawai‘i at Mānoa, the Lyon Arboretum, The Nature Center, and the Waikīkī Aquarium. This watershed is also highly impacted and could provide opportunities to evaluate restoration efforts and may not pose as much of a threat to sensitive ecosystems as other watersheds.

[329] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I.*
[330] Scheuler, T., Center for Watershed Protection. Presentation. (22 August 2002) *The Impact of Land Development of Hawaiian Streams.*
[331] State of Hawaii DLNR CWRM. (1990). *Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii's Stream Resources*
[332] Laws, E., et. al. (1993). Hypereutrophication of the Ala Wai Canal: Prospects for Cleanup.
[333] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I.*
[334] State of Hawaii DLNR CWRM. (1990). *Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii's Stream Resources.*
[335] State of Hawaii DOH. (1998). *Ala Wai Canal Watershed Water Quality Improvement Project Management and Implementation Plan-Volume I.*

Possible research that could occur through the partnership might cover a wide range of topics and include determining runoff and sediment sources and quantities, pollution sources, and the impacts of improvement actions. Collaborative efforts, where multiple analyses are done on the same samples for heavy metals, bacteria, nutrients, sediments, organics, and other parameters, could also occur so a more complete picture might be formed.[336]

[336] UH Mānoa Department of Oceanography. Personal interview. (09 December 2002).

Appendix D: Reference Database and Literature Abstracts

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Appendix D
Reference Database and Literature Abstracts

A reference database was created to log all of the documents that were found with specific references to the Ala Wai Watershed. The following is the list of those documents that were included in the reference database. This list differs from the list in Section 5 of this report in that not all of the documents in this section were cited in the text. Additionally, some of the references listed in Section 5 provided general watershed information and may therefore not be included in this database.

Several documents from the reference database were selected as being critical to understanding the issues, problems, and solutions within the Ala Wai Watershed. Abstracts of these documents were written to allow users of this report to determine the value of that document to their own efforts without actually finding and reading the report. If the reader determines that a particular report would be useful, he or she might then choose to locate and read the document himself or herself.

Ala Wai Watershed References (Sorted by ID #)

ID	Description	Sponsoring Agency	Job No/Report No	Author	Month	Year	DLNR Copies	Corps Copies
1	Post Flood Report Storm of 17-18 December 1967	DLNR	Circular C47	COE	Oct	1968	1	2
2	Study for the Ala Wai Canal Footbridge at University Avenue	CC	-	Business Investment Ltd.	Dec	1969	1	2
3	Descriptive Study of the Physical Oceanography of the Ala Wai Canal	UH	HIG-71-7/Report No. 26	F.I. Gonzalez	May	1971	1	2
4	Some Chlorinated Pesticide Residues in the Water, Sediment, and Selected Biota in the Ala Wai Canal, a Tropical Estuary on Oahu	UH	Report No. 28	C.D. Shultz	Sep	1971	1	1
5	Ecological Studies of the Biota of the Ala Wai Canal	UH	HIG-75-8/Report No. 32	J. Miller	Mar	1975	1	2
6	Final Environmental Impact Statement for Makiki Stream Flood Control, Unit I Improvement, South King Street to Ala Wai Canal, Honolulu	-	-	E.C.I.	Apr	1975	1	1
7	Primary Production in the Ala Wai Canal, A Small Tropical Estuary	UH/DLNR	-	C.L. Harris	Mar	1975	1	2
8	Improvement of the Ala Wai Canal, Final Report	UH	-	J. Miller, Cox	Dec	1976	1	1
9	Manoa Stream Park Conceptual Plan for UH	UH	-	-	-	1976		
10	Proposed Modification of the Ala Wai Canal, a Small Tropical Estuary	UH	HIG-75-7	Miller, Chave	-	1976	1	2
11	Suburface Geology of Waikiki, Moilili and Kakaako with Engineering Application	UH	-	C.C.Ferrall Jr.	-	1976		
12	Neg. Declaration and Environmental Impact Statement for Ala Wai Dredging	DLNR	-	Sunn, Low, Tom & Hara	-	1977	1	2
13	Preliminary Engineering Report for Dredging Ala Wai Canal	DLNR	-	Sunn, Low, Tom & Hara	-	1977	1	1

ID	Description	Sponsoring Agency	Job No/Report No	Author	Month	Year	DLNR Copies	Corps Copies
14	The Story of Waikiki and the "Reclamation" Project	UH	-	B.S. Nakamura	-	1979		
15	Rpt. to the 14th State Leg, 1987 Session on House Concurrent Res no. 206, 13th. State Leg requesting the State DOT to conduct a use audit of the Ala Wai Canal and to study the impacts of any future mix of commercial and recreational activities	DOT	-	DOT	Dec	1986	1	2
16	Waikiki Tomorrow Report	CC	-	-	-	1989		
17	The Ala Wai Canal	UH	-	S.A. Finstick	-	1990	1	1
18	The Watershed of the Ala Wai Canal: We are the Pollution and the Problem	-	-	M.M. Hufschmidt	-	1990		1
19	Hypereutrophication of the Ala Wai Canal: Prospects for Cleanup (Unpublished Manuscript)	UH	-	Laws, Doliente, Hiayama, Hokama, Kim, Minami, Morales	-	1993	1	1
20	Research Data on Lead Concentrations in the Ala Wai Canal Sediments	UH	-	Decarlo	-	1991		
21	The Ala Wai Canal: from Wetlands to World-Famous Waikiki	-	-	Lum & Cox	Jul	1991	1	2
22	A Maintenance Plan for the Ala Wai Canal	DLNR	31-OL-I/R-89d	Ed Noda & Assoc, Inc	Oct	1992	1	2
23	A Management Plan for the Ala Wai Canal Watershed	DLNR	31-OL-I/R-89c	Ed Noda & Assoc, Inc	Oct	1992	1	2
24	Ala Wai Canal Improvement Project: Analysis of Alternatives to Flush the Canal (Included in the Appendix of Reference # 26)	DLNR	-	Makai Ocean Engineering, Inc.	Aug	1992	1	2
25	Ala Wai Canal Improvement, Executive Summary	DLNR	R-89a	Ed Noda & Assoc, Inc	Oct	1992	1	2
26	Ala Wai Canal Improvement, Feasibility Report	DLNR	31-OL-I/R-89b	Ed Noda & Assoc, Inc	Oct	1992	1	2

ID	Description	Sponsoring Agency	Job No/Report No	Author	Month	Year	DLNR Copies	Corps Copies
27	Engineering Feasibility of Deep Saltwater Supply Wells to Increase Circulation in the Ala Wai Canal (Included in Appendix of Reference # 26)	DLNR	-	Water Resource Engineering (Tom Nance)	Sep	1992	1	1
28	Vision for Waikiki 2020 (Video Tape located at Hamilton Library)	Private	-	-	-	1992	n/a	n/a
29	Waikiki Master Plan	CC	-	-	-	1992	1	1
30	Water Quality Studies for the Ala Wai Canal (Included in Appendix of References #26)	DLNR	-	OI Consultants Inc	Aug	1992	1	1
31	Environmental Assessment and Negative Declaration for the Ala Wai Canal Improvement	DLNR	31-OL-I	Ed Noda & Assoc, Inc	Apr	1993	1	2
32	Revised Total Maximum Daily Load Estimates for Six Water Quality Limited Segments, Island of Oahu, Hawaii	DOH	-	William Freeman Pacific Environmental Research	Nov	1993	1	2
33	Ala Wai Canal Improvement Project, Computer Modeling Study of Effects of Proposed Submerged Dam on the Canal Water Quality	DLNR	31-OL-I/R-89g	Ed Noda & Assoc, Inc	Oct	1994	1	2
34	Ala Wai Canal Improvement Project, Storm Water Capacity	DLNR	31-OL-I	Ed Noda & Assoc, Inc	Jan	1994	1	2
35	Ala Wai Canal Improvement Project, Test Boring and Monitoring Well Program, Ala Wai Golf Course	DLNR	31-OL-I/R-89e	Ed Noda & Assoc, Inc	Jul	1994	1	2
36	Ala Wai Canal Improvement Project, Test Boring and Monitoring Well Program, Kapahulu Avenue (Zoo)	DLNR	31-OL-I/R-89f	Ed Noda & Assoc, Inc	Sep	1994	1	2
37	A Study to Alleviate Flooding of Manoa Stream (East Manoa Road Woodlawn Drive) Island of Oahu	DLNR	-	-	-	1995	1	2
38	Ala Wai Canal Architectural and Planning Charette Project Report	CC	-	-	April	1995	1	2
39	Ala Wai Canal Improvement Project, Well Drilling, Installation and Testing Program, Honolulu Zoo	DLNR	31-OL-I/R-89h	Ed Noda & Assoc, Inc	Oct	1995	1	2

ID	Description	Sponsoring Agency	Job No/Report No	Author	Month	Year	DLNR Copies	Corps Copies
40	Scientific Studies and History of the Ala Wai Canal, an Artificial Tropical Estuary in Honolulu	UH	-	Glenn & McMurtry	-	1995	1	2
41	Consent Decree Project Agreement, Ala Wai Canal Watershed Water Quality Improvement Project (Included in appendix of Reference # 52)	CC/DOH	-	-	-	1995	1	1
42	Draft Preliminary Conceptual Study Manoa-Palolo Drainage Canal Through the Ala Wai Golf Course	CC	-	-	-	1996		
43	Ala Wai Canal Dredging Conceptual Design and Environmental Assessment Dredge Sediment Characterization Tier II Field Trip Report #2 & Tier II Laboratory and Data Report #2	DLNR	Deliv. Nos. 2.4.2.2 & 2.4.3.2	Belt Collins	Dec	1997	1	1
44	Ala Wai Canal Watershed Water Quality Plan - Volume 1	DLNR	-	-	Oct	1997		
45	Benefit/Cost Analysis: Manoa Stream Restoration and Bike Path Project (Included in appendix of of Reference # 52)	DOH	-	UH Class Project: Prof Gary Vieth	-	1997	1	1
46	Fishers Consuming Catch at the Ala Wai Canal Nov.1997 - Jan. 1998 (Included in appendix of Reference # 52)	DOH	-	Lisa Chau; Advisors Eugene Dashiell, Jackie Miller	Nov	1997	1	1
47	Fishing Practices of the Ala Wai Canal	DOH	-	Lisa Chau; Advisors Eugene Dashiell, Jackie Miller	Aug	1997	1	1
48	Sources of Lead into the Watershed of the Ala Wai Canal from Abandoned Automotive Batteries (Included in appendix of Reference # 52)	DOH	-	Vance Igawa	Nov	1997	1	1
49	Water Quality Monitoring Report-May 1996-97 Ala Wai Canal Watershed Project	DOH	-	DOH (Clean Water Branch)	Dec	1997	1	1
50	Ala Wai Canal Dredging Final EA	DLNR	STP-0300(038)	Belt Collins	Oct	1998	1	1
51	Ala Wai Canal Watershed Water Quality Improvement Project - Management and Implementation Plan - Volume 1	CC	-	Eugene Dashiell	Apr	1998	1	1

