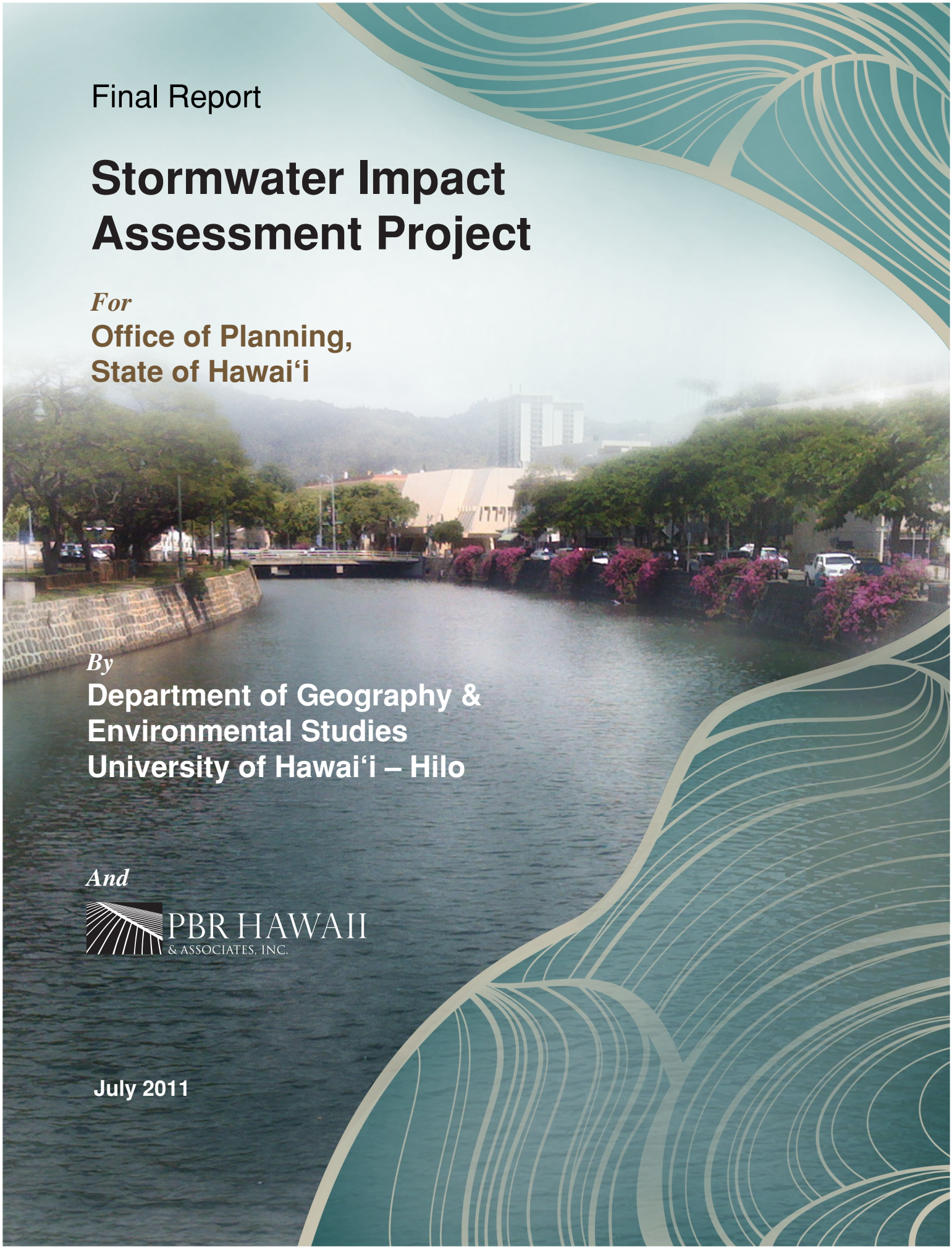
Final Report

Stormwater Impact Assessment Project

For

Office of Planning, State of Hawai‘i



By

Department of Geography & Environmental Studies
University of Hawai‘i – Hilo

And

PBR HAWAII & ASSOCIATES, INC.

July 2011

Final Report

Stormwater Impact Assessment Project

For

Coastal Zone Management Program
Office of Planning
State of Hawai'i

By

Department of Geography & Environmental Studies
University of Hawai`i-Hilo
James O Juvik Ph.D & Sonia P. Juvik Ph.D

And

PBR HAWAI`I

July 2011

A report of the Hawaii Office of Planning, Coastal Zone Management Program, pursuant to National Oceanic and Atmospheric Administration Award No. NA08NOS4190421, funded in part by the Coastal Zone Management Act of 1972, as amended, administered by the Office of Ocean and Coastal Resource Management, National Ocean Service, National Oceanic and Atmospheric Administration, United States Department of Commerce. The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA or any of its sub-agencies.

Hawaii CZM Program
Coastal Zone Management

Contents

ACRONYMS iii
Introduction 1
Study Objectives 1
Study Methodology 1
Current State of Practice in EIS's to Address Stormwater Impacts 2
HRS Chapter 343 Stormwater and Cumulative Impact Requirements 2
Stormwater Impacts 2
Cumulative Impacts 2
Representative Sampling of EIS's 3
Evaluation of Stormwater Impacts in EIS's 3
Rainfall 3
Topography, Soils and Erodibility 4
Drainage and Flood Hazard 4
Existing State of Practice to Assess Cumulative Impacts 4
Existing State of Practice to Incorporate EIS Mitigation Measures as Permit Conditions 6
Stormwater Regulatory Framework 6
Point Source Regulation under the NPDES 6
Nonpoint Source Stormwater Programs 11
Water Quality Standards for Receiving Waters 12
Proposed Methodology for Stormwater Cumulative Impact Assessment 17
State of the Art Guidance on Cumulative Impact Analysis 17
Watershed and Receiving Water Sensitivity 18
Available Watershed Studies and Methods of Analysis 19
Stormwater Modeling Parameters 21
Stormwater Mitigation Measures 25
Synthesis-- Recommended EIS Stormwater Cumulative Impact Methodology 28
Summary 29
Works Cited 30
Appendix A: Analysis of EIS Sample to Address Stormwater and Cumulative Impacts 33
Appendix B: Water Quality Standards Maps 55
Appendix C: Sensitive Watersheds 59
Appendix D: Useful GIS Sources for Stormwater Analysis 72

LIST OF FIGURES

Figure 1. Evaluation Methodology of Cumulative Impacts in EISs 4
Figure 2. Evaluation Results of Cumulative Impact Analysis in EIS Sample 5
Figure 3. Water Quality Standards Classification 13
Figure 4. Schematic of Locations of Waters of Increasing Salinity 14
Figure 5. Water Quality Standards Numeric Criteria 15
Figure 6. Relationship of Rainfall Rate, Infiltration Rate, and Runoff Rate 22
Figure 7. Hydrograph Before and After Urbanization 23
Figure 8. Effects of Impervious Surfaces on Runoff and Infiltration 24
Figure 9. Land Use Practices as Nonpoint Sources 25
Figure 10. Proposed Stormwater Cumulative Impact Assessment Steps 29
Figure 11. Representation by County 37
Figure 12. Representation by Project Type 37
Figure 13. Location by Project Type- Kauai 40
Figure 14. Location by Project Type- Oahu 40
Figure 15. Location by Project Type- Maui 41
Figure 16. Location by Project Type- Hawaii 41
Figure 17. Location by Project Size- Kauai 42
Figure 18. Location by Project Size- Oahu 42
Figure 19. Location by Project Size- Maui 43
Figure 20. Location by Project Size- Hawaii 43
Figure 21. Location by Date- Kauai 46
Figure 22. Location by Date- Oahu 46
Figure 23. Location by Date- Maui 47
Figure 24. Location by Date- Hawaii 47
Figure 25. Water Quality Standards Map- Kauai & Niihau 55
Figure 26. Water Quality Standards Map- Oahu 55
Figure 27. Water Quality Standards Map- Maui 56
Figure 28. Water Quality Standards Map- Molokai, Lanai, Kahoolawe 56
Figure 29. Water Quality Standards Map- Hawaii 57

LIST OF TABLES

Table 1. Sample Construction BMPs 9
Table 2. List of EISs 34
Table 3. Representation by Project Type 38
Table 4. Projects Sorted by Date 44
Table 5. Evaluation of Sample EISs 48

ACRONYMS

BMP	Best Management Practices
C-CAP	Coastal Change Analysis Program
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CNPCP	Coastal Nonpoint Pollution Control Program
CRAMP	Coral Reef Assessment & Monitoring Program
CZM	Coastal Zone Management
DBEDT	Department of Business, Economic Development and Tourism, State of Hawaii
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information System (computer mapping)
HAR	Hawaii Administrative Rules
HRS	Hawaii Revised Statutes
LA	Load Allocation (nonpoint sources)
LEED	Leadership in Energy & Environmental Design
LID	Low Impact Development
MEP	Maximum Extent Practicable
MS4	Municipal Separate Storm Sewer System
MUSLE	Modified Universal Soil Loss Equation
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent (application for NPDES General Permit)
PRCP	Polluted Runoff Control Program
NPDES	National Pollutant Discharge Elimination System
RUSLE	Revised Universal Soil Loss Equation
SWPPP	Stormwater Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
WLA	Waste Load Allocation (point sources)

Introduction

Study Objectives

Stormwater infiltration and runoff impacts affect the quality of groundwater, surface water, and nearshore coastal waters. The impacts occur during construction and during the long-term operational phase of a project. Managing stormwater and the effects of land use has changed significantly in recent decades. In the past, managing stormwater meant building drainage works such as pipes and lined channels to convey water quickly so it would not accumulate. However, speeding up the drainage of water out of one area often meant that storm flows increased downstream with the higher-velocity flow carrying more pollutants.

In recent years, the objectives of stormwater management has broadened through better understanding of the effect of impervious surfaces, the types of pollutants carried by stormwater, the effects on receiving waters, and the function of natural drainage systems. Control measures have evolved from structural methods to natural and biological measures, from centralized onsite measures to decentralized and watershed practices.

The purpose of this study is to examine whether the regulatory structure in Hawaii fosters these evolving best practices for stormwater management. The EIS in particular provides a means to integrate site-specific analyses in the context of the watershed through cumulative impact analyses. Since the EIS is usually prepared in the planning stages of the project for discretionary permits, the EIS could also provide an opportunity to influence, where appropriate, the consideration of broader objectives and adoption of innovative best practices in the issuance of design-phase permits (e.g., NPDES, grading permits).

The objectives of this study are:

- To assess the current state of practice in EIS's to address stormwater and cumulative impacts, and incorporation of mitigation measures as permit conditions;
- To summarize the complex regulatory requirements relating to stormwater management; and
- To recommend best practices to analyze cumulative stormwater impacts in EIS's in the context of a watershed management framework.

The recommendations are intended to initiate discussion among EIS practitioners, hydrologists, engineers, and other stakeholders to develop an integrative course of action.

Study Methodology

The recommendations in this report were developed based on the following methods:

1. *EIS Sampling to Assess Current State of Practice.* A representative sample of EIS's were examined to determine the current state of practice in analyzing stormwater and cumulative impacts. The EIS's were analyzed in terms of the following criteria:
    a. Whether the EIS addressed short-term and long-term stormwater runoff and erosion;
    b. Methodology used to develop mitigation measures;
    c. Methodology used to determine cumulative impacts;

d. Extent to which the mitigation measures were addressed, as applicable, in a Land Use Commission Decision and Order.

2. *Literature Review and Limited Agency Consultation to Understand the Existing Stormwater Regulatory Framework.* The primary sources of information included existing laws, regulations, EPA and State websites, technical reports, and consultation with the Department of Health staff handling the NPDES and nonpoint source watershed planning.
3. *GIS.* This study benefitted tremendously from previous GIS watershed data commissioned by the Office of Planning to identify sensitive watersheds, particularly *Hawaii Watershed Prioritization Process* (Marine and Coastal Solutions International, 2009).

Current State of Practice in EIS's to Address Stormwater Impacts

HRS Chapter 343 Stormwater and Cumulative Impact Requirements

Stormwater Impacts

Hawaii's EIS Rules require Draft EISs to address pollution effects by referencing various pollution control statutes:

> *The draft EIS shall address all probable adverse environmental effects which cannot be avoided. Any adverse effects such as water or air pollution, urban congestion, threats to public health, or other consequences adverse to environmental goals and guidelines established by environmental response laws, coastal zone management laws, pollution control and abatement laws, and environmental policy such as that found in chapters 128D, 205A, 342B, 342C, 342D, 342E, 342F, 342G, 342H, 342I, 342J, 342L, 342N, 342P, and 344, HRS, shall be included, including those effects discussed in other actions of this paragraph which are adverse and unavoidable under the proposed action. Also, the rationale for proceeding with a proposed action, notwithstanding unavoidable effects, shall be clearly set forth in this section. The draft EIS shall indicate what other interests and considerations of governmental policies are thought to offset the adverse environmental effects of the proposed action. The statement shall also indicate the extent to which these stated countervailing benefits could be realized by following reasonable alternatives to the proposed action that would avoid some or all of the adverse environmental effects. (HAR 11-200-17.L.)*

This reference to HRS Chapters 205A (Coastal Zone Management), 342D (Water Pollution), and 342E (Nonpoint Source Pollution Management and Control) suffices as a specific mandate for EISs to address stormwater impacts.

Cumulative Impacts

At the federal level, cumulative impact analysis requirements arise from the Council of Environmental Quality's regulations addressing the scope of an EIS (40 CFR 1508.25). The regulations define cumulative impact as follows:

> *"Cumulative impact" is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. (40 CFR 1508.7)*

At the State level, the Environmental Council's EIS Rules define cumulative impacts similarly to the federal definition (HAR §11-200-2). The content specifications for an EIS include cumulative impacts (HAR §11-200-16).

Although EPA's definition of stormwater focuses on *surface runoff*—the water that "washes down storm drains on the curbs of roads and leads directly into lakes, rivers, and streams untreated" (U.S. Environmental Protection Agency, website-b)—EIS's should also address the impacts of the stormwater component that *infiltrates* as a direct, secondary, and/or cumulative impact. For Hawaii, this is particularly salient and significant because of the high permeability of lava flows in certain areas. For example, the NPDES requirements do not include mitigation requirements for pollutants that may be carried in solution by infiltrating stormwater. The LEED credits for stormwater treatment focus on removal of total suspended solids and phosphorus, which are carried by surface runoff, and do not address removal of soluble nutrients that may be infiltrating. The EIS requirement to assess cumulative impacts broadens the scope of concern to properly assess the surface runoff and infiltration at the project and regional levels.

Representative Sampling of EIS's

DBEDT provided a list of 34 EIS's to comprise the sample. The detailed analysis is in Appendix A: Analysis of EIS Sample to Address Stormwater and Cumulative Impacts. This list varies as a representative sample in terms of:

- Jurisdiction. The 34 projects are located on the four major islands of the four counties—i.e., Kauai, Oahu, Maui, and Hawaii islands. Oahu and Hawaii are heavily represented with 13 EISs each, while Maui has 5 and Kauai 3 projects.
- Project Types. There is a good representation by project type—4 resorts, 4 commercial-industrial, 4 institutional, 2 large lot residential, and 20 residential projects with commercial or golf course.
- Project Sizes. There are no small projects under the 1 acre NPDES threshold. The projects range in size from 56 to 1,781 acres.
- Climate Regimes. Only two projects were located in wetter climate regimes on the windward side of the islands—one on Maui and one on Oahu.

The dates of the EIS's spanned from 1981 to 2010-- 8 prepared in the 1980s, 6 in the 1990s, and 20 in the 2000s.

Evaluation of Stormwater Impacts in EIS's

Major factors contributing to stormwater runoff include rainfall, topography (slope), soil type and erodibility, and surface drainage features. This section reviews the treatment of these factors by the sample of EISs to evaluate to what extent EISs currently address these basic stormwater factors. With a few exceptions (e.g. #23, # 29), EISs most often address these factors in a fairly cursory manner. In some cases this is understandable for projects proposed on recent lava flow lands with low potential for surface runoff or erosion (especially on Hawai`i Island).

Rainfall

All EISs provided annual rainfall data in terms of average or median. However, none of the EISs provided monthly rainfall for seasonal rainfall patterns. Only 8 (25%) of the 32 EISs estimated maximum rainfall intensity (inches/hr) values for their project sites and those documented intensity ranges of 1.75-4.5 in/hr. Because maximum rainfall intensity is an important variable in considerations of surface storm water runoff and erosion, failure to consider this variable, relative to project impact and possible mitigation measures, must be considered a significant omission in many of the EISs evaluated.

Topography, Soils and Erodibility

Slope. Slope conditions for the EISs under review varied from 0-50%, with the higher range slope values generally restricted to incised stream channels and steep, ephemeral gulches found within some of the project areas. However, these very steep slopes are not typically proposed for actual alteration or development. Twenty-five (78%) of all projects were within areas where local slope conditions ranged from 0-15%.

General soil conditions and erodibility. Soil condition across the 32 project sites ranged from largely barren recent lava flows (soil absent) on Hawai`i Island to well developed, deep loam and clay soils on the older islands of Kauai and Oahu (see Table 5 for specific soil types). Based on the soil erodibility factors (USDA-NRCS criteria) associated with these different soil types and related slope conditions, 18 (56%) of the projects rated site specific erodibility as "low", 8 (25%) a "low-moderate", or "moderate"; and 4 (13%) as "low or moderate" to "severe". Two projects (6%) failed to address soil type or erodibility.

Twenty-three (72%) of the EISs discussed construction-related erosion impacts and mitigation (typically commitments to follow best-practices requirements in necessary grading permits). Nine (28%) EISs failed to address construction-related soil erosion impact or mitigation, in some cases because relatively barren lava lands were involved (Hawai`i Island). Post construction erosion impact was acknowledged and discussed in 11 (34%) of the EISs under review, and in 5 (16%) project impacts were described as resulting in reduced site erosion as compared with pre-existing erosion conditions, were the property left undeveloped. Twenty-six (81%) of the 32 EISs reviewed described mitigation measures to minimize erosion (including sediment collection basins, vegetation planting, and non-development buffers around natural drainage features, etc.).

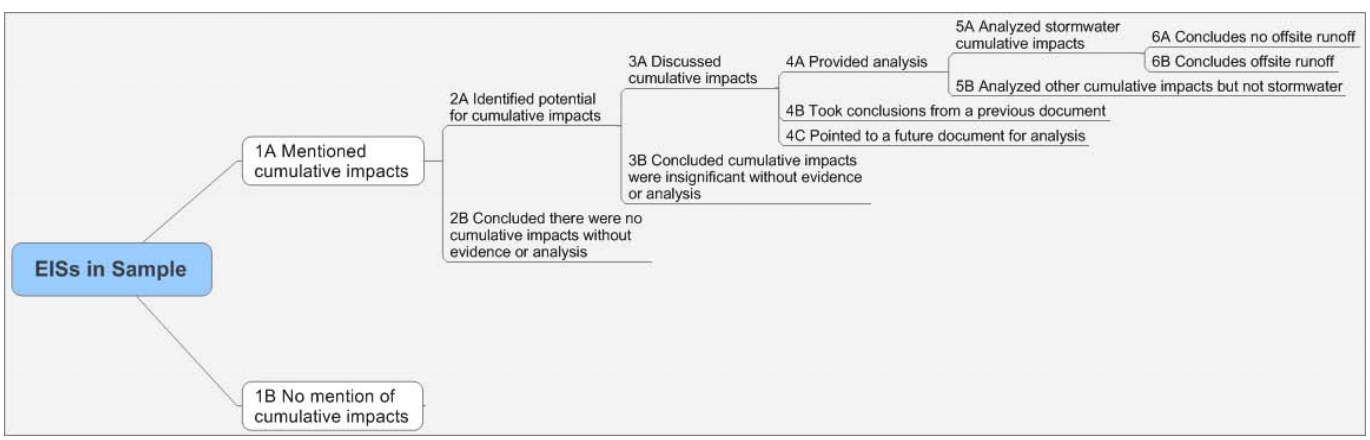
Drainage and Flood Hazard

Only 10 (31%) of the EISs indicated the presence of either perennial or ephemeral stream channels within or immediately adjacent to the project sites. Flood hazard zones were identified for each project. Thirteen of the EIS projects (41%) were reported as being in Zone "X"; 7 (22%) in Zone "C"; 6 (19%) in Zone "D" with the remainder (6 or 19%) in mixed zone settings including coastal areas with potential for ocean storm wave or tsunami inundation (Zone "V").

Existing State of Practice to Assess Cumulative Impacts

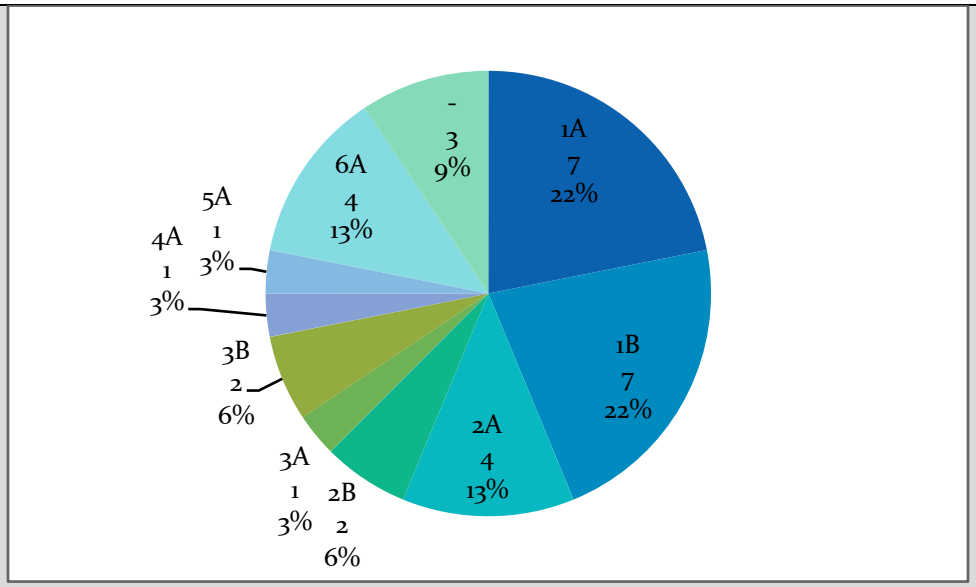
The sample of EISs were evaluated for their assessment of cumulative impacts according to the sorting method in Figure 1 (adapted from CEQ 1997):

Figure 1. Evaluation Methodology of Cumulative Impacts in EISs



The results are summarized in Figure 2. Three projects (#1, 9 and 16) had no code assigned because the environmental impact documents were unavailable or incomplete. For those 7 EISs (22%) that failed to specifically mention or discuss cumulative impact (1B), a possible reason is that the applicant concluded that there would be no additional runoff (and in some cases even reduced run off), and consequently no cumulative impact on storm water discharge. Another 7 EISs (22%) mentioned cumulative impacts relative to storm water and erosion, but provided little substantive analysis (1A). The single EIS (#23, Makaiwa, Ewa) that provided a through analysis of cumulative storm water impact must have been prompted by the existence of steep terrain and erodible clay soils at the project site (5A).

Figure 2. Evaluation Results of Cumulative Impact Analysis in EIS Sample



Cumulative Stormwater (code)‡	ID	Petitioner	Island	Total
1A	12	SCD Kaloko Makai, LLC (Kaloko Makai)	Hawaii	1
	13	Forest City (Kamakana)	Hawaii	1
	15	A&B Properties, Inc.(Spreckelsville Mauka)	Maui	1
	22	Haseko (Ewa Marine)	Oahu	1
	24	State of Hawaii, HCDCH (East Kapolei Master Plan)	Oahu	1
	26	Gentry Investment Properties (Ewa Makai)	Oahu	1
	27	Aina Nui Corporation (Kapolei West)	Oahu	1
1A Total				7
1B	3	Kona Beach Development Venture (Kohanaiki)	Hawaii	1
	4	Huehue Ranch	Hawaii	1
	10	1250 Oceanside Partners (Hokulia)	Hawaii	1
	17	Maalaea Properties, LLC; Lodi Development, Inc.(Maalaea Mauka)	Maui	1
	18	Olowalu Town LLC and Olowalu Ekolu LLC	Maui	1
	19	Kukui'ula Development Company, Inc.	Kauai	1
	20	Destination Villages Kauai, LLC (Kapalawai Resort)	Kauai	1
1B Total				7
2A	5	Bridge Aina Lea, LLC (Villages at Aina Lea)	Hawaii	1
	8	TSA International, Ltd. (Kaloko Commercial Center)	Hawaii	1

	28	Kapolei Property Development, LLC	Oahu	1
	30	Castle & Cooke Homes Hawaii, Inc.(Koa Ridge (Makai & Waiawa)	Oahu	1
2A Total				4
2B	6	(Kaupulehu Development)	Hawaii	1
	7	Lanihau Properties, LLC (Kaloko-Honokohau Business Park)	Hawaii	1
2B Total				2
3A	25	University of Hawaii, West Oahu	Oahu	1
3A Total				1
3B	31	Hawaiian Memorial Park, LTD (Hawaiian Memorial Park Expansion)	Oahu	1
	32	Dept of Env Serv, C&C of Hon (Waimanalo Gulch Landfill)	Oahu	1
3B Total				2
4A	29	DR Horton - Schuler Homes, LLC (Hoopili)	Oahu	1
4A Total				1
5A	23	Estate of James Campbell (Makaiwa Hills)	Oahu	1
5A Total				1
6A	2	Mauna Kea Properties, Inc (Mauna Kea Resort)	Hawaii	1
	11	North Kona Village, LLC (O'oma Beachside Village)	Hawaii	1
	14	Hawaii Finance and Development Corp (Villages of Leialii)	Maui	1
	21	Eric A Knudsen Trust	Kauai	1
6A Total				4
-	1	Y-O Limited Partnership	Hawaii	1
	9	Kamehameha Investment Corp. (Keauhou Subdivision)	Hawaii	1
	16	Kaanapali Development Corp.	Maui	1
- Total				3
Grand Total				32

Existing State of Practice to Incorporate EIS Mitigation Measures as Permit Conditions

For 16 (70%) of the 23 approved petitions, the Land Use Commission attached conditions dealing with drainage and storm water mitigation requirements for the projects. In most cases, conditions simply asserted the need for compliance with other Federal, State or County regulations/codes to be enforced during various project development phases. In some cases where petitions were denied (e.g. #31), storm water and erosion issues were cited as contributing to the denial decision.

Stormwater Regulatory Framework

The existing regulations attempt to manage the source of stormwater pollutants by distinguishing whether the source is a point or nonpoint source. A point source is a discrete discharge. A nonpoint source, also referred to as "polluted runoff", comes from multiple diffuse sources ((U.S. Environmental Protection Agency, website-g). The primary impetus for point and nonpoint source regulations are federal laws and regulations administered by the states but overseen by federal agencies. For point sources, the federal permit is the National Pollutant Discharge Elimination System (NPDES). For nonpoint sources, the federal program comes under the Clean Water Act and the Coastal Zone Management Program.

Point Source Regulation under the NPDES

NPDES Source of Authority. The State Department of Health (DOH) implements the NPDES permit system under HAR 11-55, promulgated pursuant to the authority of HRS 342D. The NPDES

program is a federal permit pursuant to the Clean Water Act of 1977, as amended by the 1987 Water Quality Act (P.L. 100-4) that extended the NPDES permit requirements to stormwater. Under delegated authority from the U.S. Environmental Protection Agency (EPA), the Department of Health (DOH) may issue NPDES individual permits (HAR 11-55-15) or approve coverage under a NPDES General Permit.

Stormwater Point Sources. The NPDES program regulates stormwater discharges from three potential sources: municipal separate storm sewer systems (MS4s), construction activities, and industrial activities. Since the NPDES program regulates point sources, EPA considers these three stormwater sources to be point sources (U.S. Environmental Protection Agency, website-e). There are two types of NPDES permits: an Individual Permit and a General Permit. An Individual Permit is usually for wastewater discharges. Most industrial and construction activities would qualify for the General Permit, except where the discharge is into Class AA or Class 1 waters. The NPDES General Permits are included as appendices to HAR 11-55 and cover industrial activities (Appendix B), construction sites (Appendix C), and Municipal Separate Storm Sewer Systems (MS4s).

Construction Activity NPDES General Permit. Since most EAs and EISs will involve construction, this study focuses on the NPDES requirements relating to construction sites. The General Permit for construction sites has a duration of five years; thus, a project receiving coverage in the first year of the General Permit has the full five years, compared to a project that receives coverage in the fourth year of the General Permit that would have just one year of coverage. Upon expiration of the General Permit's five years, all projects covered by that General Permit that have not closed must reapply. The rationale for the five-year period is in recognition that knowledge and technology evolve, and projects should employ the latest best practices.

Construction BMP Plan. The NPDES Notice of Intent (NOI), which functionally serves as the application for a General Permit, is usually submitted to DOH by an engineer on behalf of the landowner or developer (but a person with authorization to manage the contractor must sign and be liable under the permit) when grading plans have been completed. The NOI must include a "construction site best management practices plan" (HAR 11-55 Appendix C, §4(b)). EPA has produced a readable guide for developing such a plan—"Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites" (U.S. Environmental Protection Agency, 2007a). According to this guide, a stormwater pollution prevention plan (SWPPP, aka known as Construction Site Best Management Practices Plan, Erosion and Sediment Control Plan, or other similar plan) should contain the following elements:

- Site and activity description
- Identification of potential pollutant sources
- Description of controls to reduce pollutants
- Maintenance/inspection procedures
- Records of inspections and follow-up maintenance of BMPs
- Amendments and certifications.

The Guide suggests a site assessment as the first step in developing the SWPPP. The pertinent features identified by the Guide include features that an EA or EIS should perhaps address such as:

- Existing drainage pattern determined from a topographic map and showing as applicable streams, wetlands, and nearshore waters in the vicinity
- Features affecting erosion

    - Slopes and slope lengths
    - Soil types and particularly highly erodible soils
    - Rainfall seasonality and intensity
- Past soil contamination
- Features to be protected including trees, historic sites, endangered species, wetlands, and other sensitive resources
- Percentage of impervious surface area before and after construction
- Calculation of runoff coefficient before and after construction; runoff coefficient is the portion of total rainfall which will become runoff; coefficients generally range from 0.95 (highly impervious) to 0.05 (vegetated surface that generates little runoff).

The Guide suggests the following BMP strategies to control stormwater runoff during construction:

- Erosion control (keep the dirt in place) and minimizing the impact of construction—the first line of defense:
    - Minimize the disturbed area and stabilize soils promptly. Get the site to final grade and either permanently or temporarily stabilize all bare soil areas as soon as possible.
    - Phase construction activity. Clear only land that will be under construction in the near future.
    - Control the perimeter of the site. Divert stormwater coming on to the site by conveying it safely around, through, or under the site; divert the clean water, trap the dirty water.
    - Protect slopes and channels. Convey concentrated stormwater runoff around the top of slopes and stabilize slopes as soon as possible.
    - Reduce impervious surfaces and promote infiltration. Reducing impervious surfaces will ultimately reduce the amount of runoff leaving the site.
- Sediment controls (capture any sediment that is moved by stormwater before it leaves the site)—the second line of defense:
    - Protect storm drain inlets.
    - Establish perimeter controls.
    - Retain sediment on-site and control dewatering practices.
    - Establish stabilized construction exits to prevent tracking onto highways.
    - Inspect and maintain controls.
    - Protect receiving waters adjacent to the site. Consider additional controls on areas adjacent to receiving waters.
- Follow pollution prevention measures. Provide proper containers for waste and garbage at the site; store hazardous materials and chemicals so that they are not exposed to stormwater.

Table 1 is a sample of specific construction BMPs related to the above strategies.