ID	Description	Sponsoring Agency	Job No/Report No	Author	Month	Year	DLNR Copies	Corps Copies
52	Ala Wai Canal Watershed Water Quality Improvement Project - Management and Implementation Plan - Volume 2 (Technical Appendices)	CC	-	Eugene Dashiell	Apr	1998	1	1
53	Ala Wai Promenade Phase III, Final Environmental Assessment and Finding of No Significant Impact (FONSI)	CC	-	-	-	1998	1	2
54	Botanical Resources Assessment, Ala Wai Canal Dredging Project (Included in Appendix of Reference # 50)	DLNR	-	Char & Associates	Mar	1998	1	1
55	Draft Screening Risk Evaluation for Consumption of Fish from the Ala Wai Canal (Included in appendix of Refefence # 52)	DOH	-	Barbara Brooks, Gina Ling (DOH)	Apr	1998	1	1
56	Faunal (Bird and Mammal) Field Survey of Property Involved in the Ala Wai Canal Dredging Project, Oahu (Included in Appendix of Reference # 50)	DLNR	-	Phillip L. Bruner	Mar	1998	1	1
57	Primary Urban Center Plan	CC	-	-	-	1998		
58	Recreation Report to the Ala Wai Canal Dredging Final EA (Included in Appendix of Reference # 50)	DLNR		Belt Collins	Oct	1998	1	1
59	Survey and Evaluation of the Existing Built Environment and Assessment of Impacts of the Proposed Ala Wai Canal Dredging Project on Historic Architectural Resources (Included in Appendix of Reference # 50)	DLNR		Mason Architects, Inc	Mar	1998	1	1
60	Waikiki Planning & Program Guide	CC	-	-	-	1998		
61	Welfare of Paddlers at the Ala Wai Canal (Included in Appendix of Reference # 52)	DOH	-	Kerri Cummins; Advisor: Eugene Dashiell	Feb	1998	1	1
62	Ala Wai Canal Flushing System, Ph I Oahu Re-evaluate and Verify Computer Modeling Simulations Performed During the Feasibility Study Report R-89b dated October 1992	DLNR	25-OW-E/R-113a	Ed Noda & Assoc, Inc	Sep	1999	1	2
63	Ecosystem Restoration Ala Wai Canal Watershed (General Investigation Report)	COE	-	Eugene Dashiell	Aug	1999	1	1

ID	Description	Sponsoring Agency	Job No/Report No	Author	Month	Year	DLNR Copies	Corps Copies
64	Evaluation of Seawalls Ala Wai Canal Dreding Project	DLNR	-	Geolabs / Shigemura, Lau, Sakanashi, Higuchi & Assoc. Inc	Aug	1999	1	2
65	Tier III Field and Data Report	DLNR	-	Belt Collins	Dec	1999	1	2
66	Hawaii Stream Assessment	CWRM	-	National Park Service	Dec	1990	1	1
67	Total Maximum Daily Loads for Ala Wai Canal (Total Nitrogen, Total Phosphorous)	DOH	-	EPA/DOH	May	2001	1	2
68	Water Quality Data for Ala Wai Watershed	DOH	-	-	-	-	1	2
69	Retrospective Analysis of Anthropogenic Inputs of Lead and Other Heavy Metals to the Hawaiian Sedimentary Environment (Applied Organic Metallic Chemistry)	UH	-	DeCarlo/Spencer	-	1997	1	2
70	Trace Elements in the Aquatic Environment of Hawaii	UH	-	DeCarlo/Spencer	-	-	1	2
71	Historical Chronology of the Ala Wai Canal	DLNR	-	DLNR	-	-	1	2
72	Ala Wai Miscellaneous Article Clippings	-	-	Misc	-	-	1	2
73	Engineering Report of Alternative Structural Schemes for Makiki Stream Flood Control Unit I	CC	-	Chung Dho Ahn and Ass., Inc	Mar	1975	1	2
74	Ala Wai Dredging Conceptual Design and Environmental Assessment-Sources of Contaminants/Potential Pollutants	DLNR	Deliverable No. 4.1.2	Belt Collins	June	1998	1	2
75	Ala Wai Dredging Conceptual Design and Environmental Assessment-Existing Storm Water Runoff Data	DLNR	Deliverable No. 4.1.3	Belt Collins	June	1998	1	2
76	National Biological Treatment of Dredged Sediments From the Ala Wai Canal for Use in Land Reclamation	DLNR	-	Partners in Development and Strategies Hawaii	Mar	2000	1	2

ID	Description	Sponsoring Agency	Job No/Report No	Author	Month	Year	DLNR Copies	Corps Copies
77	Draft EA - Ala Wai Canal Watershed Project, Manoa Valley District Park Streambank Improvement	CC	-	Wil Chee-Planning, Inc.	Aug	2000	1	2
78	Statewide Marine Research and Surveys. Effects of Experimental Management on Recreational Fishing in the Ala Wai Canal	-	F-17-R	-	-	-		
79	Study Areas II and VI-C Water Quality Analysis and EA	Natl. Com. On Water Quality	-	Tetra Tech, Inc	Feb	1976	1	2
80	Final EIS Improvements at Ala Wai Boat Harbor	DOT	-	L. Raymond	Aug	1971	1	1
81	Climatic Controls on Cyclic Carbonate Sedimentation	UH	-	R. Sivaramakrishnan	-	1995		
82	Depositional History of Mercury in Sediments	UH	-	-	-	1992		
83	Screening of Ala Wai Canal Waters & Sediments	UH	-	-	-	1992		
84	News Release	UH	-	-	-	-	1	1
85	Final EIS for Makiki	UH	-	-	-	1975		
86	Mercury Cycling in a Small Hawaiian Estuary	UH	-	Samuel Luoma	-	1974	1	1
87	Aspects of the Dynamics Mercury Cycling in a	UH	-	Samuel Luoma	-	1974		
88	Waikiki Convention Center at the Ala Wai Gateway	UH	-	Myers Grays	-	1992		
89	Updated Information for the Ala Wai Community on	UH	-	-	-	1992		

ID	Description	Sponsoring Agency	Job No/Report No	Author	Month	Year	DLNR Copies	Corps Copies
90	Ala Wai Plaza Newsletter	UH	-	-	-	1991		
91	Ala Wai Canal Watershed Improvement Project, Palolo Watershed, Stream Diversion Permit App. For Loi Restoration at Anuenue School in Palolo	Anuenue School	-	Traver Carroll, AICP	-	1999	1	2
92	Flood Hazard Study, Manoa Stream Basin	COE	-	M&E Pacific	-	1977	1	
93	Preliminary Report, Palolo Stream Flood Control	CC	-	Urban Eng Consultant	-	1983	1	1
94	Report of the Meeting for the Committee on Hydrology Ala Wai Canal, Honolulu	Committee on Hydrology	-	Committee on Hydrology	-	2001	1	1
95	Ala Wai Canal Dredging	DLNR	Deliverable No. 5.1.1	Belt Collins	-	1998	1	2
96	Ala Wai Canal Dredging Conceptual Design and EA - Dredge Sediment and Characterization, Final Tier II Sampling and Analysis Plan # 2	DLNR	Deliverable No. 2.4.1.3	Belt Collins	-	1998	1	2
97	Ala Wai Canal Dredging Conceptual Design and EA Upland Disposal Study Summary	DLNR	Deliverable No. 9.1.1	Belt Collins	-	1998	1	1
98	Ala Wai Canal Dredging Conceptual Design and Environmental Assessment Upland Disposal Testing and Report	DLNR	Deliverable No. 9.2.1	Belt Collins	-	1998	1	1
99	Ala Wai Canal Dredging Conceptual Design and EA - Dredge Sediment Characterization, Tier II Field Trip Report and Tier II Laboratory and Data Report	DLNR	Deliv Nos. 2.4.2.1 & 2.4.3.1	Belt Collins	-	1997	1	1
100	Ala Wai Canal Watershed Improvement Project-Final Report	DOH	-	Clyde B. Morita	June	1999	1	1
101	Testimony in Support of Senate Bill 1401 Relating to the Ala Wai Watershed	Senate	-	Taniguchi & Hanabusa	March	2001	1	1
102	Manoa Stream Maintenance Plan: Kahaloa Drive to Woodlawn Drive	CC	-	-	April	1999	1	1

ID	Description	Sponsoring Agency	Job No/Report No	Author	Month	Year	DLNR Copies	Corps Copies
103	Examination of Some Chlorinated Pesticide Residuals in the Water, Sediment and Selected Biota in Ala Wai Canal, Oahu, Hawaii	-	-	Shultz, Cynthia Dawn	-	1971		
104	Reef and Inshore Game Fish Management Research.Pre-Management Study of Ala Wai Canal, Honolulu	-	F-5-R	-	-	1969		
105	Statewide Dingell-Johnson Program. Pre-management Study of the Ala Wai Canal, Honolulu	-	F-9	-	-	-		
106	Statewide Silt Basin Investigation	DLNR	Report No. R66	Fukunaga and Associates	Dec	1980	1	1
107	McCully Street Bridge Plans on CD (TIF Files)	DPW		DPW	Oct	1956	1	1
108	Planning Assistance to States Study Report, Ala Wai Flood Study, Honolulu, Hawaii (Draft)	DLNR		COE	Oct	2001	1	1
109	Environmental Assessment, Ala Wai Canal Golf Course Clubhouse	CC		Design Partners,Inc.	April	1988	1	1
110	Project Management Plan, Ala Wai Canal Improvement Project	DLNR		CC	July	1995	1	1
111	Ala Wai Canal Dredging Conceptual Design and Environmental Assessment of Dredge Volumes & Limits	DLNR	Deliverable 3.2.2		Feb	1998	1	1
112	Draft Toward a Management Plan for the Ala Wai Canal Watershed	DLNR		Ed Noda & Assoc, Inc	Sept	1992	1	1
113	Ala Wai Canal Dredging, Conceptual Design and Environmental Assessment; Definition and Evaluation of Alternatives	DLNR	Deliverable 4.2.1	Ed Noda & Assoc, Inc	Feb	1998	1	1
114	Estuaries and Your Coastal Watershed	EPA			July	1998	1	1
115	School Based Volunteer Water Quality Monitoring Project in the Ala Wai Canal							1

ID	Description	Sponsoring Agency	Job No/Report No	Author	Month	Year	DLNR Copies	Corps Copies
116	Negative Declaration and Environmental Impact Statement for the Proposed Ala Wai Dredging, Oahu, Hawaii	DLNR		Sunn, Low, Tom & Hara	May	1977	1	1
117	Ala Wai Canal Dredging Conceptual Design and Environmental Assessment, Dredge Sediment Characterization Final Tier II Laboratory and Data Report	DLNR	Deliverable 2.4.3.1r	Belt Collins	Jan	1998	1	1
118	Recapturing the Magic of Waikiki	CC/DLNR			Dec	1999	1	1
119	Final Environmental Statement, Harbor Maintenance Dredging	US		COE	Sep	1975	1	1
120	Tier III Sampling and Analysis Plan, Ala Wai Canal Dredging Final Design and Permitting Dredge Sediment Characterization	DLNR		Belt Collins/MEC Analytical Systems, Inc	Jul	1999		
121	Executive Orders Relating to the State Lands along the Ala Wai Canal	DLNR			Oct	1996	1	1
122	Geochemistry, Mineralogy, and Stable Isotopic Results from Ala Wai Estuarine Sediments: Records of Hypereutrophication and Abiotic Whitings	UH		Glenn, Rajan, McMurtry, Benaman		1995	1	1
123	Modeling Sediment Accumulation and Soil Erosion with Cs and Pb in the Ala Wai Canal and Central Honolulu Watershed, Hawaii	UH		Glenn, McMurtry, Snidvongs		1995	1	1
124	Heavy Metal Anomalies in Coastal Sediments of Oahu, Hawaii	UH		McMurtry,Wiltshire, Kauahikaua		1995	1	1
125	Records of Lead and Other Heavy Metal Inputs to Sediments of the Ala Wai Canal, Oahu Hawaii	UH		De Carlo, Spencer		1995	1	1
126	Preliminary Engineering Report for Dredging Ala Wai Canal	DLNR	9-OF-8	Sunn, Low, Tom & Hara	May	1977	1	1
127	Mineral Assemblages of the sediments of the Ala Wai Canal and its Drainage Basins	UH		Fan, Ng & Remular	Oct	1995	1	
128	Ala Wai Canal Watershed Iimprovement Project			Gene Dashiell			1	1