Table 1. Sample Construction BMPs

Proposed Construction Site BMPs

CATEGORY	BMP #	BMP NAME
Erosion Control BMPs	EC-1	Scheduling
	EC-2	Preservation of Existing Vegetation
	EC-3	Hydraulic Mulch
	EC-4	Hydroseeding
	EC-5	Soil Binders
	EC-6	Straw Mulch
	EC-7	Geotextiles, Plastic Covers & Erosion Control Blankets/Mats
	EC-8	Wood Mulching
	EC-9	Earth Dikes/Drainage Swales & Lined Ditches
	EC-10	Outlet Protection/Velocity Dissipation Devices
	EC-11	Slope Drains
	EC-12	Stream bank Stabilization
Sediment Control BMPs	SC-1	Silt Fence
	SC-2	Desilting Basin
	SC-3	Sediment Trap
	SC-4	Check Dam
	SC-5	Fiber Rolls
	SC-6	Gravel Bag Berm
	SC-7	Street Sweeping and Vacuuming
	SC-8	Sandbag Barrier
	SC-10	Storm Drain Inlet Protection
Wind Erosion Control BMPs	WE-1	Wind Erosion Control
Tracking Control BMPs	TC-1	Stabilized Construction Entrance/Exit
	TC-2	Stabilized Construction Roadway
	TC-3	Entrance/Outlet Tire Wash
Non-Storm Water Control BMPs	NS-1	Water Conservation Practices
	NS-2	Dewatering Operations
	NS-3	Paving and Grinding Operations
	NS-4	Temporary Stream Crossing
	NS-5	Clear Water Diversion
	NS-6	Illicit Connection/Illegal Discharge Detection and Reporting
	NS-7	Potable Water/Irrigation
	NS-8	Vehicle and Equipment Cleaning
	NS-9	Vehicle and Equipment Fueling
	NS-10	Vehicle and Equipment Maintenance
	NS-11	Pile Driving Operations
	NS-12	Concrete Curing
	NS-13	Concrete Finishing
	NS-14	Material and Equipment Use Over Water
	NS-15	Structure Demolition/Removal Over or Adjacent to Water
	NS-16	Temporary Batch Plants
Waste Management & Materials Pollution Control BMPs	WM-1	Material Delivery and Storage
	WM-2	Material Use
	WM-3	Stockpile Management
	WM-4	Spill Prevention and Control
	WM-5	Solid Waste Management
	WM-6	Hazardous Waste Management
	WM-7	Contaminated Soil Management
	WM-8	Concrete Waste Management
	WM-9	Sanitary/Septic Waste Management
	WM-10	Liquid Waste Management

Source: City and County of Honolulu, March 2007. Stormwater Management Plan, p. 6-7.

Construction vs. Permanent BMPs. Best management practices include BMPs during construction and post-construction (or permanent) BMPs. Permanent BMPs include low-impact development (LID) or green infrastructure techniques. The General Permit in HAR 11-55 Appendix C lists permanent BMPs as one of the elements to be included in a SWPPP:

> *Construction site best management practices plan containing, at a minimum, the following information:*
>
> *(J) Descriptions of measures that will minimize the discharge of pollutants via storm water discharges after construction operations have been finished. Examples include: open, vegetated swales and natural depressions; structures for storm water retention, detention, or recycle; velocity dissipation devices to be placed at the outfalls of detention structures or along with the length of outfall channels; and other appropriate measures; (HAR 11-55 Appendix C§4.B.2(J))*

Since permanent BMPs could affect the site plan, size of rights-of-way, and costs, ideally they should be considered early in the planning phase such as by an EIS, as advised by the Department of Transportation:

> *In certain situations, permanent BMPs can be extremely difficult to accomplish and may affect the feasibility of the highway alternatives being evaluated. The requirements and rights-of-way demands of permanent BMPS can greatly affect the selection of project preferred alternatives. Therefore, it is critical to develop permanent BMPs early during the project planning phase and include them in impact assessment and project cost estimating. Early consideration of storm water permanent BMPs will likely lead to more cost-effective projects. (State of Hawaii Department of Transportation, 2007)*

NPDES vs. County Approvals (Grading Permits, Drainage Plans, Flood Management). The State Department of Health issues the NPDES permit, while the counties issue other approvals related to stormwater-- grading permits, drainage plan approval, and flood control standards. Some of these approvals, particularly the NPDES permit, address both the *quantity* and *quality* issues relating to stormwater management. The grading permits focus on just one aspect of stormwater *quality*-- erosion and sedimentation. Drainage standards and flood management usually focus on stormwater *quantity* issues. However, in the case of the City and County of Honolulu, which is subject to NPDES regulation as a MS4, the City's Rules Relating to Storm Drainage Standards includes a section addressing storm water *quality* as a means for the City to comply with its NPDES permit to reduce stormwater pollutants to the maximum extent practicable. In the absence of a NPDES requirement, the other counties have not proactively updated their drainage standards to incorporate stormwater *quality* measures.

The common trigger for the NPDES and grading permits is the size of the site disturbance area. Where the site disturbance area exceeds one acre, the project will require both a grading and NPDES permit. The applications could be processed concurrently, but the counties will usually require proof that a NPDES Notice of Intent has been submitted to the State Department of Health. For site disturbance less than an acre, the project will require just a grading permit if the project exceeds the minimum area or earthmoving quantity (for example, the County of Hawaii would require a grading permit for a site disturbance less than an acre if the project requires more than 100 cy of excavation or fill).

The trigger to review whether a project is located within a 100-year flood zone usually occurs at a discretional planning permit (e.g., rezoning, special permit, SMA), subdivision, and/or building permit. The trigger for a drainage plan is less definitive. One purpose of county drainage

standards is to design public drainage facilities. The trigger to apply these standards to private projects usually occurs as a condition of discretionary planning permits, subdivision approval, or when required by grading permit applications.

Drainage standards attempt to ensure that the runoff quantity from a proposed project would not cause downstream capacity to be exceeded. Ideally, the downstream capacity should be determined based on the assumption of a fully developed watershed to prevent a "first come, first serve" approach where downstream development unduly constrains upstream development. Where an EIS has been prepared for the project, the EIS could provide pertinent information to define the fully developed watershed—i.e., the past, present, and reasonably foreseeable future development that is the purview of a cumulative impact analysis.

Nonpoint Source Stormwater Programs

Coastal Nonpoint Pollution Control Program. Pursuant to 1990 amendments to the Coastal Zone Act, the Coastal Zone Management Program (CZM), Office of Planning, administers the Coastal Nonpoint Pollution Control Program (CNPCP) to develop a CNPC program for Hawaii which meets Federal approval.

Polluted Runoff Control Program. The 1987 amendments to the Clean Water Act established the Section 319 Polluted Runoff Control Program (PRCP), which is a planning and grant program—i.e., EPA does not have any regulatory program for nonpoint sources comparable to the NPDES permit for point sources. The Department of Health administers an annual nonpoint source grant program under guidance from the Clean Water Act §319 (under EPA). To coordinate the nonpoint pollution control programs, the CNPCP and PRCP jointly prepared an Integrated Plan (DOH & CZM July 2000) to meet the requirements of EPA and NOAA. The Integrated Plan presents 15-year strategies and 5-year implementation plans to prevent and reduce polluted runoff in six categories: agriculture, forestry, urban, marinas and recreational boating, hydromodifcation, wetlands and riparian areas (State of Hawaii Department of Health, website).

Watershed Management Plans. Besides the grant program, the DOH encourages interested groups to develop watershed management plans.

> *A watershed plan is a strategy and a work plan for achieving water resource goals for a specific watershed. The watershed planning process uses a series of cooperative, iterative steps to characterize existing conditions, identify and prioritize problems, define management objectives, and develop and implement protection or remediation strategies as necessary. (State of Hawaii Department of Health, website)*

As a partner with DOH in nonpoint pollution prevention, the CZM Program, Office of Planning prepared *A Watershed Guidance* (Tetra Tech EM, Inc., 2010) to help local community organizations understand and prepare watershed plans in compliance with EPA guidelines for 319 funding (under the Clean Water Act) and also serve as a means to reintroduce the 6217 (g) measures (under the Coastal Zone Management Act). The watershed plans are intended to implement a set of "management measures" as a means to reduce the polluted runoff that reaches surface, ground and marine waters. Management measures are the best available, economically achievable practices or combinations of practices that can be used to address nonpoint source pollution. The management measures are designed to control runoff from six main sources discussed in the aforementioned Integrated Plan (i.e., forestry, agriculture, urban areas, marinas, hydromodification (shoreline and stream channel modification), and wetlands and vegetated shorelines, or riparian areas).

Priority Watersheds. Priority watersheds in Hawai`i are areas where opportunities to achieve water quality improvements have been identified (Tetra Tech EM, Inc., 2010). The priority criteria include areas that have:

- a watershed plan that meets EPA requirements,
- an approved TMDL or TMDL implementation plan,
- substantial partnerships,
- not currently impaired and require efforts to ensure these waters remain unimpaired by nonpoint source pollution.

Funding from Section 319 grants emphasizes implementing activities in priority watersheds but also allows for the support of watershed plan development. Current priority watersheds in Hawai`i are listed below (Tetra Tech EM, Inc., 2010):

- Kauai
    - Nawiliwili Bay watersheds – includes Puali, Huleai, and Nawiliwili stream watersheds
    - Hanalei Bay watersheds – includes Hanalei, Waikoko, Waipa, and Waioli watersheds
- Oahu
    - Ala Wai watersheds – includes Manoa-Palolo, Makiki, Ala Wai watersheds
    - Ko`olaupoko watersheds – includes Windward Oahu watersheds from Kualoa to Makapuu
- Maui, Molokai, Lanai
    - Kapakahi Stream watershed
    - South Moloka`i watersheds – includes watersheds from Kaluapeelua to Ohia
    - West Maui – includes watersheds from Launiupoko to Honolua
- Hawaii
    - Pelekane Bay watershed
    - Hilo Bay watersheds – includes Wailuku, Honolii, Paukaa, Maili, Pukihae, Wainaku, and Wailoa watersheds.

Water Quality Standards for Receiving Waters

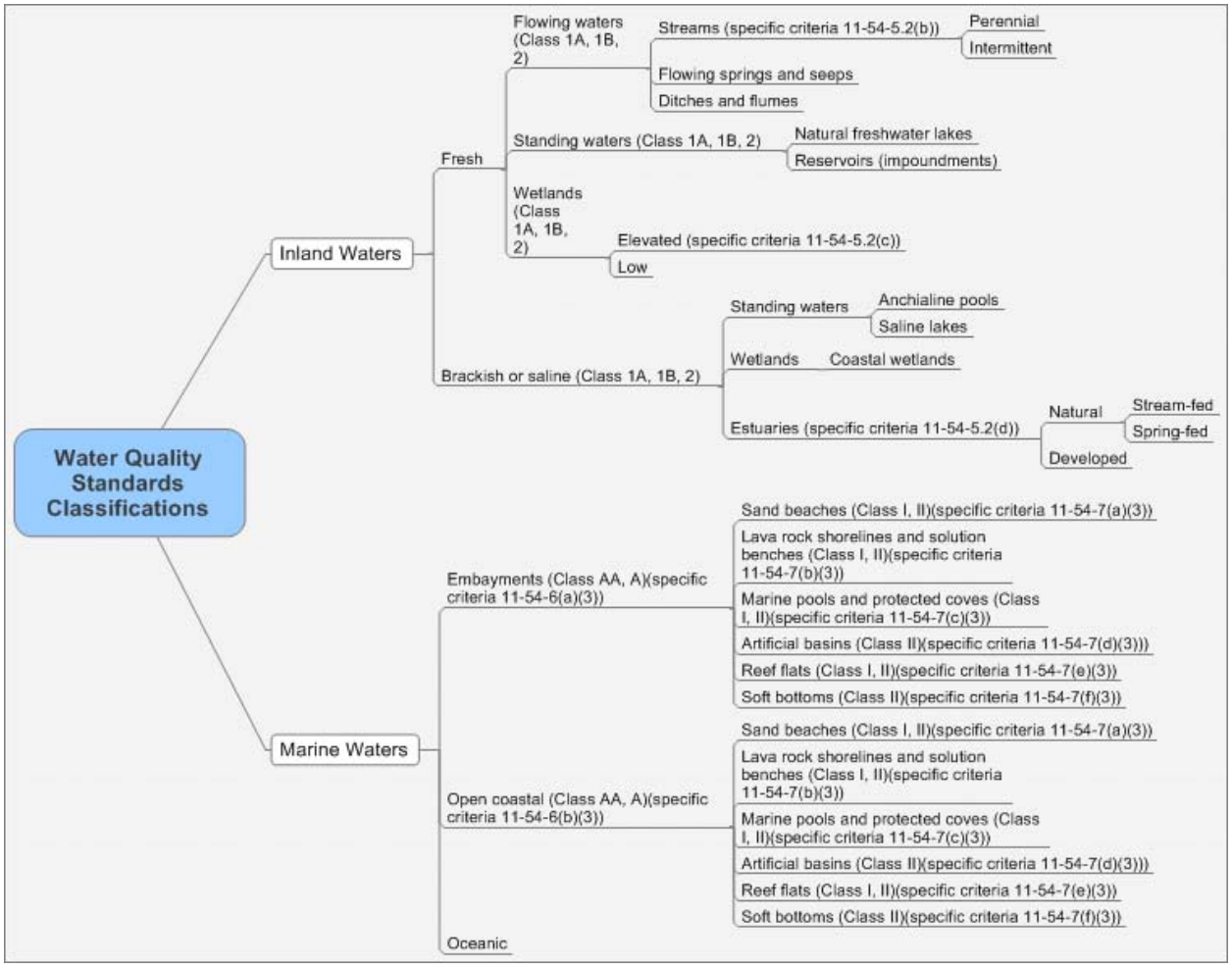
TMDL as a Means to Meet Clean Water Goals. The goal of the federal Clean Water Act is to have all waters "fishable and swimmable" (EPA's shorthand articulation of the Clean Water Act goal set forth in §101(a) for "protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water"). A high priority for cleanup are "impaired waters"—these are waters "that are too polluted or otherwise degraded to meet the water quality standards set by states" (U.S. Environmental Protection Agency, website-d). The Clean Water Act §303(d) requires that these jurisdictions "establish priority rankings for waters on the lists and develop TMDLs for these waters. A Total Maximum Daily Load, or TMDL, is a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards" (U.S. Environmental Protection Agency, website-d). The TMDL consists of allocations to point sources (referred to as "waste load allocations" or WLA) and to nonpoint sources (referred to as "load allocations" or LA), with a margin of safety and seasonal adjustments (Tetra Tech EM, Inc., 2010).

Water Quality Standards. Each state identifies "impaired waters" relative to its water quality standards. HAR 11-54 sets forth Hawaii's water quality standards, pursuant to HRS §342D-5. The water quality standards apply to "State waters" as defined in HRS §342D-1, which includes all fresh, brackish, and salt waters around and within the State, except: groundwater; ditches,

flumes, ponds, reservoirs that are part of a pollution runoff control system; and ditches, flumes, ponds, reservoirs that are used solely for irrigation and do not overflow into other State waters.

HAR 11-54 classifies State waters into inland and marine ecological categories and assigns protected uses to the various water classes. Class 1 for inland waters and Class AA for marine waters are the use classifications intended to protect identified waters in their natural state, particularly those located within natural reserves, preserves, sanctuaries, national and state parks, critical habitats, or the protective subzone of the Conservation District (see Appendix B: Water Quality Standards Maps). Areas not in those protective classes allow NPDES discharges with best treatment practices (Class 2, Class A, and Class II). The standards specify general criteria (physical, chemical, biological, bacteriological parameters) that are applicable to all classifications and specific criteria applicable to specific water types, and require sampling methods that account for natural variability and seasonal (wet/dry) differences.

Figure 3. Water Quality Standards Classification

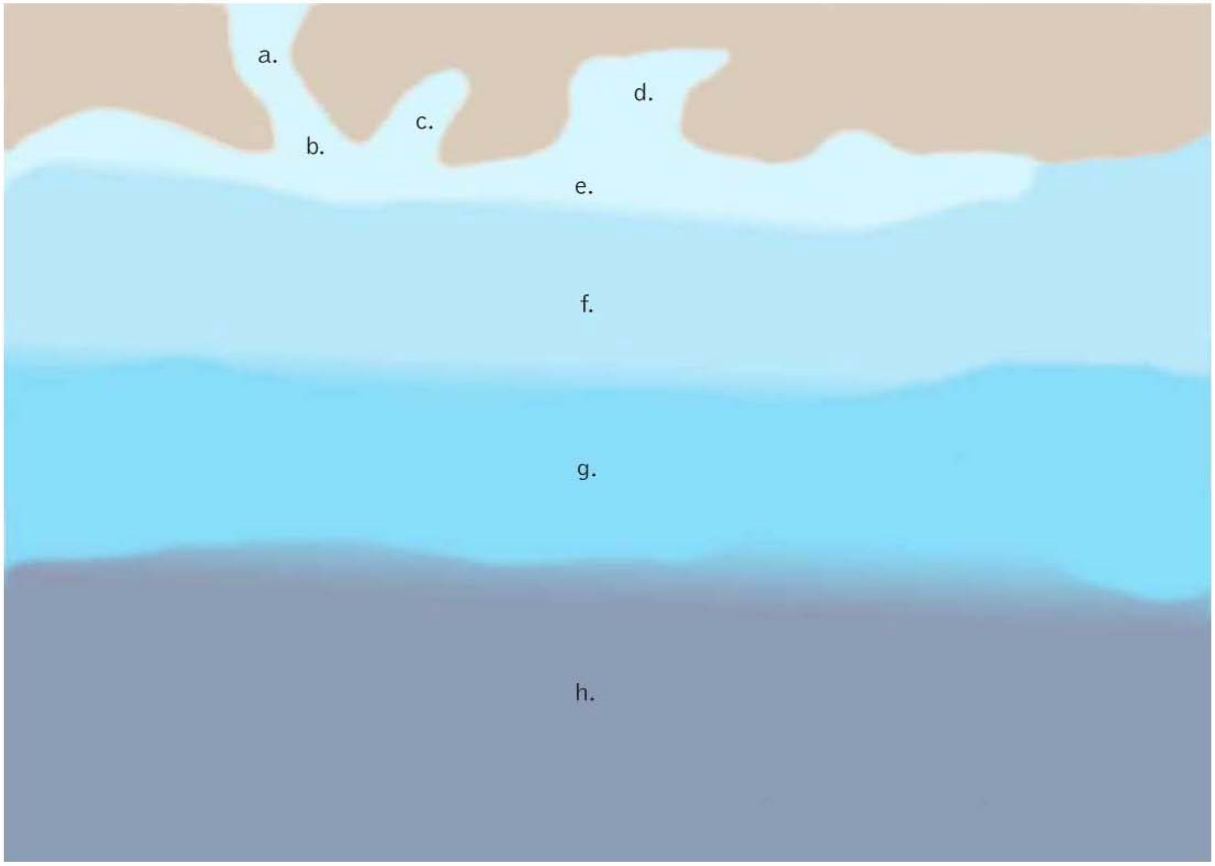


In a review of the existing water quality standards, a fundamental recommended change was to distinguish the various ecosystem types by salinity ranges based on the following rationale (see Figure 4):

> *Because most pollutants originate on land and are initially transported in non-tidal freshwater flows to sea level, and then transported in tidally-influenced brackish and saline coastal waters seaward to*

rransitional oceanic waters, a mixing gradient will exist such that pollutant concentrations and loads are progressively diluted by waters of increasing salinity from inland to the saline coastal waters and then to transitional oceanic waters. (State of Hawaii Department of Health, 2005, p. 10)

Figure 4. Schematic of Locations of Waters of Increasing Salinity



a. Stream; salinity ≤0.5 ppt (freshwaters)
b. Estuary; salinity >0.5 to ≤30.0 ppt (brackish waters)
c. Narrow bay; salinity often brackish (>0.5 to ≤30.0 ppt)near back of bay; water may be saline (> 30.0 ppt to ≤34.5 ppt) where it discharges into nearshore waters
d. Harbor; usually partly or full constructed by humans; salinity often brackish (>0.5 to ≤30.0 ppt near back of harbor); water may be saline (>30.0 ppt to ≤34.5 ppt) where it discharges into nearshore waters
e. Brackish nearshore waters (salinity >0.5 to ≤30.0 ppt), as a function of pattern and size of ground water seeps into tidally-influenced surface waters. Ground water flow lines generally converge toward deep indentations into the shoreline, resulting in brackish waters in the landward ends of narrow bays and harbors.
f. Saline nearshore waters (salinity >30.0 ppt to ≤34.5 ppt)
g. Transitional oceanic waters (salinity >34.5 ppt to <36.0 ppt)
h. Oceanic waters (salinity ~ 35.0 ppt; very stable)

Source: (State of Hawaii Department of Health, 2005)

This change to a salinity-based classification would remove the problem of identifying "embayments, " defined in the existing water quality standards as "the ratio of total bay volume to

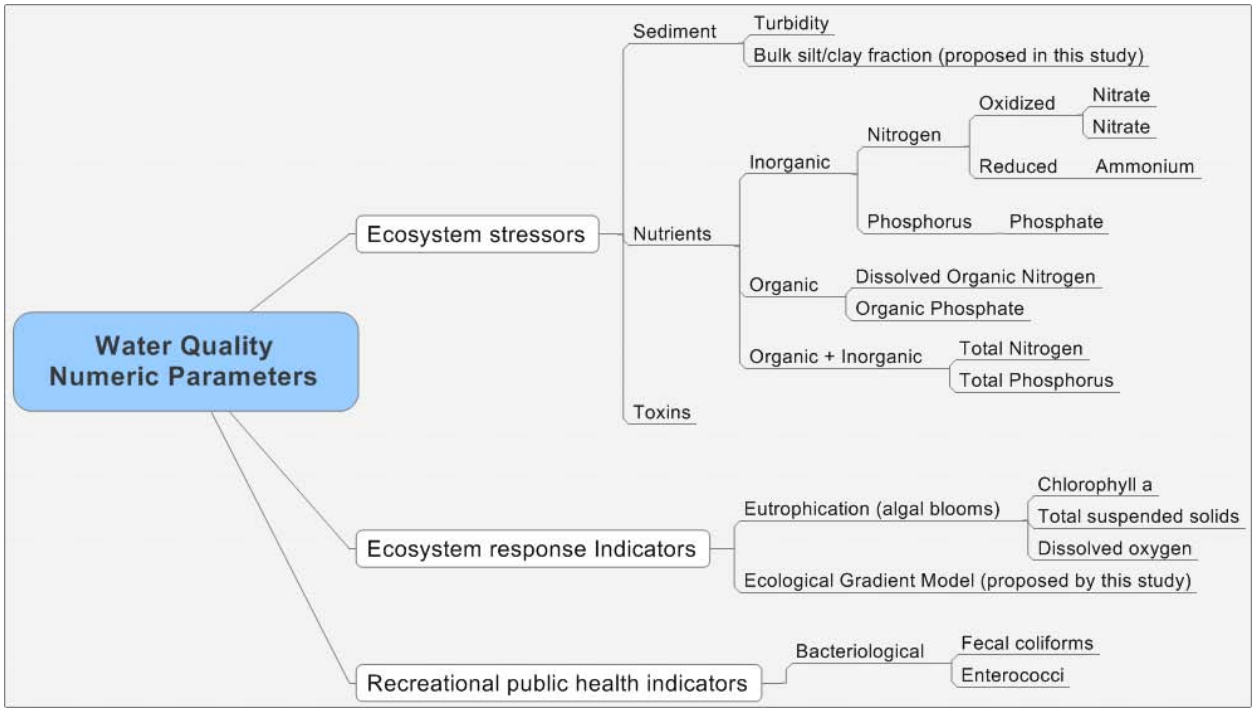
the cross-sectional entrance area of seven hundred to one or greater" (HAR 11-54-6(a)(1). A study that reviewed coastal monitoring data for developments in West Hawaii encountered that difficulty and noted: "It is extremely difficult to identify an embayment given this definition because bathymetric data does not exist to evaluate the criteria" (University of Hawaii at Hilo Marine Science Department, 2006).

Another refinement to the water quality standards may be to incorporate the Ecological Gradient Model espoused by the Coral Reef Assessment and Monitoring Program (Coral Reef Assessment & Monitoring Program, website document). The model utilizes physical factors of wave energy and depth as a first approximation to distinguish natural from anthropogenic factors. For example, low coral coverage may be more indicative of wave regimes and depth than of deteriorated conditions. The model has the ability to distinguish levels of impairment for numerous variables (e.g., low comparative ranking among sites for fine grain fraction may indicate sedimentation impacts). This model could provide a more integrative monitoring of the complex ecosystem response to pollutant loadings recognizing that "multiple, integrated parameters are often better indicators of ecosystem response than single cause and effect relationships" (U.S. Environmental Protection Agency, 2010, p. 19). For example, the health of the fisheries population, particularly the filter feeders, may play an important role in the vulnerability to nutrient loading which may become off-balanced by overfishing.

The water quality standards set quantitative criteria based on the ecosystem and designated use classifications. The quantitative criteria attempt to measure parameters indicative of potential stressors (e.g., sediment, nutrients, toxins) and parameters indicative of the ecosystem response.

Figure 5 attempts to classify the numeric water quality parameters by its intended function.

Figure 5. Water Quality Standards Numeric Criteria



Impaired Waters List. The Clean Water Act §303(d) requires states to prepare and submit biennial Impaired Waters List. The latest list contains a total of 209 marine areas (State of Hawaii

Department of Health, 2008). The number of listed waters per island are: Kauai 28 (13 percent of total), Oahu 71 (34 percent of total), Molokai 3 (1 percent of total), Lanai 6 (3 percent of total), Maui 72 (34 percent of total), and Hawai`i 31 (15 percent of total). Of the 209 marine areas, 39 new waterbodies were added, a total of four waterbodies were de-listed: Analani Pond (Puala`a), Ala Moana Beach (Diamond Head), Lanikai Beach, and Waimanalo Bay station [Waimanalo Beach County Park North]), all for enterococci. Seven previously listed waterbodies were listed for new pollutants.

Primary pollutants in Hawai`i's impaired waters are turbidity, nutrients, and bacteria. Within the 93 listed inland freshwater perennial streams, there were a total of 296 individual pollutant/waterbody combinations. The most common listing was turbidity, where the standard was exceeded in 101 of the waterbodies. The next most common listings are nitrite/nitrates (75 instances), total nitrogen (67 instances), and total phosphorus (41 instances). There were five instances of Dieldrin listings, two for chlordane, two for total suspended solids, and one listing for metals/lead (State of Hawaii Department of Health, 2008).

TMDL Status in Hawaii. EPA requires states to establish TMDLs for listed waters within a reasonable time. When the TMDL is implemented, the stormwater wasteload allocation is implemented via the NPDES stormwater permitting system. States and EPA Regions have used a variety of methods to develop stormwater source TMDLs during the past decade. With the expansion of NDPES Phase II stormwater to smaller municipalities and smaller construction activities, there has been increasing demand for more detailed quantification of stormwater allocations in TMDLs that are more useful for implementation in NDPES permits [(see (U.S. Environmental Protection Agency, 2007b) for a review of state-of-art methods applicable to stormwater allocation)]. DOH has established (or in progress) TMDLs for the following water bodies (State of Hawaii Department of Health, website):

- Kauai
    - Nawiliwili Bay watershed (four streams)
    - Hanalei Bay watershed (four stream systems)
    - Hanalei Bay marine waters (in progress)
- Oahu
    - Ala Wai Canal
    - Waimanalo Stream
    - Kawa Stream
    - Kapaa Stream
    - Kaneohe Stream
    - Upper Kaukonahua Stream
    - Kaelepulu Inland Waters (in progress)
    - Pearl Harbor watershed (7 streams) (in progress)

Limitations of TMDLs. NPDES permits require implementation of best practices. In a watershed draining into impaired waters, TMDLs may require 50% to 99% pollutant removal but removal rates for best practices are much lower (Nemura & Powers, website document). Moreover, the TMDL allocations rarely address cumulative impacts of future development, all but ensuring that water quality standards cannot be met. As a pragmatic approach, NPDES stormwater controls on muncipalities are not expressed as numeric limits but rather specify that the municpality implement controls, BMPS, and other activities identified in a Stormwater Management Plan to reduce pollutants to the "maximum extent practicable" (MEP). The MEP approach recognizes that every five years when the General Permit expires, hopefully better

technology within reasonable cost will be available to incrementally work towards the water quality goals established through TMDLs.

Proposed Methodology for Stormwater Cumulative Impact Assessment

The proposed methodology for stormwater cumulative impact assessment has the following objectives:

- Meet state of the art guidance on cumulative impact analyses;
- Match the level of analysis to the potential sensitivity of the watershed;
- Where rigorous analysis is merited, use the best available knowledge on watersheds where available, and suggest rapid assessment methods where not available;
- Distinguish and integrate the different geographic scales of analysis—the project site direct impacts as distinguished from the cumulative regional watershed impacts to estimate the proportionate impact of the project;
- Encourage mitigation measures that are consistent with and have the potential to earn credits under green building programs such as LEED;
- Provide useful base information and guidance to subsequent design-phase permits.

State of the Art Guidance on Cumulative Impact Analysis

Based on a recent study on Hawaii's EIS system, there is a definite need for guidance: "Cumulative effects assessment is neither well understood nor well implemented and is not integrated with the planning process" (University of Hawaii, 2010, p. 85). Recognizing the nascent state of knowledge to address cumulative impacts from over ten years ago, the Council on Environmental Quality (Council on Environmental Quality, 1997) and EPA (U.S. Environmental Protection Agency, 1999) sought to provide guidance on cumulative impacts. Based on these guidance documents, a cumulative impact methodology should address the following:

- Identification of Impacted Resources. "Cumulative effects need to be analyzed in terms of the specific resource, ecosystem, or human community being affected." (Council on Environmental Quality, 1997, p. 8). For stormwater, the impacted resources include the the inland and marine waters that should be protected or restored to be fishable and swimmable.
- Definition of Geographic Boundaries. "Cumulative effects on a given resource, ecosystem, or human community are rarely aligned with political or administrative boundaries. . . Cumulative effects on natural systems must use natural ecological boundaries . . ." (Council on Environmental Quality, 1997, p. 8). For stormwater, the natural geographic boundary is the watershed, which is discussed further below.
- Determining Past, Present, and Reasonably Foreseeable Future Actions. "Cumulative effects are caused by the aggregate of past, present, and reasonably foreseeable future actions. " (Council on Environmental Quality, 1997, p. 8). For stormwater, land uses are indicators of nonpoint pollution sources. Land cover data sets provide past and present land uses, while land use designations (e.g., State Land Use districts, county zoning) provide an indication of reasonably foreseeable future pollutant sources.
- Establishing Baseline Condition and Thresholds. "Each affected resource, ecosystem, and human community must be analyzed in terms of its capacity to accommodate additional effects, based on its own time and space parameters." (Council on Environmental Quality, 1997, p. 8). For stormwater, although the water quality standards provide a reference

point to serve as a threshold, there are certain resources that are more sensitive to pollutants (e.g., coral reefs) that require heightened scrutiny and monitoring, which are discussed in the following section.

Watershed and Receiving Water Sensitivity

The ecological effects of pollutants on inland and marine receiving waters is an evolving state of knowledge [see, for example, the complexity of establishing standards for nutrients in (U.S. Environmental Protection Agency, 2010)]. Certain ecological systems are more resilient than others. The thresholds may be a wide or narrow range. The water quality standards discussed previously monitor certain indicator stressors that have the following potential to cause ecological or public health effects:

- Oxygen-demanding organic wastes primarily from wastewater deplete the water's dissolved oxygen (DO) through biological decomposition. Dissolved oxygen is needed to support aquatic life. Wastewater contains organic materials that are decomposed by microorganisms, using oxygen in the process. The strength of the wastes is measured by the oxygen required to decompose them, measured by the biochemical oxygen demand (BOD). Effective biological treatment uses the natural decomposition process to stabilize organic waste.
- Nutrients such as phosphorus and nitrogen contribute to excessive growth of algae which in turn can cause turbidity and lower dissolved oxygen, a chain of events called eutrophication. The form of nutrients differs depending on the source and chemical transformation. Nitrogen can be in organic form as well as inorganic ammonia (NH_3), ammonium (NH_4^+), nitrates (NO_3^-), and nitrites (NO_2^-). Phosphorus can be in organic form or inorganic phosphate. Nutrients can be delivered by surface runoff either dissolved, suspended, or sorbed onto soil particles. Subsurface transport involves either leaching nutrients applied on the surface or direct injection of nutrients (e.g., wastewater injection well or cesspools). Nitrogen is the primary nutrient transported in the subsurface, usually leachate of fertilizers from agriculture, golf courses, urban landscaping, or injected wastewater effluent. Nitrogen fertilizers that are urea based transform to ammonium and ultimately nitrate; only the nitrate, with its negative charge, is able to leach through the soil zone and reach groundwater. Leaching of applied phosphorus fertilizer is unlikely because of both its low solubility and high reactivity (sorption) in soils; hence, the only major source of phosphorus to groundwater is from direct wastewater injection. Although groundwater discharges substantially greater annual nutrient loads than streamflow, the groundwater discharge is fairly evenly distributed in time and is dispersed over a greater length of the shoreline, while streamflows often discharge intensely for short periods of time at a few discrete locations and thus may have more substantial localized impact on coastal water quality (Soicher & Peterson, 1997).
- Suspended solids cause turbidity or sedimentation (benthic smothering). They include particles that will not pass through a 2-micron filter, including silt and clay, plankton, algae, fine organic debris, and other particulate matter. They can serve as carriers of toxics like pesticides, which readily cling to suspended particles. Solid are removed by settling in detention facilities.
- Inorganic chemicals such as toxic heavy metals (e.g., mercury, lead, zinc, copper, cadmium) can bioaccumulate through the food chain.