ID	Description	Sponsoring Agency	Job No/Report No	Author	Month	Year	DLNR Copies	Corps Copies
129	Water Quality Monitoring Report-May 1996-1997. Ala Wai Canal Watershed Project	DOH			Dec	1997	1	1
130	Draft EA Manoa Villages Association	Manoa Village Association			Oct	1997	1	1
131	Draft Honolulu Bicycle Master Plan	C&C		Helbert Hastert & Fee Planners	July	1998		
132	Information on Spills into the Ala Wai Canal	DOH		DOH	Various		1	1
133	Misc Pictures of Ala Wai on CD	DLNR		DLNR	Various		1	1
134	Ala Wai Dredging Project Contract Specifications and Plans	DLNR	9-OF-W	Belt Collins	May	2000		1
135	EPA's Impaired Water Bodies List (303(d))	DOH		EPA	Nov	2001	1	1
136	Distribution of Organic Carbon in Bed Sediments of Manoa Stream, Oahu, Hawaii			Sutherland, Ross A.	Nov	1998		
137	Gas Chromtaographic and Mass Spectrometric Identification of Chlordane Components in Fish from Manoa Stream, Hawaii			Ribick, Michael A. and Jim Zajicek		1983		
200	Sites of Oahu			Sterling, Elspeth P. and Catherine P. Summers		1978		
201	Native Planters In Old Hawaii, Their Life, Lore, and Environment			Handy, E.S. Craighill and Elizabeth Kawena Pukui		1972		
202	Waikiki			Kanahele, George				
203	Hawaii's Native and Exotic Freshwater Animals			Yamamoto, Mike N. and Tagawa, Annette W.		2000		
204	Waikiki 100BC to 1900AD An Untold Story			Kanahele, George S.		1995		

ID	Description	Sponsoring Agency	Job No/Report No	Author	Month	Year	DLNR Copies	Corps Copies
205	Subsurface Archaeological Reconnaissance Survey and Histroical Research at Fort DeRussy, Waikiki, Island of Oahu, Hawaii	COE	DACA(NAF)83-89-R-0018	Davis, Bartell D.	Dec	1989		
206	Hawaii's Native and Exotic Freshwater Animals			Yamamoto, Mike N. and Annette W. Tagawa	Nov	2000		
207	Flood Control and Flood Water Conservation in Hawaii, Volume I Floods and Flood Control	DLNR	Circular C92		Sep	1983		
208	Flood Control and Flood Water Conservation in Hawaii, Volume II General Flood Control Plan for Hawaii	DLNR	Circular C93		Sep	1983		
209	Flood Control and Flood Water Conservation in Hawaii, Volume III Agencies and Legislation	DLNR	Circular C94		May	1994		
210	Urban Flood Control Study Final Reconnaissance Report	COE			May	1992		
211	Spatial and Temporal Variability of Trace Element Concentrations in an Urban Subtropical Watershed, Honolulu, Hawaii			DeCarlo, Eric H. and Stephen S. Anthony		2002		
212	Geology and Ground-Water Resources of the Manoa-Makiki District	BWS		Wentworth, Chester K.		1940		
213	Geology and Ground-Water Resources of the Palolo-Waialae District	BWS		Wenthworth, Chester K.		1938		
214	Urban Design: Manoa Stream Park	University of Hawaii		Architects Hawaii	Apr	1978		
215	Hawaii Trail Analysis: Survey & Risk Management Data Profile	DLNR		UHM Dept. of Urban & Regional Planning Practicum 751	Mar	2001		
216	Statewide Capital Improvements Program, Flood Control Projects	DLNR	Report R98	Fukunaga & Associates, Inc.	Apr	1994		
217	Feasibility Report for Retrofitting Existing Structural Best Management Practices	ENV		ENV	Oct	2000		

ID	Description	Sponsoring Agency	Job No/Report No	Author	Month	Year	DLNR Copies	Corps Copies
218	Action Plan to Implement Feasible Opportunities for Existing Structural BMPs	ENV		ENV	Oct	2001		
219	Fiscal Year 2002 End-of-Year Report for the City and County of Honolulu Municipal Separate Storm Sewer System NPDES Permit No. HI 0021229 Covering the Period July 1, 2001 - June 30, 2002	ENV		ENV	Oct	2002		
220	Urban Runoff in Manoa and Palolo Streams			Ikeno, Debra E.	Dec	1996		
221	Effects of Alien Rodent Control on Demography of the O'ahu 'Elepaio, an Endangered Hawaiian Forest Bird			Vanderwerf, Eric A. & David G. Smith		2000		
222	Critical Habitat for the O'ahu 'Elepaio	USFWS						
223	History of the Marine Structures on Waikiki Beach and their Effects Upon the Beach			Crane, Jerald K.		1972		
224	Stream Channel Modification in Hawaii. Part A: Statewide Inventory of Streams; Habitat Factors and Associated Biota	USFWS	:ontract No. 14-16-0008-119	Timbol Amadeo S. & John Maciolek	Apr	1978		
225	Annual Storm Water Quality Monitoring Report for Fiscal Year 2002 July 1, 2001 - June 30, 2002	ENV		ENV	Sep	2002		
226	The Efficiency of Storm Drain Filters in Removing Pollutants from Urban Road Runoff, Phase I Report	ENV		DeCarlo, Eric H.	Sep	2001		
227	Hawaii rail Analysis Survey and Risk Management Data Profile	DOH/DLNR		University of Hawaii at Manoa, Practicum 751	Mar	2001		
228	The Hawaii Stream Bioassessment Protocol Version 3.01	University of Hawaii		Kido, Michael H.	Jan	2002		
229	Biocriteria for Assessing the Biological Integrity of Hawaii's Streams	University of Hawaii		Kido, Michael H. and Gordon . Smith	Jul	1997		
230	Makiki Stream Realignment, Honolulu, Oahu, Hawaii	DLNR	'79 Item K-4 & Act 300, SLH			1981		

ID	Description	Sponsoring Agency	Job No/Report No	Author	Month	Year	DLNR Copies	Corps Copies
231	A Comparitive Study of Fish and Crustacean Populations in Altered and Unaltered Hawaiian Streams	University of Hawaii		Norton, Susan E.	Dec	1977		
232	Hawaii Stream Assessment Aquatic Resources Volume I: Methods, Bibliography & Data Sheets for Kauai & Oahu	DLNR & UH Cooperative National Park Resources Studies Unit		Hawaii Heritage Program, TNCH	May	1990		
233	Description of the Ala Wai Canal Watershed Model					1994		
234	Wastewater Fine Bubble Product Information			Air Diffusion Systems, A John Hinde Co.		2002		
235	2002 List of Impaired Waters in Hawaii Final, Prepared Under Clean Water Act Section 303(d)	DOH		Henerson, Katina and June Harrigan	Dec	2002		
236	History and Status of the Moiliili Karst, Hawaii			Halliday, William R.	Dec	1998		
237	Koolau Mountains Watershed Partnership Management Plan	Koolau Mountains Watershed Partnership		Sumiye, Jason	Jan	2002		
238	Mamala Bay Study Final Report	Mamala Bay Study Commission		Mamala Bay Study Commission	Apr	1996		

Reference No.:	1
Title:	Post Flood Report, Storm of 17-18 December 1967, Islands of Kauai and Oahu, Circular C47
Prepared By:	U.S. Department of the Army, Honolulu District, Corps of Engineers
Prepared For:	State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development
Date of Publication:	October 1968

Report Summary

Objective: To briefly describe the high winds on the island of Kauaʻi on December 17, 1967, and the storm, flood conditions, and damages on the island of Oʻahu on December 18, 1967. Precipitation and stream flow data were also included in the report.

Relevance to Ala Wai System or Watersheds in General: On December 17, 1967, torrential rains started falling on Oʻahu. Pālolo Valley, Waiʻalae-Kāhala, Niu Valley, and Waimānalo suffered extensive flood damages.

Findings: Niu Valley was hit hardest by the cloudburst. Pālolo Valley (Station 718), recorded 10.06 inches of rain between midnight and 0800 hours, with 2.4 inches from 0400 to 0500 hours; the 24-hour total was 10.88. Wilhelmina Rise (Station 721) recorded 9.62 inches, the highest 24-hour rainfall since its establishment in 1927. Similar measurements were recorded by areas included in the Ala Wai System: Mānoa – 9.43, University of Hawaiʻi – 9.5, Mānoa Tunnel 2 – 10.42. Pālolo Stream near Honolulu registered a record high stream flow discharge of approximately 4,300 cubic feet per second (cfs) and the Mānoa-Pālolo Drainage Canal at Mōʻiliʻili discharged 10,100 cfs. The Ala Wai Canal overflowed at the confluence with Mānoa-Pālolo Drainage Canal. The flow of the flood waters from Mānoa and Pālolo Streams, affected by the incoming high tide of two feet, overshot the left bank near Lewers Road. Ala Wai Boulevard and adjacent streets near the confluence, homes, yards, and basement garages were inundated with the Canal water. Damage in the Ala Wai Canal area was estimated at $10,000. There were landslides, debris, road damages, and erosion in Pālolo Valley.

Recommendations: A survey report for the Pālolo-Mānoa Flood Control Project was in progress at the time this report was issued; therefore, no recommendations were presented.

Reference No.: 3
Title: Descriptive Study of the Physical Oceanography of the Ala Wai Canal
Prepared By: Gonzales, Frank I., Jr.
Prepared For: University of Hawaii, Hawaii Institute of Geophysics
Date of Publication: May 1971

Report Summary

Objectives: To describe the circulation, mass transports, residence times, and temperature-salinity structure in the Ala Wai Canal under varying runoff, tide, and wind conditions and to examine chemical and bacteriological parameters which would be useful in the analysis of pollution in the Canal.

Relevance to Ala Wai System or Watersheds in General: The report provides research data on bathymetry, tides, fresh water runoff, wind, salinity and temperature, currents, dissolved oxygen, nutrients, suspended load, and bacteria specifically relating to the Ala Wai Canal.

Findings: (1) The Ala Wai Canal is a partially mixed, moderately stratified estuary; (2) its degree of stratification is strongly dependent on runoff, tidal stage, and wind conditions; (3) seasonal variations occur in the temperature structures, e.g., from 27°C during the summer to 25°C during the winter in the deeper layers; (4) different rates of silting at different locations created a deep basin at the extreme landward end of the Canal; (5) renewal of water in the basin is infrequent and anoxic conditions prevail in the bottom meter of the water column; (6) average silting on the sill is 20 cm/yr but parts of the sill exhibit rates as high as 28 cm/yr; (7) average fresh water residence time in the surface layer is strongly influenced by wind conditions and changes rapidly with runoff values less than about 1 m^3/sec and may exceed 30 hours; for higher runoff values, the residence time remains essentially constant at about 3 hours; (8) residence time of sea water underlying the surface layer is about half a tidal cycle in the channel and almost 4 tidal cycles on the sill; (9) fecal coliform and fecal streptococci are introduced by the Mānoa-Pālolo Drainage Canal; high coliform counts also exist in the Ala Wai Yacht Harbor but it is not likely that the organisms are transported from the harbor into the Canal.

Recommendations: None; this was not the intent of the research.

Reference No.: 5
Title: Ecological Studies of the Biota of the Ala Wai Canal
Prepared By: Miller, Jacquelin N.
Prepared For: University of Hawaii, Hawaii Institute of Geophysics
Date of Publication: March 1975

Report Summary

Objectives: To provide the basis for management recommendations to increase the recreational value of the Canal to the people of Hawaii.

Relevance to Ala Wai System or Watersheds in General: This report describes in detail the physical-chemical parameters of oxygen, temperature, and salinity with regard to their horizontal, vertical, and seasonal distribution in the Ala Wai Canal. The parameters were used to evaluate the distribution and species composition of the various marine organisms of recreational value and their associated food species.