- Disease-causing microorganisms include pathogenic bacteria, viruses, and protozoans that also live in human and animal disgestive systems. Members of two bacteria groups, coliforms and fecal streptococci, are used as indicators of possible sewage contamination because they are commonly found in human and animal feces.

The sensitivity of the receiving waters to these pollutants depends on flushing capacity, habitat quality, or beneficial designated use. Based on these factors, sensitive receiving waters include:

- Designated beneficial use and/or habitat quality:
    - Class AA marine waters or Class 1 inland waters;
    - Coastal reserves;
- Exceptional habitat quality:
    - Coral reefs;
    - High quality perennial streams;
- Low flushing capacity or high freshwater input:
    - Embayments;
    - Anchialine ponds;
    - Low-salinity nearshore coastal waters.

Appendix C: Sensitive Watersheds identifies watersheds that drain into a sensitive receiving water and therefore are candidates for heightened cumulative impact analysis.

Available Watershed Studies and Methods of Analysis

The highest level of available watershed information are TMDL studies and allocations. However, TMDLs are done only for impaired waters and require substantial resources to prepare. When TMDLs are available, the TMDL establishes the allocations for specific pollutant sources among potential point and nonpoint sources within the watershed, and the cumulative impact analysis needs to reconcile with these allocations.

If TMDLs are not available, the next best source of watershed information is a 319 watershed plan. The watershed plan, which are prepared for watersheds that merit restoration or protection, comprehensively assesses the past, present, and future state of the watershed and recommends threshold loadings and allocations. The data and findings in a watershed plan should be the bases for cumulative impact analyses. Ideally, the watersheds that drain to sensitive resources should be priorities for watershed planning funds.

The procedure and contents of a watershed plan are explained in *Hawaii Watershed Guidance* (Tetra Tech EM, Inc., 2010). Watershed plans often utilize intermediate or advanced modeling that require substantial data inputs and technical expertise. EPA's Modeling Toolbox is a collection of models used over the past decade in development of TMDLs (U.S. Environmental Protection Agency, website-f). One model used in past Hawaii TMDL studies is NOAA's N-SPECT (Nonpoint-Source Pollution and Erosion Comparison Tool). This tool projects surface water runoff volumes, pollutant loads, pollutant concentrations, and total sediment loads. Although it was found to overestimate sediment load ((Group 70 International, Inc. and Oceanit Center, 2007), NOAA plans to work with the State to further test and calibrate this model.

In the absence of TMDLs or watershed plans, there are rapid-assessment methods that are usually relatively simple and rely on existing information. The following is a sampling of such methods organized by what the model predicts:

- Stormwater quantity
    - Peak discharge as flow rate. The peak discharge is a primary design variable for the design of stormwater facilities such as pipe systems, storm inlets and culverts, and small open channels. The widely-used Rational Method calculates peak discharge in terms of the maximum volume flow rate passing a particular location during a storm event and is expressed as volume/time (e.g., cubic feet per second). EPA's manual on construction BMP's recommends this method ((U.S. Environmental Protection Agency, 2007a). Although the method has been criticized for being unnecessarily conservative leading to expensive and oversized systems, it is a reasonable "first cut" approximation of peak discharge but should be limited in its use to drainage areas less than 200 acres (Randolph, 2004). This method relies on the following variables:
        - Rainfall intensity (i) (inches/hour). Uses a nomograph to determine time of concentration, then uses that time of concentration as the storm duration to determine the rainfall intensity from a frequency-intensity-duration chart. The model assumes rainfall intensity and duration is uniform over the area of study. It also assumes that the storm duration is equal to or greater than the time of concentration of the watershed. When the duration of the storm equals the time of concentration, all parts of the watershed are contributing simultaneously to the discharge at the outlet.
        - Drainage area (A) (acres)
        - Land cover runoff coefficient (C). The percent of the various land uses are multiplied by the runoff coefficient from a table and added together.
    - Peak discharge as volume (runoff depth). The NRCS Urban Hydrology for Small Watersheds TR 55 calculates peak discharge in terms of runoff depth. TR55 is considered more accurate than the Rational Method for larger urban drainage areas because it takes into account more factors and involves less judgment on the part of the user particularly in the choice of the time of concentration (Randolph, 2004). By modifying the land use and cover conditions in the drainage area, it can be used to predict the peak discharge effects of different land use scenarios. This method relies on the following variables:
        - Land cover influence on infiltration and runoff expressed as the Curve Number (CN). The type of land cover is used to estimate imperviousness and infiltration based on hydrologic soil classification (A, B, C, D).
        - Rainfall intensity. Based on the design return frequency (e.g., 2-, 10-, 25-, 100-year) for a 24-hour storm, the rainfall depth is determined by multiplying the rainfall intensity (inches/hour) by the duration (24 hours). A table converts rainfall depth to runoff depth for different Curve Numbers.
        - Hydraulic parameters such as channel length, slope, shape, and surface roughness to calculate time of concentration (Tc). The time of concentration is the time for the runoff to travel from the hydraulically most distant point of the watershed to the point of interest or stream mouth outlet.
- Stormwater quality
    - Soil erosion and sediment yield. Erosion threatens agricultural production capacity and is the major source of damaging sediment in inland and marine waters. Sediment causes turbidity, smothering, is a carrier of adsorbed toxics or

nutrients, and/or changes the water flow/storage capacity or gradient. The Revised Universal Soil Loss Equation (RUSLE) updated the USLE in 1990 by fine-tuning some of the parameter values and improving applications on nonagricultural lands. The RUSLE calculates the expected annual potential soil loss per acre based on inherent site conditions (rainfall, erodibility, slope geometry) and management practices (plant cover and conservation practices). The soil survey provides values for soil erodibility (K factor) and a tolerance value of soil loss (T value). Highly Erodible Lands (HEL) are defined as lands with an Erodibilty Index (EI) greater than 8. The EI is defined by: EI = (K x R x LS)/T. Although developed primarily for cropland, the RUSLE has improved its application to construction sites to evaluate different erosion and sediment control practices. Soil erosion estimates apply to a project site. Sediment yield is the total sediment load that leaves a watershed. Coarse sediment is transported as bedload and fine sediment as suspended load. Factors affected sediment yield include soil texture, proximity to stream, channel density, basin area, slope, length, land use cover, and rainfall-runoff characteristics. The Modified USLE (MUSLE), can be used to estimate sediment yield of a single event (Blaszczynski, website document).

- Pollutant concentrations and loads. Pollutant load is the mass or weight of pollutant that passes a cross-section of a stream in a specific amount of time. Flux is the instantaneous rate as the load is passing a point of reference (e.g., sampling station). However, since flux cannot be measured directly, the load is calculated as a product of concentration and flow. Concentration comes from a series of discrete samples. The sampling interval is key. Since most flux occurs during periods of high discharge (e.g., 80-90% of annual load in 10-20% of time), it is usually best to use flow-proportional samples, compared with grab samples or fixed-interval samples (Purdue University, website document). The Simple Method estimates pollutant load (annual load in terms of pounds) (Randolph, 2004). This method relies on the following variables:
    - Rainfall intensity for selected design storm
    - Fraction of annual rainfall events that produce runoff (usually 0.9)
    - Impervious cover in the watershed
    - Pollutant concentration by land use from a table based on national data.

Further testing of these models is needed to assess the applicability of the models at the project and watershed scales, and the ability to compare pre- and post-development effects.

Stormwater Modeling Parameters

There are some common parameters used by the various models mentioned above that an EIS, where pertinent, can usefully compile data for cumulative impact analysis or to facilitate the preparation or review of subsequent design stormwater permit applications. Appendix D: Useful GIS Sources for Stormwater Analysis identifies the source of GIS data for these parameters where available.

Watershed. Topography determines how surface water drains. The watershed is the topographic unit delineating where a drop of rain would flow. Watersheds have been defined for Hawaii as a GIS layer. Depending on the location of the sensitive receiving waters relative to the proposed project, it may be more appropriate to limit the analysis to subwatersheds. Subwatersheds may be identified in TMDL studies or watershed plans; otherwise, GIS software

can be used to delineate a subwatershed (University of Texas). At the project level, the subwatershed draining to the project site is referred to as the catchment area.

Precipitation Patterns. Stormwater effects begin with rainfall. Rainfall patterns are depicted in terms of annual averages, monthly averages to determine seasonal variability, and intensity/duration to characterize storm events. Two areas with similar average rainfall may differ significantly in the frequency of storm events. The infrequent but heavy rainfall storm events cause the most damage to the receiving waters. For example, a study on Pelekane Bay on the Big Island found that 83% of the sediment yield comes from very large storms (Group 70 International, Inc. and Oceanit Center, 2007). Storm events are described in terms of frequency and magnitude. The frequency (or return interval) is a way of stating the probability that the given event will be equaled or exceeded in any given year. The magnitude of rainfall received during the event is a function of the duration and intensity (e.g., inches/hour) of the storm. Intensity is derived from the depth of rainfall over the duration of the event recorded from rain gauges. The data for rainfall intensity data is published on the Internet (http://hdsc.nws.noaa.gov/hdsc/pfds) where there is a clickable map to download site-specific information. GIS contour rainfall intensity shapefiles can also be downloaded from the website, as well as seasonality data (NOAA, 2009 (version 2.1)). The pertinent rainfall intensity is determined by the design storm specified in drainage standards, BMP manuals, or certification programs such as LEED. For example, the County of Hawaii's drainage standard specifies the design storm as the 10-year, 1-hour storm, while LEED specifies a 2-year, 24-hour storm for certain of its calculations.

Infiltration vs. Runoff. Precipitation that does not evaporate either infiltrates or runs off the surface. Some of the infiltrated water ultimately seeps out of the ground contributing to stream baseflow between storms. Perennial streams normally flow all year long with a baseflow fed by groundwater. Intermittent streams flow during the wet season. Ephemeral streams flow only during and immediately after storms (Randolph, 2004). Because of the high permeabilities of the rocks and soil in Hawaii favoring rapid infiltration and little surface runoff during low and moderate rainfall, there are few perennial streams. In undeveloped areas, the texture of the soil determines its permeability and infiltration rate. As soils become saturated from a given storm, a greater percentage of the precipitation runs off the surface. Figure 6 shows the relationship of rainfall intensity, infiltration rate, and runoff rate. The NRCS Soil Survey classifies soil into hydrologic soil groups (A, B, C, D). Group A soils have the highest infiltration rates and group D soils have the lowest.

Figure 6. Relationship of Rainfall Rate, Infiltration Rate, and Runoff Rate

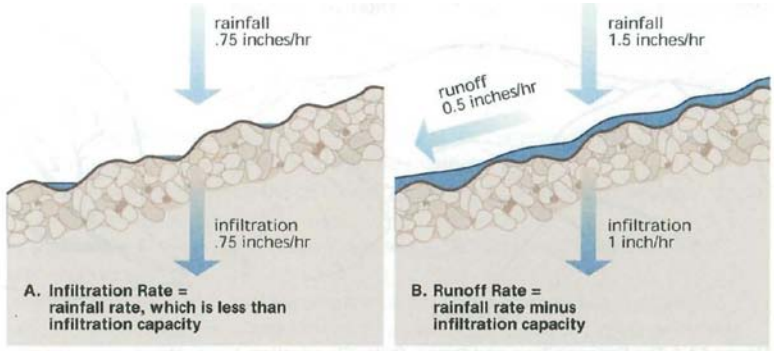


Figure 13.5 Precipitation Rate and Infiltration Rate Determine the Runoff Rate. Infiltration rate depends on soil texture, soil moisture, and vegetative cover. *Source:* FISRWG (1998).

Source: (Randolph, 2004)

Stream Characteristics—Hydrological and Biological. A hydrograph shows over time the response of streamflow at a specific point to a given storm over the watershed (see Figure 7). The streamflow curve will usually show the flow rate building to a peak discharge rate, then returning to a base flow condition without the storm event. This peak discharge rate will occur at some time after the peak of the storm, called the lag time. Because watersheds in Hawaii are small compared with those in other parts of the world and have steep valley walls, streams in Hawaii are flashy with hydrographs that typically show a sharp rise and recession with a short lag time, generally less than 1 to 2 hours (Macdonald, Abbott, & Peterson, 1983).

Figure 7. Hydrograph Before and After Urbanization

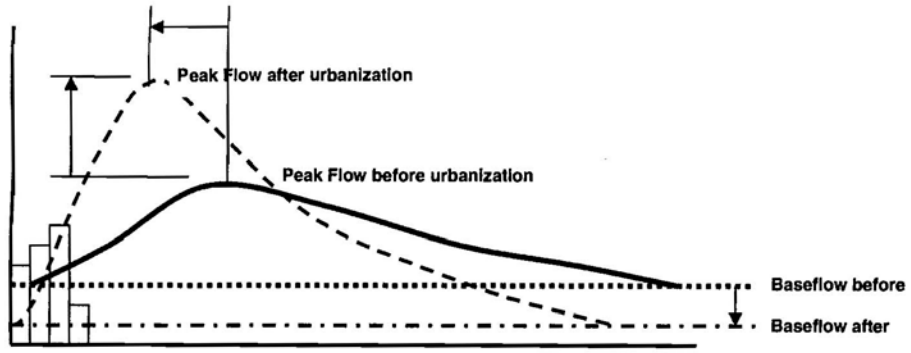


Figure 13.11 Effect of Urbanization's Impervious Surfaces on Peak Flows and Baseflows

Source: (Randolph, 2004)

Hawaii's native stream animals have amphidromous life cycles, meaning that they spend their larval stages in the ocean, then return to fresh water streams to spend their adult stage and reproduce. Newly hatched fish larvae are carried downstream to the ocean where they become part of the planktonic pool in the open ocean. The larvae remain at sea from a few weeks to a few months, eventually migrating back into a fresh water stream as juvenile post-larvae. Once back in the stream, the distribution of the five native fish species are largely dictated by their climbing ability along the stream's longitudinal gradient.

Amphidromy has many advantages, the most important being the potential for repopulating a stream with a full complement of its formerly predominant vertebrate and invertebrate species. Streams in Hawaii experience many natural disturbances in the stream ecosystem, including floods, landslides, hurricanes, and drought. Post-larvae oceanic recruitment (amphidromy) allows rapid recolonization of streams after catastrophic events and prevents genetic isolation of populations. In addition, the periodic drying of lower stream reaches and the flashy nature of Hawaii's streams with the sudden peak flows that allow for flushing of debris from the streambed, encourage migration and spawning by aquatic organisms. There has also been evidence that the timing of reproduction and recruitment is strongly influenced by freshets and periods of heavy rain (State of Hawaii Commission on Water Resource Management, 2009).

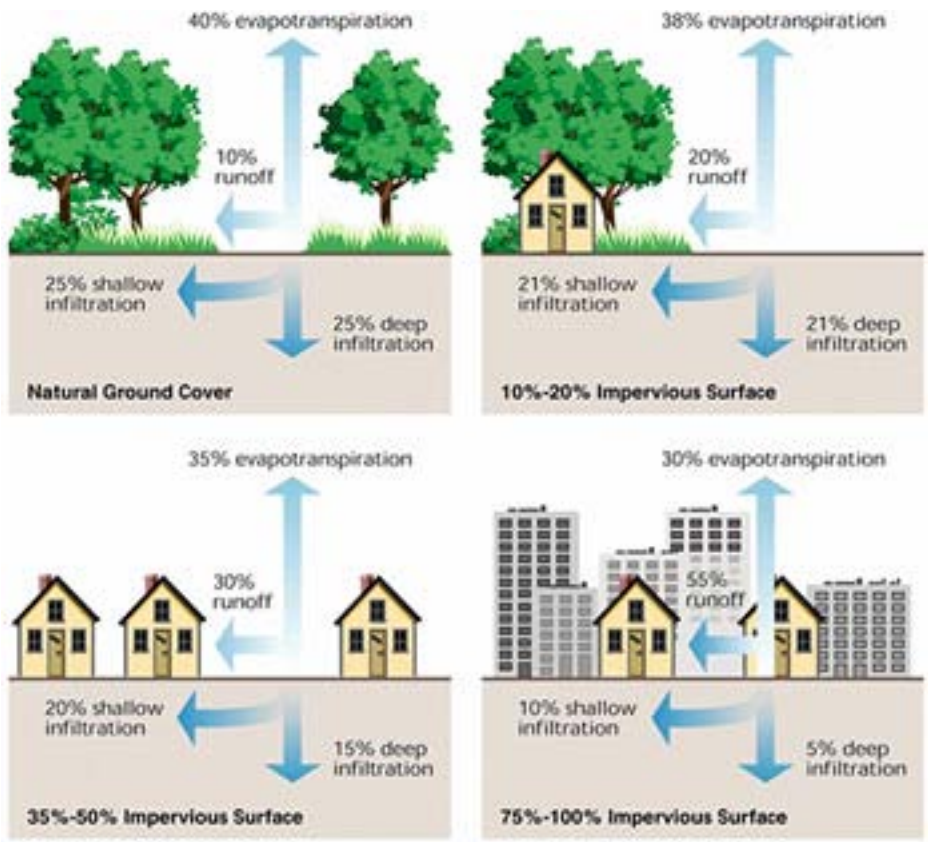
The Hawaii Stream Research Center of the University of Hawaii has developed a Watershed Health Index that provides an indication of the health of perennial streams in terms of the stream biotic integrity along longitiudinal gradients from headwater to mouth ((Kido, 2008). The *Atlas*

of Hawaiian Watersheds and Their Aquatic Resources provides physical and biological data for nearly all streams in the State (Parham & others, 2009).