Findings: (1) The Ala Wai Canal is a long, man-made, estuarine canal of considerable use as a recreational facility in the center of Waikiki; (2) salinity, temperature, and oxygen in the surface waters indicate wide daily variations equaling or exceeding seasonal variation and surpassing horizontal variability, except in areas immediately adjacent to maximum storm drain or stream runoff; (3) salinity and temperature in the bottom waters show little variability either daily or seasonally, except in areas noted above; oxygen values in the eastern end show a marked and significant reduction due to the restricted circulation resulting from the bottom topography; (4) tide and wind are major factors influencing the distribution of temperature, salinity, and oxygen; (5) profuse and varied zooplankton fauna is present and, with minor exceptions, there is little horizontal or seasonal variability in the frequency of occurrence or numbers of zooplankters present (6) holoplankters and meroplankters were approximately evenly divided; holoplankters frequently exceeded meroplankters by 2:1, primarily due to the abundance of copepods; (7) copepods were the single most abundant and universally occurring zooplankter; (8) 2 species of crab (*Thalamita crenata* and *Podophthalmus vigil)* formed more than 95% of all macrocrustacea captured; (9) *Thalamita crenata* is ubiquitous in its distribution in the Canal and Stream; *Podophthalmus vigil* is restricted to the makai area; (10) male crabs of both species were taken more frequently than female; berried *Podophthalmus vigil* occurred most frequently in May through July; berried *Thalamita crenata* occurred most frequently in February but were taken in all months except June and August; (11) low oxygen values in the mauka or eastern end were cited as cause for the limited distribution of Crustacea in those areas; (12) 21 species of fish were recorded; 11 are considered of recreational importance; (13) *Elops hawaiiensis* (awa awa), *Chanos chanos* (awa), *Mugil cephalus* (mullet), and *Tilapia Mozambique* are the most abundant recreational species; (14) *Elops hawaiiensis* is heavily fished by the local people using the released aquarium fish, *Molliensia*, for bait; (15) *Chanos chanos* is abundant for 10 months of the year and is an excellent food fish but is rarely if ever taken by the local people on hook and line as it is primarily an algae feeder; (16) stomach contents of 7 of the major recreational species were examined and the gobiids, nehu, and, to a lesser degree, apogonids (cardinal fish) form the primary food source for the carnivorous fishes; crabs and shrimp were rarely present; and in addition to algae and diatoms normally utilized by the herbivores, about 30% of the *Chanos* stomachs contained significant numbers of copepods.

Recommendations: None

Reference No.: 6
Title: Final Environmental Impact Statement for Makiki Stream Flood Control, Unit 1 Improvement, South King Street to Ala Wai Canal, Honolulu
Prepared By: City and County of Honolulu, Department of Public Works
Prepared For: Governor, State of Hawaii
Date of Publication: April 1975

Report Summary

Objectives: To provide an assessment of the impact upon the environment surrounding the project area. The purpose of the project was to relieve the periodic overflow occurrences along the existing drainage canal by widening and deepening the existing Makiki Drainage Canal between South King Street and Ala Wai Canal.

Relevance to Ala Wai System or Watersheds in General: The Makiki Stream is a part of the Ala Wai Watershed and its drainage basin's outlet is the Ala Wai Canal.

Findings: The Ala Wai Canal is heavily laden with silt from the Mānoa–Pālolo Drainage Canal and the Makiki Drainage Canal discharges. Despite maintenance dredging in 1966, the siltation continues at a rate of approximately 20 cm/year. The benthic environment contains considerable organic material and plastic, rubber, and metal debris. Most water quality observations taken in the Canal exceed the State of Hawaii standards; high concentrations of fecal coliform and trace metals have been found. All aspects of the marine environment in the Canal and around the Makiki Drainage Canal indicate a degraded existing condition. The project was not expected to appreciably change the quality and quantity of storm-induced runoff currently carried by the drainage facility.

Recommendations: The report indicates support of the project

Reference No.: 8
Title: Improvement of the Ala Wai Canal
Prepared By: Cox, Doak C. and Jacquelin N. Miller
Prepared For: State of Hawaii, Office of Environmental Quality Control
Date of Publication: December 31, 1976

Report Summary

Objectives: To improve the water quality of the Ala Wai by introducing a flow of clear salt water at the head of the Canal, increasing the flushing rate of water in the Canal. A clear-water Ala Wai would rapidly become a favorite recreational area for both residents and tourists. An adjunct objective is that the study would provide a conspicuous example of government action in improving Hawaii's environment.

Relevance to Ala Wai System or Watersheds in General: The State of Hawaii Department of Land and Natural Resources was preparing to dredge the Canal to a depth of six feet to remove the mud bar and improve circulation in the Canal. However, removal of the mud bar by itself would not result in a clean Ala Wai. The key to improving water quality is the introduction of a constant flow of clean salt water in the head end of the Canal to provide constant flushing. The study examined ways of providing that constant flow of clear salt water and examined the effects on the sedimentation processes, water quality, and biological productivity. The clear salt water introduction could be supplied via pumping from off the mouth of the Ala Wai Yacht Harbor or from salt water wells in the vicinity of the head of the Ala Wai.

Findings: (1) The additional water flow will have little effect on the sedimentation processes; increased sedimentation in the Yacht Harbor would not occur and the sill would continue to form at the mouth of Mānoa-Pālolo Stream; periodic dredging to remove the sill would still be necessary; (2) there is a high concentration of total coliform bacteria; flushing will certainly be an improvement; (3) if the water is drawn from salt water wells, there could be subsidence in the area around the walls due to differential compaction of the clay layer, which could seriously affect the roads and building foundations in Waikiki; (4) the flushing may negatively affect the biota; low-nutrient salt water will reduce the standing stock of phytoplankton.

Recommendations: The basic objective of flushing appears desirable and sound; however, there is a need for an engineering study of the subsurface properties to determine the extent of the effect of pumping before a recommendation can be made as to the source of the water and though high coliform counts will be reduced, a reduction by dilution sufficient to meet State standards appear to require an economically unrealistic flow of salt water.

Appendices

A Proposed Modifications of the Ala Wai Canal
B Sedimentation Processes of the Ala Wai Canal
C Water Quality Characteristics of the Ala Wai Canal and Effects of Mechanical Flushing
D Well Hydrology, Ala Wai Canal
E Biological Aspects of the Proposed Mechanical Flushing of the Ala Wai Canal
F Estimated Cost

Reference No.: 10
Title: Proposed Modification of the Ala Wai Canal
Prepared By: Miller, Gaylord R. and Warren Chave
Prepared For: State of Hawaii, Office of Environmental Quality Control
Date of Publication: 1976

Report Summary

Objectives: To identify the conventional pumping system that is the most cost effective means of improving the water quality in the Ala Wai Canal.

Relevance to Ala Wai System or Watersheds in General: The Canal flushes poorly due to its length-to-width ratio and, with the high nutrient levels discharged into it from the Mānoa and Makiki area and the sedimentation from the Mānoa-Pālolo Streams, there is a persistent water quality problem. The proposed modification will exchange the water sufficiently and rapidly so that recreational activities could be conducted in the Canal.

Findings: Possible modifications explored were: (1) passive modification via simple re-dredging, periodic dredging, completing the loop for the Canal on out to the beach in the Kapi‘olani-Kūhiō Park region, and a purely biological approach; and (2) active modification via underwater pipeline pumping, tidal pumping, and alternate energy source pumping. The proposed system consisted of a large diameter pipe laid the length of the Canal with the seaward terminus near the entrance to the Ala Wai Yacht Harbor. A secondary pipe would extend up the Mānoa-Pālolo Drainage canal branching off the main pipe. The pump near the Ala Wai Harbor entrance would force water into the pipe, thereby increasing the exchange rate for the Canal system to the point where the waters would be essentially clean although slightly more turbid than waters off Waikīkī in appearance. The modifications which result from the improved flushing are improvements and the resulting environmental impacts would be favorable. If the pumping system had to be turned off for an extended period of time, the appearance of the water would revert to the present status in a matter of days. Noise, atmospheric, and visual pollution are zero to minimal.

Recommendations: Consider results of the pumping system being off for an extended period of time then consider two independent pump units sharing the load to allow for equipment failure. Study results indicate the proposed project to be the most cost effective of the modification options.

Appendices

A Tropical Estuary Ecosystem Analysis and Proposed Modifications

B System of Nine Linear Differential Equations Used to Simulate the Ala Wai Canal System

Reference No.: 22
Title: A Maintenance Plan for the Ala Wai Canal
Prepared By: Edward K. Noda and Associates, Inc.
Prepared For: State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development
Date of Publication: October 1992

Report Summary

Objectives: To provide a plan for periodic monitoring for preventive maintenance and planning/budgeting for routine maintenance activities to prevent serious problems from arising.

Relevance to Ala Wai System or Watersheds in General: The Ala Wai Canal is the repository of significant amounts of floating and sunken urban-related debris and substantial loads of natural and urban-related vegetative debris and sediment. If the debris is left to accumulate, the hydraulic capacity of the Canal is also reduced, resulting in increased hazards to public health and safety.

Findings: Ala Wai: (1) Roughly 1/3 of all the debris was organic litter; aluminum cans (floating and on the Canal bottom) were the most obvious and there was a substantial amount of other food containers, e.g., beverage bottles, cups, plastic wrappers, Styrofoam cartons; the most numerous floatable items were cigarette butts, which, along with larger litter items, are likely washed directly from the areas adjacent to the canal; (2) roadside and curb areas on the makai side of the Canal were clean and maintained; the mauka side roads had large volumes of road grit and dirt mixed with large quantities of cigarette butts and some food wrappers and containers; this waste has easy and direct access to the Canal through storm drains. Mānoa-Pālolo: There were significant amounts of debris on the bank areas but mostly near bridges at stream crossings, e.g., construction-related debris such as scraps of wood and metal, large automobile engine and urban-related litter; at the lower reach of the Canal were some small asphalt and cement piles from the construction of the bike path and parking lots in the park; the asphalt piles can be problematic as they contain leachable petroleum-related organic compounds. Identifiable Problems: (1) Significant amounts of litter found just mauka of the Canal bank near the Golf Course, Field and Playground, and mouth of the Mānoa-Pālolo Drainage Canal; other areas on the mauka side were not heavily littered but not maintained and easily accessible to youth and others leaving litter from parties, etc.; the makai/Waikīkī side of the Canal was very clean and well maintained; a large bus stop adjacent to the Canal at the McCully Street Bridge had no trash cans and significant amounts of litter, cigarette butts, and road grit/dirt near storm drain inlets; (2) stream-side "hangouts" near UH and other schools along the Mānoa-Pālolo Drainage Canal had large volumes of beer bottles and related litter; (3) urban areas just adjacent to the Ala Wai and Mānoa-Pālolo Drainage Canals and areas adjacent to bridges that cross the canals had larges pieces of litter, shopping carts, tires, and construction debris. Sedimentation: Based on present and past studies, the rate of siltation has been consistent at approximately 9,000 to 11,000 cubic yards per year. Maintenance Responsibilities: The State Department of Land and Natural Resources has general maintenance responsibility for the Ala Wai Canal while the City and County Department of Parks and Recreation has maintenance responsibility for shoreline areas directly adjacent to the Canal.

Recommendations: Removal of Floating Debris: Minor modification of the existing debris trap at the Ala Moana Street bridge; install additional debris traps at one or two locations upstream of the Canal, e.g., under the mauka side of the Kalākaua bridge and the makai side of the McCully bridge; inspect and main traps on a timely basis, e.g, removal within a 24-hour time frame for large storms. Removal of Vegetative and Urban Debris from Streambanks and Shoreline Areas: Inspect and clear shoreline areas prior to and just after the winter wet season; encourage private landowners to maintain their shoreline areas; implement management measures as part of a watershed management plan. Ala Wai Canal Wall Maintenance: Assess maintenance needs through annual inspections in the spring or early summer, after the wet season flows and during a low tide when much of the wall is exposed; repairs should be completed before serious deterioration becomes evident. Removal of Bottom Debris: Bring maintenance boat, HARBOR-MOG, into service; conduct annual surveys, in the spring or early summer, to identify areas that require maintenance and/or removal of debris; include Mānoa-Pālolo Canal in the annual survey and clean-up and utilize the HARBOR-MOG where accessible; implement a watershed management plan to prevent entrance of debris. Maintenance Dredging: Based on the past history of maintenance dredging and an analysis of the rate of sedimentation within the Ala Wai Canal, the maintenance plan at a minimum should include budgeting for major maintenance dredging of at least 100,000 cubic yards every 10 years. An alternative to major dredging of the Ala Wai itself is that DOWALD dredge the Mānoa-Pālolo Drainage Canal on a periodic basis, then major maintenance dredging of the Ala Wai may be necessary only every 40-50 years.

Appendices

A Evaluation of Sediment Basin Trapping Efficiency

B Rainfall-Runoff-Suspended Sediment Load Modeling

C Cost Estimates for Maintenance Dredging

Reference No.: 23
Title: A Management Plan for the Ala Wai Canal Watershed
Prepared By: Edward K. Noda and Associates, Inc.
Prepared For: State of Hawaii, Department of Land and Natural Resources
Date of Publication: October 1992

Report Summary

Objectives: To study the feasibility of improving water quality in the Ala Wai Canal to meet acceptable standards for water recreational activities.

Relevance to Ala Wai System or Watersheds in General: This report focuses on various watershed management measures to control and mitigate nonpoint source pollution.

Findings: The Ala Wai Canal and its watershed face numerous water-quality problems; (1) major problems are high levels of fecal coliform bacteria; nutrients; lead and copper; the pesticides dieldrin, chlordane, and heptachlor epoxide; sediment levels; and litter and garbage dumping throughout the watershed; (2) a large component of the nutrient load is from groundwater contributions directly to the Canal and/or to the Mānoa-Pālolo Drainage Canal; other substantial nutrient loads are likely from natural sources high in the watersheds; these nutrient loads result in the most visible and often-cited problems of the Canal: eutrophication and increased algae growth, which give it the turbid murky green appearance and an unpleasant odor when the resulting organic matter decomposes; it is likely that the limiting factor to algae growth is light; flushing with seawater would assist in reducing the nutrient supply to growing algae; (3) watershed management activities are immediately useful for cleaning up litter debris and bulky items from streambanks and streets, reducing erosion rates through improved enforcement of grading permit regulations, and expanding hazardous waste and toxic substance collection and disposal activities; longer-term watershed management activities can improve water quality through the control of pesticides and heavy metals.

Recommendations: The State of Hawaii contract a qualified non-profit organization to lead the implementation of a community-based public/private program of watershed management activities; its major tasks are: (1) develop and lead community participation in cleaning up and maintaining the Ala Wai Canal Watershed, (2) plan and coordinate an immediate action program of watershed management measures, (3) develop proposals for funding from EPA, foundations, and private sources; and (4) promote monitoring and research. The State should provide funds for the first two years ($100,000 in each fiscal year) and seek external funds for year three and beyond. Additionally, the State should provide seed money ($50,000 each fiscal year) for the University of Hawaii to begin monitoring and research activities where they are known to be inadequate and where progress in planning and development or further management actions is known to be impeded by a lack of baseline or trend data.

Appendices

A Water, Sediment, and Biota Data for the Ala Wai Canal and Its Watershed
B Preliminary Cancer Risk Calculations for Three Pesticides in Fish from the Ala Wai Canal and Mānoa Steam (for Chlordane, Dieldrin, and Heptachlor Epoxide only)
C State Classification of Waters and State Standards for Water Quality and Toxics in Seafood

Reference No.: 26
Title: Ala Wai Canal Improvement, FeasibilityReport
Prepared By: Edward K. Noda and Associates, Inc.
Prepared For: State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development
Date of Publication: October 1992

Report Summary

Objectives: To increase water flow and circulation in the Ala Wai Canal while addressing environmental concerns.

Relevance to Ala Wai System or Watersheds in General: The Canal is the major drainage system for the Waikīkī district, conveys surface runoff from the watershed directly mauka, is a sediment deposition basin and a collection system. Excessive phytoplankton growth results in a murky green discoloration and, with heavy rain, the waters display a brown discoloration. The State desires to improve the water quality to standards acceptable for water-based recreational activities.

Findings: The focus was on the physical, biological, and water quality conditions; initial tasks involved extensive field measurement programs. Options were: (1) submerged pipeline; (2) non-trenched underground pipeline using directionally controlled technology; (3) injection of groundwater from wells drilled at the Ala Wai Golf Course. The submerged pipeline and deep groundwater well supply options proved to be technically feasible. The directionally drilled pipeline was beyond the state-of-the-art, there were significant risks involved, and the cost estimate was considerably larger.

Recommendations: Select the deep groundwater well supply system for further feasibility evaluations. For the concept evaluation, a prototype production well drilling and testing program was proposed. If the prototype confirms the technical and environmental feasibility of the concept, update and revise the present conceptual design and construction cost estimate for the saltwater well supply system and evaluate the new construction cost estimate for implementation. If the prototype indicates that the concept is not feasible, consider the submerged pipeline system. The overall environmental impacts after the construction of either option would be minimal and there would be measurable water clarity and quality improvement to the Canal waters.

Appendices

A Ala Wai Canal Bathymetry Cross-Sections
B Ala Wai Canal Current Meter and Drogue Measurements
C Coastal Current Meter and Drogue Measurements
D Dye Measurements and Vertical Current Profile Data
E Ala Wai Canal and Coastal Area, Biological and Water Quality Measurements
F 2-D Model Output Results
G Ala Wai Canal Improvement Project: Analysis of Alternatives to Flush the Canal
H Engineering Feasibility of Deep Saltwater Supply Wells to Increase Circulation in the Ala Wai Canal

Reference No.: 32
Title: Revised Total Maximum Daily Load Estimates for Six Water Quality Limited Segments, Island of ORevised Total Maximum Daily Load Estimates for Six Water Quality Limited Segments, Island of O‘ahu, Hawaii
Prepared By: Freeman, William, Pacific Environmental Research
Prepared For: State of Hawaii, Department of Health
Date of Publication: November 1993

Report Summary

Objectives: To approximate maximum daily loads of nutrients that can be assimilated by the receiving waters, such that each of the receiving water bodies can reasonably be expected to meet State of Hawaii water quality standards as specified in Hawaii Administrative Rules Chapter 11-54. The report is to estimate total maximum daily loads of total nitrogen (TN) and total phosphorous (TN) for six water-quality limited segments: Ala Wai Canal, Kewalo Basin, Honolulu Harbor, Ke‘ehi Lagoon, Pearl Harbor, and Kāne‘ohe Bay.

Relevance to Ala Wai System or Watersheds in General: The Ala Wai Watershed is a part of this study. Maps of spatial data used in modeling were: land use, streams, rainfall, and soil types reclassified for Soil Conservation Service hydrologic groups. Brief descriptions of pertinent spatial features, such as major land uses in the watershed and bordering the receiving water body and major streams in the watershed, are also mentioned.

Findings: The Ala Wai Canal is, on a per liter basis, and as a function of the present state of knowledge of TN and TP inputs, a fully water quality-limited waterbody for both TN and TP. In many regions of O‘ahu, there is virtually no data of any kind, or if data exists, they are too old to be useful.

Recommendations: Rainfall: Increased data collection needs to be implemented for the mauka area of the watershed. Stream gauge data: Further research and detailed land use analysis will be required in the future; more effort must be made to install new stream gauges and to keep current ones in operation. Water quality monitoring in receiving waters: More water quality data for physical parameters are needed; these data should include a notation for each sample as to the part of the tidal cycle when the sample was taken; more stations are needed. Suspended sediment load relationships: More current suspended sediment loading data are needed; increased stream gauge monitoring would dramatically increase the ability to estimate suspended sediment loads. Pollutant loading: Of all the information used for this project, pollutant loading data and research were the most lacking; basic pollutant loading research is needed to assess the effects of current land use activities, e.g., estimate the magnitudes of pollutant loading for many pollutants with respect to specific land uses; determine the “first-flush” and other antecedent time relationships between nonpoint pollutant loadings and runoff concentrations of pollutants; determine the effects and efficiency of basic urban management measures (such as street sweeping) on reducing pollutant loads. Research in receiving water bodies: More research is needed to understand the fate of the various loadings in receiving water bodies, e.g., determine the turnover times and tidal mixing patterns in each water body; determine the fate of particular pollutants in the water body.

Appendices

A Description of the Ala Wai Canal Watershed Model (ALAWAT)
B Summary Regression Statistics for Stream Flow Model Runs
C Suspended Sediment and Nutrient Discharge Rating Curves

Reference No.: 34
Title: Ala Wai Canal Improvement Project, Storm Water Capacity Study
Prepared By: Edward K. Noda and Associates, Inc.
Prepared For: State of Hawaii, Department of Land and Natural Resources
Date of Publication: January 26, 1994

Report Summary

Objectives: To analyze the storm water inflow rates from the connected watersheds into the Canal corresponding to various flood frequencies; evaluate the flow capacity of the Canal in the existing condition for the various flood frequencies; and evaluate different Canal depth options to increase the storm water capacity of the Canal.

Relevance to Ala Wai System or Watersheds in General: Flood data, available from the US Geological Service, was used as calibration and the discharge rates were then calculated based on the respective drainage areas and the regression coefficient b, which varies for different return periods. No historic rare event flow data, no similar watershed study, and no obviously reliable watershed model are available that can be used to refine the results or to directly give better results at present.

Findings: The Canal has marginal capacity to handle the 10-year or more frequent event flood flows but definitely cannot handle the 100-year event flood flow.

Recommendations: An up-to-date survey of the present top-of-bank elevations is needed to accurately evaluate the flood capacity for purpose of designing storm water capacity improvements for the Ala Wai Canal.

Reference No.: 37
Title: A Study to Alleviate Flooding of Mānoa Stream (East Mānoa Road to Woodlawn Drive), Island of Oahu
Prepared By: State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development
Prepared For:
Date of Publication: January 1995

Report Summary

Objectives: To identify the limits of flooding of the Mānoa Stream that would occur during storm conditions and propose possible solutions to aid homeowners living adjacent to the stream.

Relevance to Ala Wai System or Watersheds in General: The Mānoa Steam is a part of the Ala Wai Watershed and its drainage basin's outlet is the Ala Wai Canal.

Findings: General: Local flood problems are caused by the inadequate capacity of the natural stream to handle flood waters and is further aggravated by the numerous bridge crossings; in the lower portion, the flatter terrain causes higher-level, slow-moving, subcritical flows, which, when coupled with several bridge constructions, creates a flooding potential; property owners along the stream bank experience erosion problems. Climate: Relatively moderate climate; maximum average rainfall occurs about 1/2 to 3/4 miles leeward of the Ko'olau crest; the amount of rainfall declines at a regular rate; weakened trade winds, particularly during winter (Kona weather) brings heavy rainfall to the area; average temperature range is 70 to 76°F at the 500-foot elevation; estimated relative humidity remains fairly constant from 60% at 2:00 p.m. and 78% at 2:00 a.m. Flood history: Local floods caused two known deaths by drowning on December 3, 1918, and December 3, 1950; detailed flood damage reports are lacking; past records, data from the State Civil Defense Agency and the National Weather Service flash flood specialist, and reports by local residents indicate minor damage thus far. Past Actions: The City proposed improvements from Pāwaina to Kalawao Streets; 1952 - improvements from 500 feet upstream of Lowrey Avenue to East Mānoa Road, designed and constructed; 1970's - upstream and downstream sections designed but not constructed; bridges constructed at East Mānoa Road in 1949, Lowrey Avenue in 1952, Kahaloa Drive in 1953, and Woodlawn Drive in 1974; various improvements downstream from East Mānoa Road bridge along the Stream since the 1988 New Year's Eve flood. The State and City jointly constructed a rock wall along the eroded section of the Stream near the Mānoa Village Condominium. 1989 - Mānoa Market Place's owner initiated a stream bank protection on the makai side of the Stream, near and in back of the old KC Drive In Restaurant; 1993 and 1994 - thick concrete layer and CRM (concrete rubble masonry) wall constructed within Nekota property; 1992 and 1993 - State (DLNR) expended $4,000/year in cleaning debris and vegetation overgrowth.