Soil Characteristics. The USDA Soil Survey includes attributes for soil erodibility (K factor), tolerance value of soil loss (T factor), and hydrologic soil classification (A, B, C, D).

Land Use. Urbanization resulting in an increase of impervious surfaces reduces infiltration resulting in: increased peak discharge due to the greater amount of surface runoff; reduced lag time; and lower baseflow as less water is available from groundwater-contributed baseflow (see Figure 8). A land cover dataset from NOAA called the Coastal Change Analysis Program (C-CAP) provides a general overview of land uses: undeveloped areas (forest, shrub land, grassland, bare land), agricultural areas (cultivated land), and urban areas (low intensity and high intensity). High intensity development has 75% or greater impervious surface, while low intensity development has 25-74%.

Figure 8. Effects of Impervious Surfaces on Runoff and Infiltration



Besides affecting the hydrology, changes in land cover also introduce nonpoint and point source pollutants. Land cover datasets such as C-CAP can be used to indicate potential nonpoint sources of pollution such as the following:

- Agriculture
  - Crop farming that is carried out with inadequate soil conservation practices, excessive fertilizer use, pesticides carried away by runoff;
  - Ranching (animal production) that causes overgrazing, concentration in feedlots, cows-in-creek syndrome where animals are allowed to concentrate on streambanks causing organic pollution and streambank destruction.

- Commercial forestry that is not carried out with regard to strict soil conservation practices for trail construction, road maintenance and harvesting methods.
- Urban areas where impervious surfaces (pavements and roofs) intensify rainfall runoff, poor maintenance of drainage pipes and swales clauses flooding, industrial and commercial activity concentrate pollution discharges, construction activity increase soil erosion, oil and dust residue from vehicular traffic increase toxic substances carried in rain water, and trash and other urban debris add solid waste that clog watercourses
- Golf courses where excessive fertilizer, herbicide and pesticide are inputs that can increase toxicity and nutrient load in receiving waters.

Figure 8 summarizes the nature of the land use activity generating pollutants, the consequences, and suggested controls.

Figure 9. Land Use Practices as Nonpoint Sources

		Practice	Result	Consequence	Control
Agriculture	Crop Production	Soil Disturbance	Erosion;	Smothers benthos;	Conservation tillage; Contour cropping; Filter
		Excessive fertilizer	Nutrients pollution	Algal growth; Eutrophication	Input management
		Excessive pesticide	Toxic pollution	Bioaccumulation	Input management; Integrated pest management
		Excessive irrigation	Increased runoff	Increased transport of pollutants	Drip irrigation
	Animal Production	Concentration in feed lots	Organic pollution	DO depletion	Collection & treatment of wastes/runoff
		Concentration on stream banks	Organic pollution	DO depletion	Spatial control; fencing
			Bank damage	Channel erosion	Stream bank protection
		Overgrazing	Increased erosion	Sedimentation	Planned grazing systems; fencing
Forestry		Access system	Erosion	Sedimentation	Contour roads; Stream buffers; filter strips
		Harvesting	Erosion	Sedimentation	Filter strips; buffers; Reduced clear cut areas
		Crop regeneration; excessive fertilizer	Nutrient pollution; toxic pollution	Algal growth; Bioaccumulation	Reestablish cover; Input management
Golf Courses		Construction activity	Erosion	Sedimentation; transports pollutants	Site design; Phased construction; Mulching; Filter strips; Runoff control; Permanent BMPs
		Excessive fertilizer	Nutrients pollution	Algal growth; Eutrophication	Input management
		Excessive pesticide	Toxic pollution	Bioaccumulation	Input management
		Excessive irrigation	Increased runoff	Increased transport of pollutants	Water management; Climate specific landscaping
Urban Land Use		Construction activity	Erosion	Sedimentation; transports other pollutants	Site design; Phased construction; Mulching; Filter strips; Runoff control
		Impervious surfaces	Increased runoff	Transports pollutants; Flooding	Stormwater Management Practices; Permanent BMPs
		Excessive fertilizer	Nutrient pollution	Algal growth	Input controls; Education
		Excessive pesticide	Toxic pollution	Bioaccumulation	Input controls; Education
		Transportation vehicle residues	Oil pollution	Toxicity	Street vacuum
		Litter; Debris	DO depletion; aesthetics	Floating debris; Organics	Street vacuum; Solid waste control

Source: Modified after Figure 13.21 from page 401 of *Environmental Land Use Planning and Management* by John Randolph (Island Press, 2004)

Stormwater Mitigation Measures

Where there are sensitive receiving waters, heightened mitigation measures may be appropriate. These heightened measures may include onsite measures to mitigate direct project impacts, but may also include offsite measures to address cumulative impacts.

The notion of a contextual perspective that includes offsite mitigation is being encouraged by green building programs such as LEED. LEED for Neighborhood Development (LEED-ND) focuses not just on the building site but the project's location within the larger watershed. Under the current rating system, the strategic siting of a project within the watershed to minimize the development footprint may qualify for points (Smart Location and Linkage (SLL) Prerequisite 1 and Credit 1), as well as avoiding flood plains (SLL Prerequisite 5). The conservation, restoration, or management of natural areas on- or offsite may also qualify for points (SLL Prerequisite 3, Credit 7 (conserve), Credit 8 (restore), Credit 9 (long-term management)). Additionally, there are

bonus points for Innovation and Exemplary Performance where it may be possible for a creative project team to gain credits for offsite mitigation measures as the point system continues to evolve in this direction. There is no minimum or maximum size for a project to qualify for LEED-ND, although the LEED manual suggests a reasonable minimum size to be two habitable buildings and the maximum neighborhood area to be 320 acres or half a square mile (Congress for the New Urbanism, Natural Resources Defense Council, U.S. Green Building Council, 2010).

For onsite mitigation measures of direct project impacts, if a project can meet the standards for LEED for New Construction (LEED-NC), the project may possibly qualify for points under both LEED-ND and LEED-NC. The point systems for both LEED-ND and LEED-NC encourage the use of Low-Impact Development (LID) measures, and require at least no net increase in pollutant load generated from the site, and in some cases require a reduction between pre- and post-development conditions.

These on-site standards include:

- LEED-ND
    - Minimize erosion by preserving steep slopes in a natural, vegetated state (Smart Location and Linkage (SLL) Credit 6).
    - Reduce pollution from construction activities by controlling soil erosion, waterway sedimentation, and airborne dust generation (Green Infrastructure and Buildings (GIB) Prerequisite 4).
    - Minimize site disturbance in design and construction (GIB Credit 7).
    - Manage stormwater by retaining onsite, through infiltration, evapotranspiration, and/or reuse, the rainfall volumes exceeding the 80th percentile (GIB Credit 8).
- LEED-NC
    - Maximize open space through vegetated roofs, permeable pavements, or detention ponds (Sustainable Site (SS) Credit 5.2).
    - Reduce stormwater discharge rates (Sustainable Site (SS) Credit 6.1) and remove stormwater pollutants (SS Credit 6.2) through bioretention, permeable pavements, vegetated roofs, rainwater harvesting, and other methods. Some of these methods may also qualify for credits to reduce Heat Island Effects (SS Credit 7) (e.g., permeable pavements, vegetated roofs) and Water Efficiency (Water Efficiency Credit 1) (e.g., rainwater harvesting).

      To receive credit for stormwater quantity reduction (SS Credit 6.1), the post-development peak discharge should not exceed the predevelopment discharge rate for a 1.5-year 24-hour storm for a relatively undeveloped site (less than or equal to 50% imperviousness), or results in a 25% decrease decrease for a relatively developed site (greater than 50% imperviousness). To receive credit for stormwater quality (SS Credit 6.2), the stormwater treatment system must remove 80% of the average annual post-development TSS and 40% of the average annual total phosphorus based on average annual loadings for all storms less than or equal to the 2-year, 24-hour storm.

Low-Impact Development (LID) is a stormwater management approach that seeks to manage runoff using decentralized micro-scale controls. LID's goal is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. Instead of conveying and treating stormwater solely in large end-of-pipe

facilities located at the bottom of drainage areas, LID addresses stormwater through small-scale landscape practices and design approaches that preserve natural drainage features and patterns.

LID techniques include site design measures and stormwater control measures:

- Site Design Measures. As a mitigation measure, a project could commit to LID site design measures that would maximize infiltration, filtering, and storage by preserving natural areas, minimizing impervious surfaces, disconnecting impervious surfaces, and increasing drainage flow paths (Prince George's County, Maryland, Department of Environmental Resources, 1999). Some LID site design practices include:
    - Narrower roads;
    - Clustered lot layouts;
    - Green roofs;
    - Rain harvesting;
    - Rain gardens;
    - Permeable pavement;
    - Riparian buffers.
- Stormwater Control Measures. Some LID measures to reduce peak flow and increase infiltration can be implemented during construction and become part of the overall site design. These practices often use natural systems to capture, cleanse, and reduce stormwater runoff using plants, soils, and microbes, and are also referred to as "green infrastructure" ((Center for Watershed Protection, website document). When incorporated as BMPs during construction as part of a NPDES permit, they are referred to as "permanent BMPs". Examples of Permanent BMPs include (State of Hawaii Department of Transportation, 2007):
    - VEGETATED SWALES – Open channels that are designed to capture and treat storm water runoff using check dams. They vary in their space requirements and can be useful in residential areas and along roads though they require a minor slope to function.
    - INFILTRATION FACILITIES – Trenches and basins where permeable soils and vegetation are used to capture and infiltrate storm water runoff over a period of time.
    - STORM WATER WETLANDS – Open wetlands allow for the storage of large amounts of storm water runoff and a means for treating heavily polluted runoff. They have the added benefits of providing habitat and improved aesthetics.
    - STORM WATER PONDS – Grass basins that collect storm water runoff while allowing sediment and pollutants to settle. Storm water both infiltrates and moves through a low volume outfall. These ponds are usually low maintenance and are effective for larger areas.
    - FILTERING SYSTEMS – Collected storm water is directed over beds of permeable material to filter out pollutants. These systems may be placed above ground or concealed below. These systems are effective for urban areas with a high amount of impervious surfaces.

Other off-site mitigation ideas that may or may not qualify for LEED credits are based on a concept of compensatory mitigation used for wetlands (U.S. Environmental Protection Agency, website-a) or carbon trading. The idea is to offset impacts generated by the project by reducing pollutant loads generated elsewhere in the watershed. The process to determine the proportionate reallocation would require further elaboration and testing that may benefit from

EPA's explorations into the concept of water quality trading (U.S. Environmental Protection Agency, 2004). In the absence of a formal institutionalized process for offsetting impacts, EIS preparers can consider the following options:

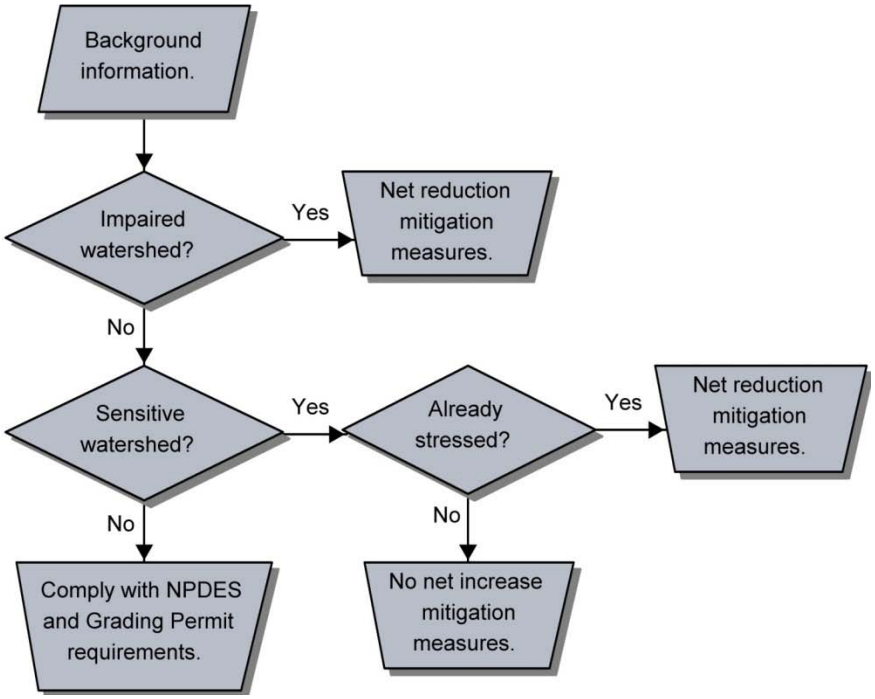
- Seek load reductions from natural areas by supporting implementation activities of a Watershed Partnership Alliance, if one exists in the watershed, or consulting with federal or state agencies who have jurisdiction of natural areas within the watershed for their suggestions to support their management needs;
- Seek load reductions from agricultural areas by supporting an agricultural operation to implement nonpoint source management measures (U.S. Environmental Protection Agency, website-c);
- Establishment and payment into a fund for watershed monitoring or management. The concept of a fund could be based on a donation to a nonprofit with watershed management responsibilities, utility service charge (e.g., Bellevue, WA), impact fee, exaction, or stormwater community facilities district.

Synthesis-- Recommended EIS Stormwater Cumulative Impact Methodology

Applying the above concepts, the recommended steps to analyze cumulative stormwater impacts are as follows (see Figure 9):

1. *Background Information.* Provide background information pertinent to the development of a pollution prevention plan for a NPDES Permit including:
    - Identification of the watershed;
    - Watershed area;
    - Proximity of streams;
    - Land uses within the watershed;
    - Rainfall intensity;
    - Hydrological soils group.
2. *Impaired Watershed.* Does the watershed drain into an impaired receiving water or identified as high priority for restoration? If yes, then propose onsite mitigation measures to reduce pollutant generation between pre-and post-development that would be eligible to meet LEED-NC SS 6.1 and 6.2 credits, as well as comply with a TMDL allocation if available. Mitigation measures should address as a minimum the pollutant with TMDL allocations, but should consider other potential sources generated by the various land uses within the watershed and pollutants transported by groundwater;
3. *Sensitive Watershed.* If not impaired, does the watershed drain into a "sensitive" receiving water? If yes, determine if the receiving waters are already stressed through a watershed plan, rapid assessment model, or salinity gradient method.
    - If stressed, propose on- or offsite mitigation measures to reduce pollutant loads through onsite and/or offsite measures.
    - If not stressed, propose on- or offsite mitigation measures that result in no net increase.
4. If not impaired or sensitive, comply with applicable NPDES and Grading Permit requirements. Projects in impaired or sensitive watersheds must also comply with applicable NPDES and grading permits in addition to heightened mitigation measures identified in previous steps.

Figure 10. Proposed Stormwater Cumulative Impact Assessment Steps



Summary

EISs can play a role to improve the overall stormwater management in the following ways:

- Alert design-phase engineers when heightened mitigation measures are warranted to protect or restore sensitive receiving waters;
- Incorporate such heightened measures as permit conditions to ensure that they are considered;
- Demonstrate and encourage the applicability of offsite measures and onsite LID measures to receive LEED points;
- Integrate and support TMDLs and watershed plans;
- Test and help to advance rapid assessment methods as economical but effective means to determine proportionate impact of the project relative to the cumulative impact of the watershed.

Water quality standards are the critical reference points that serve as the indicators of ecological degradation. To enable adaptive response to our imperfect knowledge, it is imperative to establish a systemic monitoring system and to vigilantly improve the standards. Three suggestions discussed in this study include incorporation of a salinity parameter to better determine flushing capacity, bulk silt/clay fraction of bottom sediments, and an integrative ecological gradient model.