Recommendations: Interim, limited protection measures: Embankment protection -- Construct CRM walls 13 feet high along sections of the Stream, which are State owned. Stream maintenance program -- Incorporate a yearly maintenance program to maintain embankment areas free of vegetation overgrowth and to allow more water flow; coordinate with the City's debris removal maintenance program at bridge approaches to allow the maximum flow for flood waters. Long-term measures: Widen and deepen upstream and downstream approaches to the Woodlawn Bridge (to increase flow capacity under the bridge and eliminate the bottleneck) coupled with a strong maintenance program. Final recommendations were to be made after input from the Mānoa Community, the Mānoa Neighborhood Board, and interested parties.

Reference No.: 49
Title: Water Quality Monitoring Report – May 1996-97, Ala Wai Canal Watershed Project
Prepared By: State of Hawaii, Department of Health, Clean Water Branch
Prepared For:
Date of Publication: December 1997

Report Summary

Objectives: To address nonpoint source pollution issues and problems.

Relevance to Ala Wai System or Watersheds in General: The project is part of a support activity to the DOH's watershed protection initiatives, e.g., Ala Wai Canal Watershed Improvement Projects. Water quality of the three major streams in the Watershed was monitored. Tests showed high levels of pollutants suggesting the presence of sources that may have a direct role in the degradation of instream water quality and waters of the Canal.

Findings: Nutrient levels exceed the Standard in the Watershed—nitrogen and phosphorus in the Canal; phosphorus in the Makiki watershed significantly greater than Mānoa and Pālolo watersheds; highest median concentration of nitrogen and exceptionally high levels of indicator bacteria in Pālolo Stream.

Recommendations: There is a need for erosion control, construction site BMP's, impervious surfaces, forest management practices, ground cover, urban street dust, etc., in controlling sediment as well as phosphorus loadings in receiving waters. Use parameter-specific TMDL's for each watershed rather than the use of a multiple parameter TMDL for the Canal for a more manageable approach to nutrient management. Effective BMP's, enforcement actions, and corrective measures to mitigate sewage contamination should result in restoring water quality to acceptable levels for water recreation in the Canal.

Appendix - Descriptive Statistics

Reference No.: 50
Title: Ala Wai Canal Dredging – Final Environmental Assessment
Prepared By: Belt Collins Hawaii
Prepared For: City and County of Honolulu, Department of Transportation Services/Department of Design and Construction
Date of Publication: October 1998

Report Summary

Objectives: To satisfy the requirements and implementing regulations of the National Environmental Policy Act of 1969; Environmental Impact Statements, Hawaii Revised Statutes Chapter 343; and United States Code, Title 49, Section 303 of the Department of Transportation Act of 1966; to evaluate whether an action may have a significant environmental impact.

Relevance to Ala Wai System or Watersheds in General: The proposed action was to increase water depth in the Ala Wai Canal. Removal of accumulated sediment in the Canal will restore sediment holding capacities, decrease risk of flooding in surrounding areas during high intensity storm events, and improve conditions for recreational use of the Canal and its environs.

Findings: Six components comprised the proposed action: (1) limits of dredging, (2) dredge method, (3) sediment transportation, (4) work support areas, (5) sediment processing, and (6) sediment placement. Subjects evaluated for impact were: affected environment and potential effects, biota, pollutants in the Canal, public health, recreation, socioeconomics, transportation, air quality, noise, aesthetics, utilities, cultural resources, land use compatibility, environmental justice, cultural practices, and comments and coordination. Multiple options were evaluated for each component by the following criteria: (1) dredge limits – related to the volume and characteristics of the material to be disposed and the area and extent of disruption to recreational uses during dredging; (2) dredge method – related primarily to compatible transportation options, requirements for dewatering, and water quality; (3) transport – primarily interference with navigation and traffic; (4) use of waters and shore-side lands for dredging support operations – temporary disruption of existing land uses and requirements for landscape restoration; (5) processing – primarily to water quality; (6) placement – primarily to water quality and compatibility with adjacent and future land uses.

Recommendations: Impacts of any particular set of options comprising a feasible alternative will need to be evaluated based on the collective effect of the options.

Appendices

A	Regulatory Documentation and Conceptual Design
B	Terrestrial Flora Report
C	Terrestrial Fauna Report
D	Recreation Report
E	Historic Sites Reports
F	Rosters
G	Consultation Letters
H	Comment Letters and Responses

Reference No.: 51
Title: Ala Wai Watershed Water Quality Improvement Project, Management & Implementation Plan, Volume 1
Prepared By: The Steering Committee, City and County of Honolulu, State of Hawaii
Prepared For:
Date of Publication: April 1998

Report Summary

Objectives: To provide a guide for selection and implementation of future environmental management projects in the watershed.

Relevance to Ala Wai System or Watersheds in General: The purpose of the Plan is to improve the water quality of the Ala Wai Canal, tributary streams (Makiki, Mānoa, and Pālolo), and related groundwater flows.

Findings: Factors that contribute to the complex water quality problems in the Watershed are: rapid population growth, high density development, more vehicles, modern conveniences (plastics, fast foods), economic changes (from sugar to tourism), improved household incomes, shift from household gardens to supermarkets, more visitors, more paved surfaces. Remedial actions can be started now; there is no need for additional information about the quantity, type, or location of certain contaminants. The City has installed debris-catching booms to be maintained by a volunteer group. Soil erosion and litter reduction projects can be started now. Problems of overlapping agency jurisdictions, inefficient regulation and enforcement, and little regular or integrated planning or maintenance can best be remedied by establishing a Watershed District and Board.

Recommendations: The focus must shift from dredging the Canal to healing the watershed. (1) Plan and manage the forest and streams in the Conservation District, extend management practices for streams from the Conservation District to the Canal; (2) reduce urban streams and improve public access; (3) improve maintenance dredging; (4) investigate the feasibility of increasing the flood-carrying capacity of the Canal and its tributary streams; (5) reduce the amount of contaminants of vehicle origin from reaching the Canal; (6) reduce litter reaching the Canal; (7) reduce health risks by reducing exposure to pathogens in water and not eating contaminated fish; (8) restore streams and enhance their quality to improve the environment for people, aquatic plants, and animals; (9) improve future watershed conditions; (10) update agency capabilities and programs; (11) initiate a process to transfer certain property rights from private to public; (12) implement a regional approach to watershed management.

Appendices

A Proposed Legislation – 1998
B Review Comments Received Regarding the Draft Management and Implementation Plan
C Management & Implementation Plan – Volume II, Technical Appendices

Reference No.: 63
Title: Ecosystem Restoration, Ala Wai Canal Watershed, Honolulu, Hawai'i
Prepared By: Dashiell, Eugene P.
Prepared For: U. S. Army Corps of Engineers
Date of Publication: August 1999

Report Summary

Objectives: To investigate and recommend appropriate solutions to accomplish ecosystem restoration in the Ala Wai Canal watershed area.

Relevance to Ala Wai System or Watersheds in General: Successful implementation of the proposed project will improve water quality; sedimentation and soil erosion; litter and debris; flooding; recreation; and species diversity, threatened and endangered species, and native species in the Ala Wai Canal Watershed.

Findings: Based on previously identified problems, the following alternatives were reviewed: canal dredging: will contribute to overall improvement in water quality and circulation; however, other alternative measures may also be necessary to restore and maintain the preferred ecosystem; flushing system: would improve water circulation, reduce turbidity and odors, and improve the habitat for diverse migratory species, e.g., gobies and shrimp; sediment detention basins and bank stabilization: reduction of sediment discharge coupled with maintenance dredging would aid in ecosystem restoration; native species will have a greater chance at survival; improvements to stream bottom design: improved flood flow and accessibility for periodic stream maintenance would be a major step in restoring the stream ecosystem. These alternatives would result in net environmental benefits through ecosystem restoration; incidental benefits may also be derived from flood control and recreation. All of the alternatives would provide the increased habitat diversity necessary for threatened and endangered species. The proposed alternatives to be considered for the next feasibility phase would be technically feasible, environmentally sound, and could be justified for implementation.

Recommendations: Proceed to a cost-shared feasibility study with the State of Hawaii Department of Land and Natural Resources as the local cost-sharing sponsor for ecosystem restoration of the Watershed.

Reference No.: 66
Title: Hawaii Stream Assessment, A Preliminary Appraisal of Hawaii's Stream Resources
Prepared By: Hawaii Cooperative Park Service Unit
Prepared For: State of Hawaii, Commission on Water Resource Management
Date of Publication: December 1990

Report Summary

Objectives: To identify streams appropriate for protection; to produce a reference document on Hawaii's 376 perennial streams.

Relevance to Ala Wai System or Watersheds in General: The Ala Wai Canal System (Mānoa, Pālolo, and Makiki Streams) is included as a part of this study.

Findings: The report is a reference document--a broad-based inventory and assessment of the majority of the instream uses described in the state water code. It does not address important offstream uses of water, water rights, Hawaiian rights, economics, landownership, zoning or navigation, nor does it map or provide location information for the various resources of characteristics. It is a physical inventory of perennial streams and working maps, an assessment of resources associated with the streams, and a database. The Ala Wai Canal System was not identified as a candidate stream for protection; however, information on the Canal System was assembled relating to: gauging, water quality, water supply, dams and diversions, hydroelectric power, channelization, and special areas (estuaries, embayments, wetlands, recovery habitats, special management areas, natural area reserves, wildlife refuges and sanctuaries, private preserves, national natural landmarks, historic sites, research and educational sites, parks, and waterfalls). Resources associated with streams that were assessed included aquatic, reparian, cultural, and recreational.

Recommendations: Instead of recommendations, future actions were identified: maintain and enhance the Hawaii Stream Assessment, develop long-term stream management strategies, and institute interim actions to preserve management options.

Reference No.:	67
Title:	Total Maximum Daily Loads for Ala Wai Canal, Island of Oahu, Hawaii
Prepared By:	U.S. Environmental Protection Agency, Region 9, and Hawaii Department of Health
Prepared For:	State of Hawaii, Department of Health
Date of Publication:	May 2001

Report Summary

Objectives: To provide more detailed load and waste load allocations in order to assist in identifying additional implementation needs. These are formal revisions to the TMDLs for total nitrogen and total phosphorus, which were completed by the Department of Health in 1995. That report identified nutrient loading reductions needed at a watershed scale to meet the Water Quality Standards.

Relevance to Ala Wai System or Watersheds in General: Ala Wai Canal is an impaired water body. The revised TMDL identify allowable nutrient loads by nutrient source category as well as the estimated percent reductions in nutrient loading from different source categories which would be necessary to meet the TMDLs and State Water Quality Standards. In combination with stream restoration and Canal maintenance activities being planned, TMDL implementation should result in attainment of SWQS in the Canal.

Findings: Aggressive actions to reduce nutrient loadings from both urban and non-urban areas will be necessary to implement the allocations; management practices designed to address erosion prevention and control will assist in attaining the nutrient allocations. Phosphorous loadings appear to be closely associated with sediment loadings to the watershed. Actions to ensure that cesspool loadings are effectively eliminated are necessary to implement the nitrogen allocations. Canal dredging and stream restoration will increase the watershed's capacity to assimilate nutrient loadings due to the filtering effects of restored streambank vegetation, improvements in Canal water mixing, and removal of existing nutrient reservoirs in Canal sediments. Aggressive best management practices are necessary for land uses and activities that potentially introduce pollutants into the Watershed.

Recommendations: Dredging, stream banks restoration, trash removal, and enhancing flushing flows are insufficient to address the nutrient problems but will address a difficult pollutant problem. Additionally, flushing pollutants from the Canal may simply move them into the Ala Wai Boat Harbor, Māmala Bay, and nearby beach areas. The TMDLs should be implemented and shown to be effective as part of any strategy to address other causes of water quality problems in the Watershed

Reference No.: 74
Title: Ala Wai Canal Dredging, Conceptual Design and Environmental Assessment, Sources of Contamination/Potential Pollutants
Prepared By: Belt Colllins Hawaii
Prepared For:
Date of Publication: June 16, 1998

Report Summary

Objectives: To identify sources of contamination and potential pollutants in the Ala Wai Canal.

Relevance to Ala Wai System or Watersheds in General: The Watershed's three major streams are identified as the primary physical sources contributing to the general contamination and pollution of the Canal.

Findings: Three transport mechanisms for pollution are in the form of surface runoff conveyances: streams, storm drains, and overland flow. There are three major streams in the Watershed: Mānoa, Pālolo, and Makiki. Mānoa and Pālolo Streams converge to form the Mānoa–Pālolo Drainage Canal; they outlet into the Ala Wai Canal together with Makiki Stream. The storm drain system owned and operated by the City and County of Honolulu serves the urbanized areas in the Watershed. The system consists of an underground pipe network interconnected by catch basins and inlets, along with surface drainage ditches. Storm water sheet flows from streets, sidewalks, and private developments into the inlets for conveyance in the pipe network. The storm drain system discharges at numerous locations along the Watershed's streams and also directly to the Ala Wai Canal. Seawater and groundwater also discharge to the Canal. Seawater is introduced via tidal exchange; groundwater input is from natural seepage and could also enter in the form of dewatering effluent from construction activities. Atmospheric deposition and rainfall contribute pollutants directly into the Canal. Another form of direct inputs is uncontrolled dumping and spills. Chemical pollutants appear to be conveyed from the following sources: (1) subsurface and surface waters via streams and storm sewers – termicides and chemicals associated with residential activities; (2) storm sewers – automotive pollutants, such as lead, zinc, and polycylic aromatic hydrocarbons, from streets and highways; and (3) tidal flux – marine anti-fouling agent residuals associated with vessel repair facilities seaward of the project area.

Recommendations: None provided.

Reference No.: 75
Title: Ala Wai Canal Dredging, Conceptual Design and Environmental Assessment, Existing Storm Water Runoff Data
Prepared By: Belt Collins Hawaii
Prepared For:
Date of Publication: June 23, 1993

Report Summary

Objectives: To evaluate storm water runoff flowing into the Canal; to determine the portion of Canal storm water runoff flow that is directly attributable to public roadway areas.

Relevance to Ala Wai System or Watersheds in General: The Ala Wai Canal receives storm water runoff from three subwatersheds: Mānoa–Pālolo, Makiki, and Kapahulu.

Findings: The three subwatershed areas encompass a total of about 16.3 square miles. Based on representative tax map key parcels, roadway areas were estimated at between 15 and 30 percent of all residential, commercial, and industrial land areas; this equates to about 8 percent of all watershed areas, or about 860 acres. Drainage standard references were for years 1969 and 1988. Contribution from public roadway areas was estimated at 15 percent.

Recommendations: None provided.

Appendices

A Sample DPW Storm Drain Data Sheets Proposed Legislation – 1998

Reference No.: 77
Title: Ala Wai Canal Watershed Project, Manoa Valley District Park Streambank Improvements
Prepared By: Wil Chee – Planning, Inc.
Prepared For: Walters, Kimura, Motoda, Inc.
Date of Publication: August 2000

Report Summary

Objectives: To ensure that systematic consideration is given to the environmental consequences of the proposed Mānoa Valley District Park stream bank improvements.

Relevance to Ala Wai System or Watersheds in General: The Mānoa Valley District Park Streambank Improvement Project ties into the Ala Wai Canal Watershed Improvement Project. Both of the Projects are major community-based planning endeavors, ongoing efforts including participants from Federal, State, and City agencies, as well as citizens' groups. The Ala Wai Canal Watershed Improvement Project seeks to provide mitigation measures to improve water quality and environmental conditions, in general, within the streams, Canal, and Watershed area.

Findings: Environmental aspects evaluated were geology and topography; soils; hydrology; climate; air quality; noise quality; flora; fauna; historical and archaeological resources; land use; aesthetic considerations; circulation and traffic; public services and facilities; and socio-economic conditions. In general, no adverse consequences were expected. In instances where there would be short-term negative impacts due to construction activities (e.g., potential soil erosion and sedimentation; dust and particulate emissions; noise; circulation and traffic), mitigation measures were suggested. The proposed action was expected to result in no significant impact on the environment.

Recommendations: No environmental impact statement is required. A finding of no significant impact was anticipated and determined to be in order.

Reference No.: 80
Title: The Environmental Impacts of the Proposed Construction (Phase I) for the Ala Wai Boat Harbor
Prepared By: Lawrence P. Raymond, Oceanic Institute
Prepared For: State of Hawaii, Department of Transportation
Date of Publication: September 7, 1972

Report Summary

Objectives: To identify consequences likely to occur if the construction (expansion and improvement of the Ala Wai Boat Harbor to meet the increasing demands for docking and mooring facilities) is carried to completion; to consider differences between effects of short- and long-term consequences that may arise from this project; and to list biological, physical, social, and economic resources, which will be, or have already been, permanently consumed by this operation.

Relevance to Ala Wai System or Watersheds in General: The Ala Wai Canal opens into the northwest corner of the Ala Wai Boat Harbor discharging waters collected from the Mānoa and Pālolo valleys. The Canal was constructed to protect Waikīkī Beach from storm water originating in the Mānoa and Pālolo valleys as part of the Waikīkī Reclamation Project. These collected storm waters were originally discharged at Kewalo Basin, but were diverted to their current location during the construction of the Boat Harbor.

Findings: The present environment in the Boat Harbor is characterized by nutrient concentrations significantly above the permitted limits prescribed by the State, productivity levels among the highest ever recorded for tropical waters, high turbidity, supersaturated oxygen concentrations, and organismic population instability. Significant deleterious changes will occur sometime in the future even if no additional construction is made. If certain controls with regard to waste materials and water circulation are not implemented, the construction will accelerate the rate of eutrophication within the Harbor. If the recommendations that follow are implemented, the environmental quality of the Harbor and offshore areas will be significantly improved by the construction of the proposed Harbor extension.

Recommendations: Enforce full and rigid control of the concentrations of the limiting nutrient and of circulation within the Harbor; enrichment experiments on the Harbor waters must be conducted to demonstrate conclusively the limiting nutrient; nutrient source elimination must occur; the waters within the Harbor should be monitored continually; major consideration must be given to constructions which will maintain circulation through the Harbor; sufficient contingency funds should be available to correct adverse effects.

Appendices

I	Analysis of Current Patterns
II	Procedures for Collection of Samples and Field Data
III	Methods of Laboratory Analysis
IV	Method for Productivity Analysis
V	Methods for Specific Socio-Economic Analyses
VI	Methods of Statistical Analysis
VII	Data – Chemical Analyses
VIII	Productivity Data
IX	Bacteriological Data
X	Field Data
XI	Diver Observations
XII	Heavy Metals and Pesticides
XIII	Final Plan for Proposed Harbor Improvements
XIV	Comments and Disposition

Reference No.: 92
Title: Flood Hazard Study, Manoa Stream Basin
Prepared By: M & E Pacific, Inc.
Prepared For: U.S. Army Corps of Engineers
Date of Publication: September 1977

Report Summary

Objectives: Identify the limits of flooding of the Mānoa Stream basin that would occur during storm conditions. Identifying these limits will provide a basis for further study and planning into future developments whereby optimum use of flood-prone areas can be made.

Relevance to Ala Wai System or Watersheds in General: The Mānoa Steam is a part of the Ala Wai Watershed and its drainage basin's outlet is the Ala Wai Canal. The periodic overtopping of stream banks from high frequency flows in a flood plain is a natural occurrence. In the past, stream levees, channel lining, and other structures were built to contain flood waters; flood control measures, however, are costly.

Findings: Mean annual rainfall varies from 160 inches at the Koʻolau crest, 80 inches in the Woodlawn area, and 25 inches at the coastline; average annual temperature range is 70 to 76° F at the 500-foot elevation; estimated relative humidity remains fairly constant throughout the year, the maximum daily fluctuation is 60% at 2:00 p.m. and 78% at 2:00 a.m. Thunderstorms and Kona storms are of common concern because of their destructive potential; these heavy rains, with local flooding, are more prevalent during the winter months. Local flooding has caused two known deaths by drowning on December 3, 1918, and December 3, 1950; 5.7 inches of rain and 53 mph winds were recorded during the 1918 storm and 6.1 inches of rain during the 1950 storm. Maximum recorded discharges at two gauged stations on the east and west branches of the Stream were 3,090 and 3,250 cfs respectively; these discharges occurred on January 16, 1921. Detailed flood damage reports are lacking. Local flooding problems are caused by the inadequate capacity of the natural stream and are aggravated by 12 bridge crossings; the lower reaches (particularly below the Woodlawn area) are where the limits of flooding are greatest. Information on four flood frequencies (10-, 50-, 100-, and 500-year recurrence) describing drainage area versus stationing curve, drainage area versus frequency discharge curve, flood discharge, and water surface profiles are reflected on "plates," which are included as a part of the report.

Recommendations: None; this was not the intent of the study.

Reference No.: 93
Title: Preliminary Report, Pālolo Stream Flood Control
Prepared By: Urban Engineering Consultants, Inc.
Prepared For: City and County of Honolulu, Department of Public Works
Date of Publication: March 1983

Report Summary

Objectives: To investigate and evaluate Pālolo Stream, from Keanu Street to below the 3rd Avenue entrance road to Chaminade College, for significant deficiencies and problem areas in relation to possible improvements to an existing unlined portion of the Stream.

Relevance to Ala Wai System or Watersheds in General: The combined Mānoa-Pālolo Stream sub-watersheds discharge to the Ala Wai Canal, which eventually drains out to the sea.

Findings: Technical analysis of the existing Stream indicates that improvements are not justifiable. Some abutting property owners have taken it upon themselves to protect their properties with rock and/or masonry walls (the structural integrity of the existing walls was beyond the scope of this report). The properties within the project site appear to be intact with no indications of damages except for properties immediately downstream of the Pālolo Stream Flood Control Unit II improvements. The erosion problem experienced by the upstream property owners could be attributed to: (1) properties situated at the curve or bend of the Stream; it is a normal occurrence for the configuration of the land to change at stream bends; and (2) property owners added fill to their property without any flood erosion protection (it would not have taken a flood to erode the "fill" area away). The City offered to share in the cost to construct a stream wall; however, the offer was not accepted. From records and questionnaires, properties were not subjected to inundation and no major damages resulted from floods. The natural condition of the Stream is adequate to convey the storm run-off. A stream improvement project would enhance the environment and adjacent properties; however, since no damages to homes and contents occurred as a result of storm flood waters and based on the City's benefit to cost criteria, the expenditures of government funds for a stream improvement project is not justified.

Recommendations: (1) The full channel improvements were unjustified; (2) the channel transition at the end of the Unit II improvements, which was washed away, should be reconstructed up to the existing City property line; (3) energy dissipators should also be installed; (4) the bottom of the Stream should periodically be cleared of large debris, boulders, and trash; (5) the property owners should be encouraged to protect their properties at their own expense.

Appendices

A Hydraulic Calculations
B Estimated Construction Costs
C Project Photographs
D List of Property Owners and Historic Flood Data Questionnaire Responses
E Correspondence (Bound Separately)

Reference No.: 94
Title: Report of the Meeting for the Committee on Hydrology; 6-8, June, 2001; Ala Wai Canal
Prepared By: U.S. Army Engineer Committee on Hydrology
Prepared For:
Date of Publication: January 1995

Report Summary

Objectives: To present results of hydrologic analyses for the Ala Wai Canal Flood Control Study.

Relevance to Ala Wai System or Watersheds in General: The effects and associated costs of various flood damage reduction alternatives for the Ala Wai Canal were investigated.

Findings: Inadequate rainfall and stream gauged data to determine sub-basin response to storms of varying intensity; kinematic wave routing was performed for hydrograph development in the middle and lower basins; landslides and debris flows can occur within the upper basins; design storm rainfall frequency isohyet maps needed updating; interior coincident flooding during high stages in the Canal may be an issue.