Works Cited

Blaszczynski, J. (website document). *Estimating Watershed Runoff and Sediment Yield Using a GIS Interface to Curve Number and MUSLE Models.* Retrieved July 2011, from http://www.blm.gov/nstc/resourcenotes/respdf/RN66.pdf

Center for Watershed Protection. (website document). *Stormwater Management*. Retrieved July 2011, from Center for Watershed Protection: http://www.cwp.org/your-watershed-101/stormwater-management.html

City & County of Honolulu. (2007). *Storm Water Management Plan.* Approved by DOH as part of MS4 General Permit.

Congress for the New Urbanism, Natural Resources Defense Council, U.S. Green Building Council. (2010). *LEED 2009 for Neighborhood Development.*

Coral Reef Assessment & Monitoring Program. (website document). *Ecological Gradient Model*. Retrieved July 2011, from CRAMP: cramp.wcc.hawaii.edu/EG%20Model.htm

Council on Environmental Quality. (1997). *Considering Cumulative Effects Under the National Environmental Policy Act.*

Group 70 International, Inc. and Oceanit Center. (2007). *Pelekane Bay Watershed Sediment Runoff Analysis.* Prepared for U.S. Army Corps of Engineers.

Kido, M. H. (2008). *Island of Hawaii-- Stream Condition Along a Human Distrubance Gradient.* Prepared for the State of Hawaii Department of Health.

Macdonald, G. A., Abbott, A. T., & Peterson, F. L. (1983). *Volcanoes in the Sea (2nd Ed.).* Honolulu: University of Hawaii Press.

Marine and Coastal Solutions International. (2009). *Hawaii Watershed Prioritization Process.* Prepared for State of Hawaii Office of Planning Coastal Zone Management Program.

Nemura, A., & Powers, E. (website document). *Maximum Extent Practicable Meets TMDL for Municipal Stormwater Permits-- Which Will Prevail.* Retrieved May 2011

NOAA. (2009 (version 2.1)). *Precipitation-Frequency Atlas of the United States, volume 4: Hawaiian Islands.*

Parham, J., & al, e. (2009). *Atlas of Hawaiian Watersheds & Their Aquatic Resources.* Division of Aquatic Resrouces, State of Hawaii Department of Land & Natural Resources and the Bishop Museum.

Prince George's County, Maryland, Department of Environmental Resources. (1999). *Low-Impact Development Design Strategies: An Integrated Design Approach.* http://www.lowimpactdevelopment.org/pubs/LID_National_Manual.pdf.

Purdue University. (website document). *Monitoring and Pollutant Load Estimation.* Retrieved July 2011, from www.ctic.purdue.edu/media/10_Loadestimation.ppt

Randolph, J. (2004). *Environmental Land Use Planning and Management.* Washington, D.C.: Island Press.

Soicher, A. J., & Peterson, F. (1997). Terrestrial Nutrient and Sediment Fluxes to the Coastal Waters of West Maui, Hawaii. *Pacific Science* , vol. 51, no. 3: 221-232.

State of Hawaii Commission on Water Resource Management. (2009). *Instream Flow Standard Assessment Report: Island of Maui, Hydrologic Unit 6057, West Wailuaiki.* PR-2009-08.

State of Hawaii Department of Health. (2008). *2006 State of Hawaii Water Quality Monitoring and Assessment Report: Itnegrated Report to the U.S. Environmental Protection Agency and the U.S. Congress Pursuant to Sections 303(d) and 305(b), Clean Water Act (P.L. 97-117).*

State of Hawaii Department of Health. (2005). *Draft Rationale for Proposed Amendments to the Hawaii Administrative Rule, Chapter 11-54, Water Quality Standards.* Retrieved May 2011, from http://hawaii.gov/health/environmental/environmental/env-planning/goals/wqm/pdf/revrationale.pdf

State of Hawaii Department of Health. (website). *Polluted Runoff Control Program*. Retrieved May 2011, from Department of Health: http://hawaii.gov/health/environmental/water/environmental/water/cleanwater/prc/index.html

State of Hawaii Department of Land and Natural Resources. (2009). *Instream Flow Standard Assessment Report: Island of Maui, Hydrologic Unit 6057, West Wailuaiki.* Report No. PR-2009-08.

State of Hawaii Department of Transportation. (2007). *Storm Water Permanent Best Management Practices Manual.*

Tetra Tech EM, Inc. (2010). *Hawaii Watershed Guidance.* State of Hawaii Office of Planning, Coastal Zone Management Program.

U.S. Environmental Protection Agency. (website-a). *Compensatory Mitigation*. Retrieved July 2011, from EPA: www.epa.gov/owow_keep/wetlands/wetlandsmitigation/index.html

U.S. Environmental Protection Agency. (1999, May). *Consideration of Cumulative Impacts in EPA Review of NEPA Documents.* Retrieved June 2011, from EPA: http://www.epa.gov/compliance/resources/policies/nepa/cumulative.pdf

U.S. Environmental Protection Agency. (2007a). *Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites.*

U.S. Environmental Protection Agency. (website-b). *EPA Glossary*. Retrieved July 2011, from EPA: http://water.epa.gov/learn/kids/estuaries/glossary_index.cfm

U.S. Environmental Protection Agency. (website-c). *Getting Paid for Stewardship: An Agricultural Community Water Quality Trading Guide.* Retrieved from http://ctic.org/media/users/lvollmer/pdf/GPfS_final%281%29.pdf

U.S. Environmental Protection Agency. (website-d). *Impaired Water and Total Maximum Daily Loads*. Retrieved May 2011, from EPA: http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/

U.S. Environmental Protection Agency. (2010). *Nutrients in Estuaries: A Summar Report of the National Estuarine Experts Workgroup 2005-2007.*

U.S. Environmental Protection Agency. (website-e). *Stormwater Basic Information*. Retrieved May 2011, from U.S. Environmental Protection Agency: http://cfpub.epa.gov/npdes/stormwater/swbasicinfo.cfm

U.S. Environmental Protection Agency. (2007b). *Total Maximum Daily Loads with Stormwater Sources: A Summary of 17 TMDLs.* EPA 841-R-07-002.

U.S. Environmental Protection Agency. (2004). *Water Quality Trading Assessment Handbook: Can Water Quality Trading Advance Your Watershed's Goals?*

http://water.epa.gov/type/watersheds/trading/upload/2004_11_08_watershed_trading_handbook_national-wqt-handbook-2004.pdf.

U.S. Environmental Protection Agency. (website-f). *Watershed and Water Quality Modeling Technical Support Center*. Retrieved 2011 July, from EPA: http://www.epa.gov/athens/wwqtsc/index.html

U.S. Environmental Protection Agency. (website-g). *What is Nonpoint Source Pollution? Questions and Answers*. Retrieved July 2011, from EPA: http://www.epa.gov/owow/NPS/qa.html

University of Hawaii at Hilo Marine Science Department. (2006). *A Review of Coastal Monitoring Data for Development in West Hawaii.* Prepared for County of Hawaii Planning Department.

University of Hawaii. (2010). *Final Report on Hawaii's Environmental Review System.* Prepared for the Hawaii State Legislature.

University of Texas. (n.d.). *Catchments and Watersheds.* Retrieved July 2011, from http://www.crwr.utexas.edu/gis/gishydro00/ArcGIS/Chapter4/chapter4.pdf

Appendix A: Analysis of EIS Sample to Address Stormwater and Cumulative Impacts

Table 2 is the list of 34 EIS's that DBEDT selected to comprise the sample.

Representativeness

This list varies as a representative sample in terms of:

- Jurisdiction. The 34 projects are located on the four major islands of the four counties—i.e., Kauai, Oahu, Maui, and Hawaii islands. Oahu and Hawaii are heavily represented with 13 EISs each, while Maui has 5 and Kauai 3 projects (see Figure 10).
- Project Types. There is a good representation by project type—4 resorts, 4 commercial-industrial, 4 institutional, 2 large lot residential, and 20 residential projects with commercial or golf course (see Figure 11 and Table 3). The locations of these projects by project type are shown in Figure 12 through Figure 15.
- Project Sizes. There are no small projects under the 1 acre NPDES threshold. The projects range in size from 56 to 1,781 acres. The locations of these projects by project size are shown in Figure 16 through Figure 19.
- Climate Regimes. Only two projects were located in wetter climate regimes on the windward side of the islands—one on Maui and one on Oahu.

The dates of the EIS's spanned from 1981 to 2010-- 8 prepared in the 1980s, 6 in the 1990s, and 20 in the 2000s. The locations of these projects by project date are shown in Figure 20 through Figure 23.

Evaluation of Stormwater Impacts in EIS's

Major factors contributing to stormwater runoff include rainfall, topography (slope), soil type and erodibility, and surface drainage features. Table 5 summarizes the analysis of these factors.

Table 2. List of EISs

ID	Island	Docket	Petitioner	Location	Acres	Description	Project Type	Climate Regime	Document Date
1	Hawaii	A81-525	Y-O Limited Partnership	North Kona	411	Residential; 1433 residential lots/units; 5.5 acres commercial	Residential; commercial	Leeward	1981
2	Hawaii	A84-574-2	Mauna Kea Properties, Inc (Mauna Kea Resort)	Hapuna	399	Residential; golf course; residential community	Residential; golf course	Leeward	1984
3	Hawaii	A86-599	Kona Beach Development Venture (Kohanaiki)	Kohanaiki	479	zoning application under review; CDUA for water system submitted	Resort	Leeward	1986
4	Hawaii	A86-603	Huehue Ranch	North Kona	667	Hotel; residential; recreational; commercial (800-1350 hotel units; 2000 resort condos; 800 residential lots	Resort	Leeward	1986
5	Hawaii	A87-617	Bridge Aina Lea, LLC (Villages at Aina Lea)	Waikoloa	1060	Master planned community w/18hole golf course; single-fmaily and multi-family residential; commercial facilities	Residential; golf course	Leeward	1987
6	Hawaii	A93-701	(Kaupulehu Development)	Kona	1010		Resort	Leeward	1993
7	Hawaii	A00-730	Lanihau Properties, LLC (Kaloko-Honokohau Business Park)	Honokohau	336		Industrial/commercial	Leeward	2000
8	Hawaii	A00-732	TSA International, Ltd. (Kaloko Commercial Center)	Honokohau	102	light industrial; industrial/commercial; Kaloko Industrial Park II/IV	Industrial/commercial	Leeward	2000
9	Hawaii	A04-747	Kamehameha Investment Corp. (Keauhou Subdivision)	Keauhou	488	Rural	Large lot residential	Leeward	2004
10	Hawaii	A06-769	1250 Oceanside Partners (Hokulia)	N/S Kona	1434	Residential lots, 665 ag lots 18 hold golf course	Large lot residential; golf course	Leeward	2006
11	Hawaii	A07-774	North Kona Village, LLC (O'oma Beachside Village)	Ooma, North Kona	181	950 to 1200 residential units	Residential; commercial	Leeward	2007
12	Hawaii	A07-778	SCD Kaloko Makai, LLC (Kaloko Makai)	Kaloko, N. Kona	952	5000 sf/MF comm/elementary; middle school; Master planned community with mixed use	Residential; commercial	Leeward	2007
13	Hawaii	A10-785	Forest City (Kamakana)	Kaohulou	271		Residential	Leeward	2010

ID	Island	Docket	Petitioner	Location	Acres	Description	Project Type	Climate Regime	Document Date
14	Maui	A89-652	Hawaii Finance and Development Corp (Villages of Leialii)	Lahaina	1120	Residential ; public parks; recreation, facilities; golf course ; commercial	Residential; golf course	Leeward	1989
15	Maui	A98-725	A&B Properties, Inc.(Spreckelsville Mauka)	Spreckelsville	212	residential; 9-hole golf course; park	Residential; golf course	Windward	1998
16	Maui	A05-756	Kaanapali Development Corp.	Kaanapali	849	857 single-family; 853 multi-family and 390 mixed use units; recreational ; open space; golf course and commercial use	Residential; golf course	Leeward	2005
17	Maui	A06-765	Maalaea Properties, LLC; Lodi Development, Inc.(Maalaea Mauka)	Maalaea	260	949 SF, MF Apts, Sr citizen units, comm. Ctr, master-planned	Residential; commercial	Leeward	2006
18	Maui	A10-786	Olowalu Town LLC and Olowalu Ekolu LLC	Olowalu	320	master planned community; only EISPN available	Residential; commercial	Leeward	2010
19	Kauai	A93-696	Kukui'ula Development Company, Inc.	Koloa	537	residential golf course; clubhouse; commercial; marina;	Residential; golf course	Leeward	1993
20	Kauai	A00-731	Destination Villages Kauai, LLC (Kapalawai Resort)	Makaweli	153	Low-density, low-impact resort with existing vacant former residence of Robison family as primary structure located on the property	Resort	Leeward	2000
21	Kauai	A05-761	Eric A Knudsen Trust	Poipu	127	Residential community; bike/pedestian path, parks, archaeological preserves. Also includes 19-B (Hapa Road)	Residential	Leeward	2005
22	Oahu	A89-651	Haseko (Ewa Marine)	Ewa	1100		Commercial; golf course	Leeward	1989
23	Oahu	A92-687	Estate of James Campbell (Makaiwa Hills)	Ewa	1781	Residential; commercial parks; roadways; open space (4100 res units, 78 ac commercial	Residential; commercial	Leeward	1992
24	Oahu	A99-728	State of Hawaii, HCDCH (East Kapolei Master Plan)	Ewa	1300	Single family; multi-famliy; commercial; parks; open space; recreational	Residential; commercial	Leeward	1999

ID	Island	Docket	Petitioner	Location	Acres	Description	Project Type	Climate Regime	Document Date
25	Oahu	A99-728(a)	University of Hawaii, West Oahu	Ewa	500		Institution/Park/Facility	Leeward	1999
26	Oahu	A00-734	Castle & Cooke Hawaii, Inc./Pacific Health Community (Koa Ridge)	Waipio & Waiawa	1246	medical park; residential; public facilities, commercial; recreation uses	Residential; commercial	Leeward	2000
27	Oahu	A03-738	Gentry Investment Properties (Ewa Makai)	Ewa	283	residential; industrial and commercial; parks; open space; community facilities	Residential; commercial	Leeward	2003
28	Oahu	A04-753	Aina Nui Corporation (Kapolei West)	Honouliuli	174	golf / residential community	Residential; golf course	Leeward	2004
29	Oahu	A06-763	Kapolei Property Development, LLC	Honouliuli	331	business industrial park (light manufacturing and warehousing	Industrial/commercial	Leeward	2006
30	Oahu	A06-771	DR Horton - Schuler Homes, LLC (Hoopili)	Ewa	1553	residential 11750 SF/MF units	Residential	Leeward	2006
31	Oahu	A07-775	Castle & Cooke Homes Hawaii, Inc.(Koa Ridge (Makai & Waiawa)	Waipio & Waiawa	767	Mixed use community w/SF & MF units; commercial; light industrial, health care, hotel lodging and parks, recreation centers and schools	Residential; commercial	Leeward	2007
32	Oahu	A07-777	Hawaiian Memorial Park, LTD (Hawaiian Memorial Park Expansion)	Kaneohe	56	expansion of memorial park adjacent to historic sites	Institution/Park/Facility	Windward	2007
33	Oahu	A08-780	Dept of Env Serv, C&C of Hon (Waimanalo Gulch Landfill)	Honouliuli	200	Expansion of Waimanalo Gulch Landfill	Institution/Park/Facility	Leeward	2008
34	Oahu	SP87-362	Dept of Env Serv, C&C of Hon (Waimanalo Gulch Landfill)	Honouliuli	200	Expansion of Waimanalo Gulch Landfill	Institution/Park/Facility	Leeward	1987