Recommendations: (1) Submit stream and rain gauge plan of the Watershed for programming; (2) investigate in more detail the storage capacity of detention basins and its effects on runoff hydrographs; include an emergency spillway outlet; (3) consider flood storage/sediment basin on the Golf Course to reduce overtopping the Canal; (4) document rainfall and stream flow data and Canal high water marks for the June 5 storm; conduct backwater analysis of the Canal during that event to help estimate hydraulic parameters of the Canal; (5) install crest stage gauges at all bridges and strategic locations for slope of hydraulic gradient during flood events; (6) reexamine U.S. Geological Survey data used for December 1967 stream flow of 10,100 cfs at Mānoa-Pālolo Drainage Canal; (7) use UNET hydraulic model; (8) conduct bridge blockage sensitivity analysis of floating debris; (9) investigate potential flooding along Mānoa Pālolo Drainage Canal due to debris blockage at Date Street bridge; (10) investigate functionality of Kapahulu Avenue storm drain; (11) analyze the Canal similar to a lake; (12) determine sediment deposits quality in the Canal; (13) obtain and review storm data from historical floods of 1965 and 1967 and obtain tidal conditions during the peak flood event; (14) consider rerouting Mānoa-Pālolo Drainage Canal through Waikīkī directly into the ocean; (15) consider diverting first flush of storm event into sewage system and the rest of the flood flow into the Canal; (16) verify all existing storm sewers function as planned; (17) compute depth damage curves specific for the region; (18) consider reversible pumping system linking upstream end of Canal to Kapahulu Avenue storm drain ocean outlet.

Appendix - Ala Wai Canal Flood Control Study, Honolulu, Hawaii; Hydrology and Flood Plain Hydraulics Appendix

Reference No.: 95
Title: Ala Wai Canal Dredging, Conceptual Design and Environmental Assessment, Water Quality Research Report
Prepared By: Belt Collins Hawaii
Prepared For:
Date of Publication: March 6, 1998

Report Summary

Objectives: To provide an overview of the water quality and biological characteristics of the Ala Wai Canal and to discuss the expected impacts of the proposed dredging activities in the Canal with respect to water quality and biological parameters.

Relevance to Ala Wai System or Watersheds in General: Despite prior dredging activities, water quality problems are apparent in the Canal. The proposed project was to selectively dredge specified sections of the Canal to improve the water quality and overall health of the aquatic estuary.

Findings: The Canal was identified as WQLS (Water Quality Limited Segment) and, together with two of its feeder streams, was listed as an impaired water body The overall adverse effects of dredging in the Canal would not be significant; the effects associated with re-suspension of sediments would not differ significantly from existing conditions and would not likely result in increased health risks; impacts to bottom-dwelling biota and the habitats which support them were not considered significant. Long-term effects would be improvement of water quality and overall health of the aquatic system in the estuary.

Recommendations: The proposed dredging was expected to result in improved water quality and natural values within the Canal. Improvement of water quality and ecological and natural functions will lead to improved aesthetic values and enhanced recreational opportunities. The proposed improvements would have social and economic benefits for the residents of and visitors to Waikīkī, and, through the improved image of Waikīkī as Hawaii's premier international tourism destination, benefits will also accrue to the local economy and the people of the State as a whole.

Reference No.: 100
Title: Ala Wai Canal Watershed Improvement Project, Final Report of the Outreach Coordinator
Prepared By: Clyde B. Morita
Prepared For: State of Hawaii, Department of Health, Clean Water Branch
Date of Publication: June 1999

Report Summary

Objectives: To develop and implement project goals and objectives, defined by stakeholders; to develop community-based vision for the watershed; generate and fund community-initiated water quality projects; support development of long-term, sustainable, community organization that serves as a steward for the watershed; and provide training opportunities and technical assistance for community participants on water quality, stewardship, cultural, and organizational issues.

Relevance to Ala Wai System or Watersheds in General: DOH is committed to the long-term goal of restoring water quality in the Ala Wai Canal Watershed; to improve the quality of both surface and ground waters in the Watershed through a long-term, community-based, public-private program of non-point source management activities. In the short-term, DOH is interested in providing a framework for the development of a vision supported by a common understanding of the problems/solutions for the Watershed.

Findings: The Community Advisory Committee is committed to participate for the benefit of the Watershed and their communities. The Ala Wai Community Board can become a viable, sustainable organization to lead a community-agency-business partnership for the Watershed. It is important to have the agencies continue to play a key, participative role as they have the resources which affect land management and water quality.

Recommendations: Overall: Encourage and fund community-based, stewardship projects; focus attention on building a relationship of trust among the stakeholders; accept the lengthy action timeframe as the dynamic, human process necessary to assimilate, accept, and support a project or program. DOH: Support the Board--participate in meetings; provide funding and technical assistance; coordinate input of permit reviews; loan equipment and materials; ensure sufficient, permanent, Polluted Runoff Control staff; develop new initiatives for watershed programs. EPA: Fund refreshments for volunteer projects and meetings of the Board and the Center for a Sustainable Future; continue staff presence at critical meetings. AWCB: Set up staff, communications, and an office; provide funding to Youth for Environmental Service; provide the Executive Committee with support and trust; incorporate cultural values in their role as trailblazers.

Reference No.:	108
Title:	Ala Wai Flood Study, Island of Ala Wai Flood Study, Island of Oahu, Honolulu, Hawai'i, Planning Assistance to States Study R (Final)
Prepared By:	U.S. Army Corps of Engineers
Prepared For:	State of Hawaii, Department of Land and Natural Resources
Date of Publication:	October 2001

Report Summary

Objectives: To investigate and recommend appropriate solutions to resolve continual flooding from the Ala Wai Canal.

Relevance to Ala Wai System or Watersheds in General: The dredging of the Ala Wai Canal was designed to improve the flood carrying capacity of the Canal and should not be confused with maintenance dredging, which occurred more than 20 years ago.

Findings: The study reviewed hydraulic design alternatives; residual flooding; operations and maintenance; real estate affected; cost estimates; economic analysis; coordination with Federal, State, and regional agencies. There are possible structural alternatives to mitigate flooding from the Ala Wai Canal by increasing the flood carrying capacity of the Canal. The study predicted that flood mitigation measures such as dredging, adding levees and floodwalls, and adding a detention/sedimentation basin in the golf course area can prevent inundation damages and provide an average annual benefit of approximately $9.7M.

Recommendations: Adding levees and floodwalls was the alternative with the greatest net benefits; however, the foundation supporting these walls must be evaluated and agency and public views regarding the great heights of the walls must be considered and addressed. The State should proceed with more refined analysis of the alternatives presented, particularly the adding of levees and floodwalls to the Canal system and the combination of dredging, levees, and sedimentation basin.

Reference No.: 208
Title: General Flood Control Plan for Hawaii
Prepared By: State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development
Prepared For:
Date of Publication: September 1983

Report Summary

Objectives: To provide a revised and updated version of the comprehensive study of flood control programs in the state. The original Plan was published in 1963.

Relevance to Ala Wai System or Watersheds in General: The Plan contains specific updates to the Pālolo and Mānoa Valleys as well as the Makiki Stream Flood Control Projects.

Findings: Pālolo and Mānoa Valleys Flood Control Project: During a century of recorded floods, Mānoa Stream has caused more than twelve major floods and claimed one life; Pālolo Stream, eight major floods and six lives. Existing improvements afforded a degree of protection; however, during heavy rainfall in the sub-watershed, damage continues to occur in the valleys and in the Ala Wai Canal area. Without adequate facilities, severe damage is possible in view of the rapid development within the critical zones of the flood plain. Makiki Stream Flood Control Project: The threat of inundation by the overflow of Makiki Ditch and Kanahā Stream has not been reduced appreciably. Records of flood damage are sketchy; however, inadequate interior drainage facilities have caused damages in the low-lying areas in the vicinity of Washington Intermediate School.

Recommendations: Pālolo and Mānoa Valleys Flood Control Project: Establish encroachment zones in the potential tsunami inundation areas and regulate use of the undeveloped flood plain; construct the channel improvements for Pālolo and Mānoa Streams; organize flood fighting sub-units to stress the techniques of proper preparation and clean-up procedure; maintain surveillance during tsunami and small craft warnings; evacuate when instructed by the responsible agency. Makiki Stream Flood Control Project: Works of improvement should be constructed; flood plain zoning and relocation of properties within the flood plains appear to be impractical because of the extent of existing development in the flood plain.

Reference No.:	210
Title:	Urban Flood Control Study, Honolulu, Hawaii – Final Reconnaissance Report
Prepared By:	U.S. Army Corps of Engineers
Prepared For:	State of Hawaii (Legislature and Governor) and City and County of Honolulu (Mayor)
Date of Publication:	May 1992

Report Summary

Objectives: To determine whether planning for flood damage reduction improvements in urban Honolulu should proceed further into a feasibility phase.

Relevance to Ala Wai System or Watersheds in General: The existent flood control facilities were planned and designed using traditional fluvial design and construction criteria; very few existing flood control works in Hawaii are designed to accommodate landslides or debris flow effects.

Findings: This study of the New Year's Eve Flood of 1987 was limited to the eastern end of O'ahu. $35M estimated damages resulted from intense, localized rainfall during a 24-hour period. Neither the current meteorological capabilities nor the present flood control facilities proved adequate to predict or control the flooding. Post-flood studies indicated that excessive runoff accompanied by landslides and debris flows all contributed to the failure of the flood control and drainage system; blockage of drainage systems caused diversions of flood waters, resulting in extensive damage to many upland neighborhoods.

Recommendations: Prevent the transport of debris into the existing flood control system by retaining the material upstream. Technical issues need resolution before investigations into the advisability of Federal participation can be initiated. There were no Federal guidelines for evaluating anticipated damages from debris flow flooding. There did not appear to be sufficient cause for the Federal government to participate in flood damage reduction studies in the other basins of Ko'olau Poko and Honolulu Districts.

Appendices

A	Urban Flooding and Debris Flow Analysis for Niu, 'Āina Haina, and Kuli'ou'ou Valleys
B	Environmental Effects of Alternative Measures
C	Feasibility Cost-Sharing Agreement (Wailupe)
D	Technical Appendix (Wailupe)
E	Technical Appendix (Niu)
F	Technical Appendix (Kuli'ou'ou)
G	Cultural Resources

Reference No.: 216
Title: Statewide Capital Improvements Program, Flood Control Projects
Prepared By: Fukunaga & Associates, Inc.
Prepared For: State of Hawaii, Department of Land and Natural Resources
Date of Publication: April 1994

Report Summary

Objectives: To formulate criteria for a State Capital Improvements Program (CIP) for flood control improvements and/or engineering studies. The program's intent is to identify State funding opportunities in flood control; this funding could be used to supplement County and/or Federal projects.

Relevance to Ala Wai System or Watersheds in General: Projects to mitigate flood problems in various areas were categorized by priority. Dredging of the Ala Wai Canal was one of the five high-priority projects identified for O'ahu.

Findings: The Ala Wai Canal 100-year flood zone is very extensive. The Canal carries combined flows from Mānoa and Pālolo Streams as well as drainage water from the Waikīkī-Ala Moana areas. Heavily silted conditions lead to threats of flooding in the lower reaches of the Mānoa-Pālolo watershed and the Waikīkī-Ala Moana area. A flooding problem persists with the Makiki Stream/Ditch due to inadequate interior drainage. The lower reaches of the Pālolo Mānoa Streams experience flooding due to inadequate capacity of natural streams and the situation is aggravated by 12 bridge crossings.

Recommendations: Dredge the Canal again; maintenance is the State's responsibility. Conduct a study to investigate possible solutions to the flooding problem of the Makiki Stream/Ditch. Determine the extent of improvements required, the costs of improvements, and the partition of funds between different agencies. Pool State and County resources to address project priorities.

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