Figure 11. Representation by County

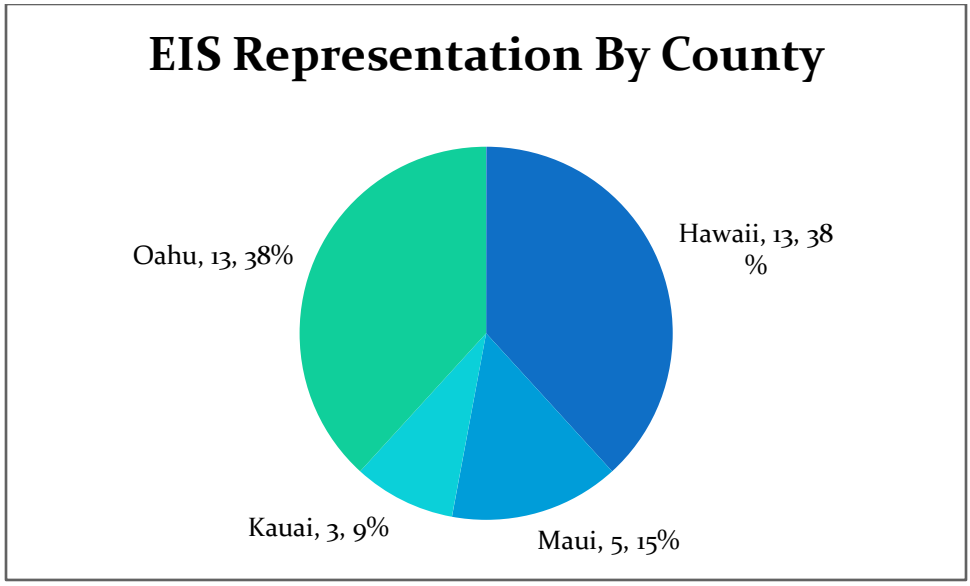


Figure 12. Representation by Project Type

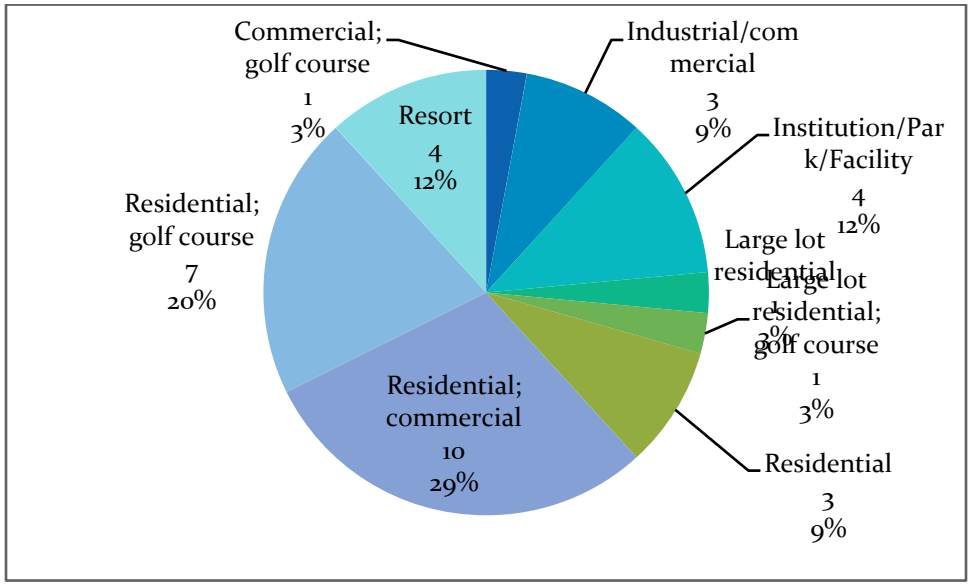


Table 3. Representation by Project Type

Project Type	ID	Petitioner	Island	Total
Commercial; golf course	22	Haseko (Ewa Marine)	Oahu	1
Commercial; golf course Total				1
Industrial/commercial	7	Lanihau Properties, LLC (Kaloko-Honokohau Business Park)	Hawaii	1
	8	TSA International, Ltd. (Kaloko Commercial Center)	Hawaii	1
	29	Kapolei Property Development, LLC	Oahu	1
Industrial/commercial Total				3
Institution/Park/Facility	25	University of Hawaii, West Oahu	Oahu	1
	32	Hawaiian Memorial Park, LTD (Hawaiian Memorial Park Expansion)	Oahu	1
	33	Dept of Env Serv, C&C of Hon (Waimanalo Gulch Landfill)	Oahu	1
	34	Dept of Env Serv, C&C of Hon (Waimanalo Gulch Landfill)	Oahu	1
Institution/Park/Facility Total				4
Large lot residential	9	Kamehameha Investment Corp. (Keauhou Subdivision)	Hawaii	1
Large lot residential Total				1
Large lot residential; golf course	10	1250 Oceanside Partners (Hokulia)	Hawaii	1
Large lot residential; golf course Total				1
Residential	13	Forest City (Kamakana)	Hawaii	1
	21	Eric A Knudsen Trust	Kauai	1
	30	DR Horton - Schuler Homes, LLC (Hoopili)	Oahu	1
Residential Total				3
Residential; commercial	1	Y-O Limited Partnership	Hawaii	1
	11	North Kona Village, LLC (O'oma Beachside Village)	Hawaii	1
	12	SCD Kaloko Makai, LLC (Kaloko Makai)	Hawaii	1
	17	Maalaea Properties, LLC; Lodi Development, Inc.(Maalaea Mauka)	Maui	1

Project Type	ID	Petitioner	Island	Total
	18	Olowalu Town LLC and Olowalu Ekolu LLC	Maui	1
	23	Estate of James Campbell (Makaiwa Hills)	Oahu	1
	24	State of Hawaii, HCDCH (East Kapolei Master Plan)	Oahu	1
	26	Castle & Cooke Hawaii, Inc./Pacific Health Community (Koa Ridge)	Oahu	1
	27	Gentry Investment Properties (Ewa Makai)	Oahu	1
	31	Castle & Cooke Homes Hawaii, Inc.(Koa Ridge (Makai & Waiawa)	Oahu	1
Residential; commercial Total				10
Residential; golf course	2	Mauna Kea Properties, Inc (Mauna Kea Resort)	Hawaii	1
	5	Bridge Aina Lea, LLC (Villages at Aina Lea)	Hawaii	1
	14	Hawaii Finance and Development Corp (Villages of Leialii)	Maui	1
	15	A&B Properties, Inc.(Spreckelsville Mauka)	Maui	1
	16	Kaanapali Development Corp.	Maui	1
	19	Kukui'ula Development Company, Inc.	Kauai	1
	28	Aina Nui Corporation (Kapolei West)	Oahu	1
Residential; golf course Total				7
Resort	3	Kona Beach Development Venture (Kohanaiki)	Hawaii	1
	4	Huehue Ranch	Hawaii	1
	6	(Kaupulehu Development)	Hawaii	1
	20	Destination Villages Kauai, LLC (Kapalawai Resort)	Kauai	1
Resort Total				4
Grand Total				34

Figure 13. Location by Project Type- Kauai

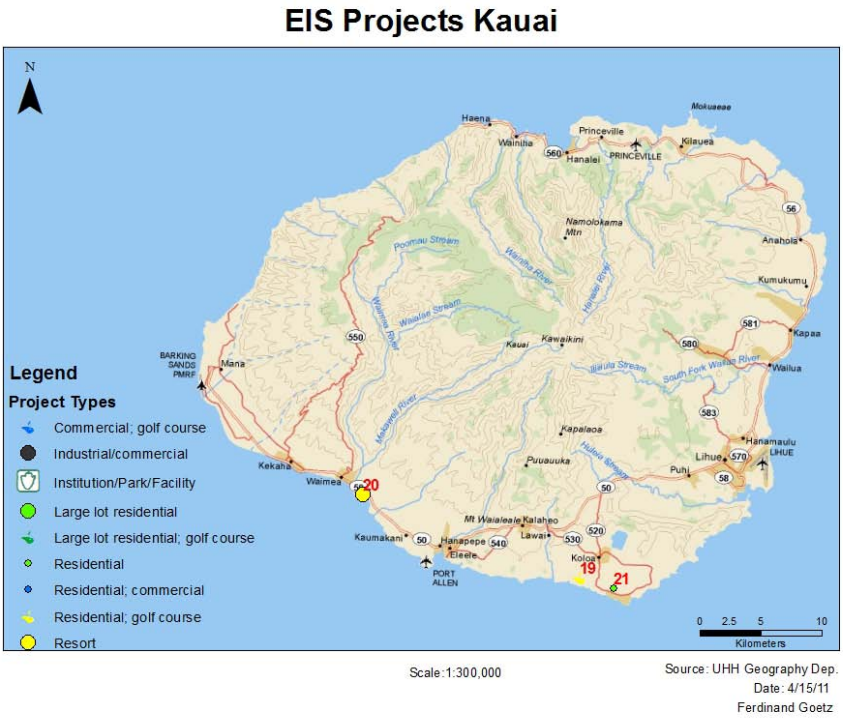


Figure 14. Location by Project Type- Oahu

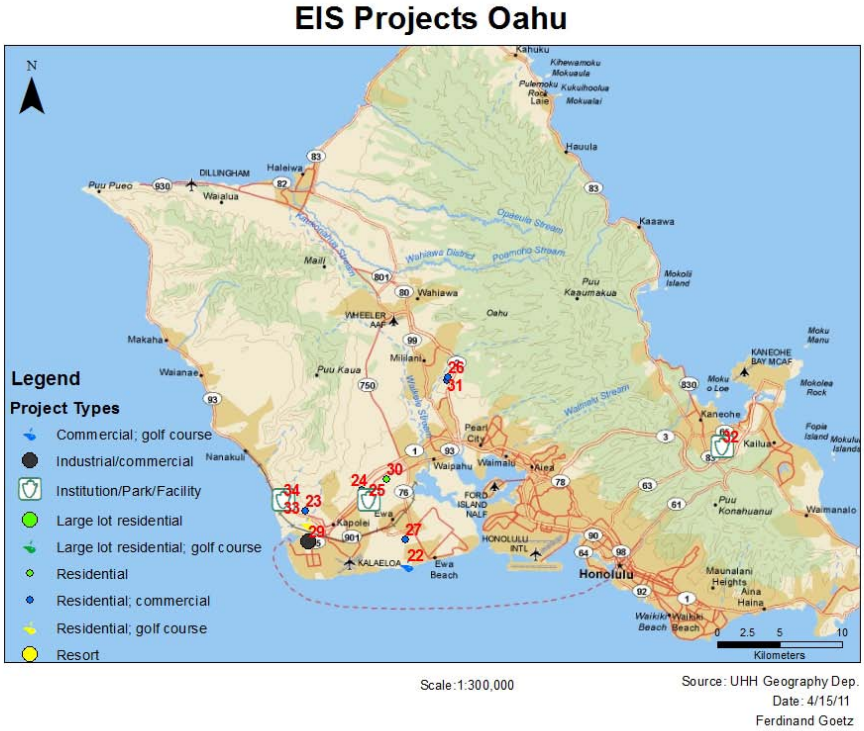


Figure 15. Location by Project Type- Maui

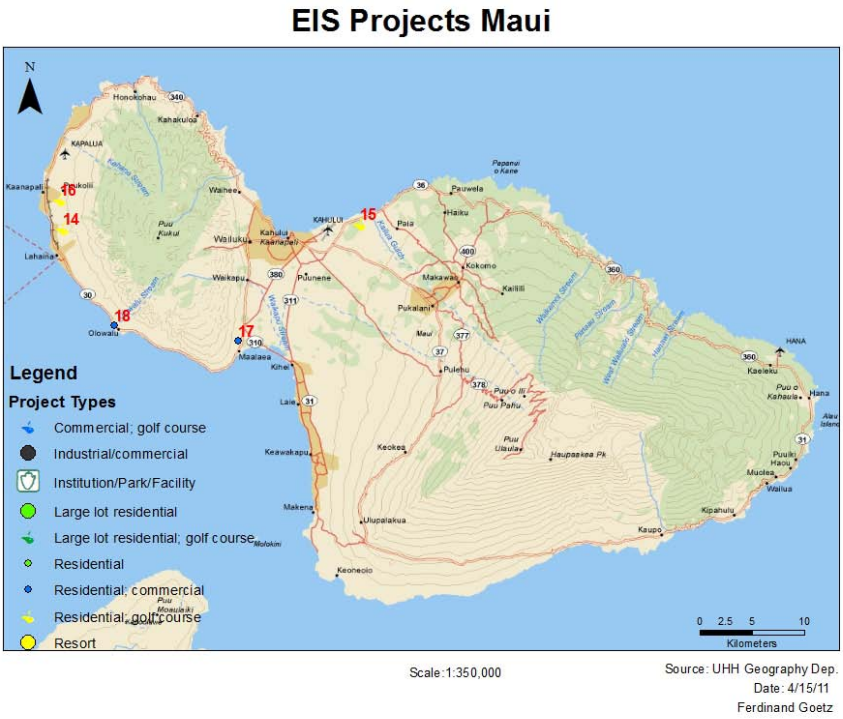


Figure 16. Location by Project Type- Hawaii

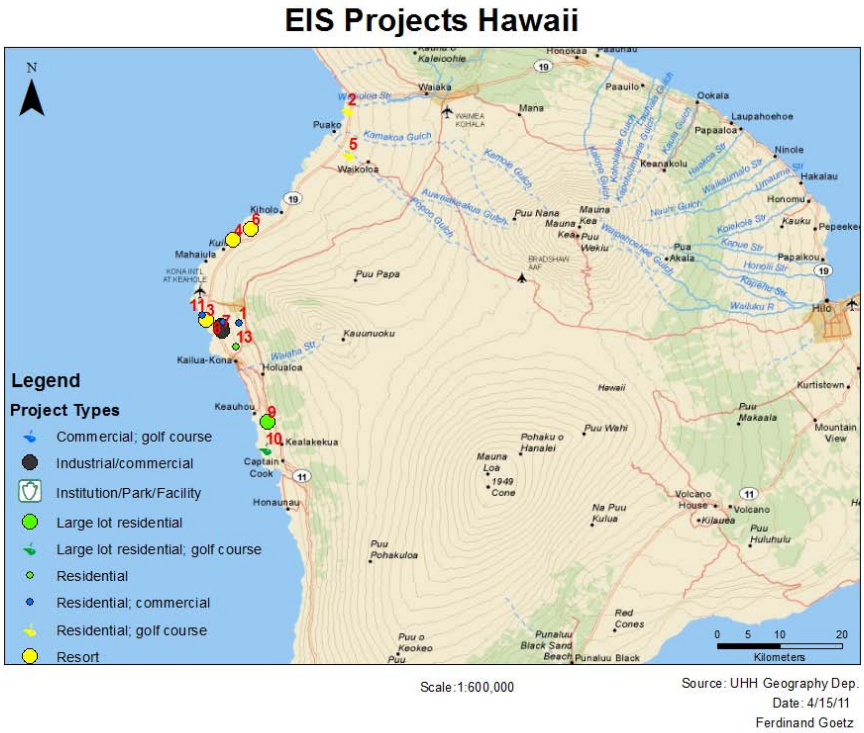


Figure 17. Location by Project Size- Kauai

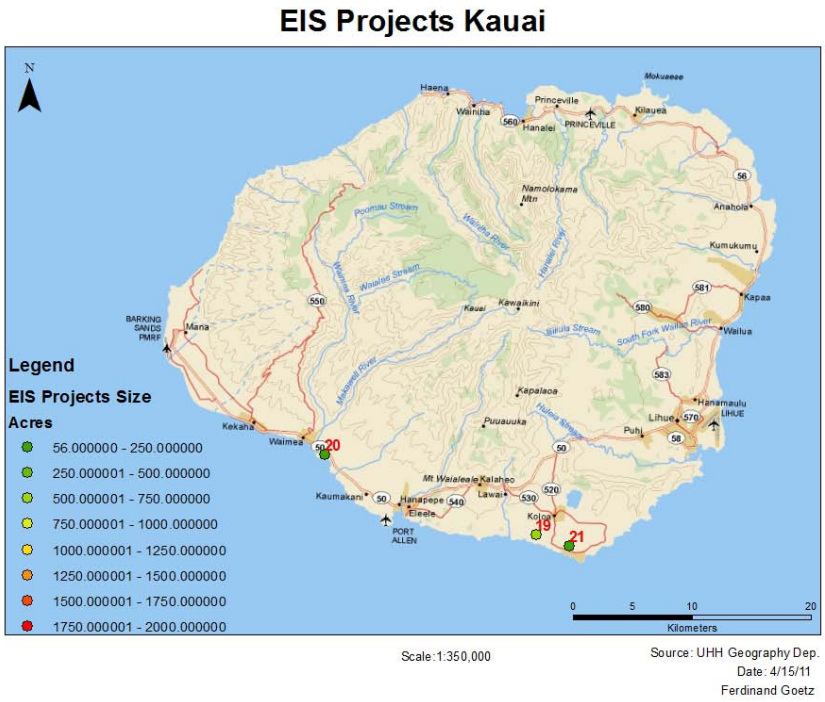


Figure 18. Location by Project Size- Oahu

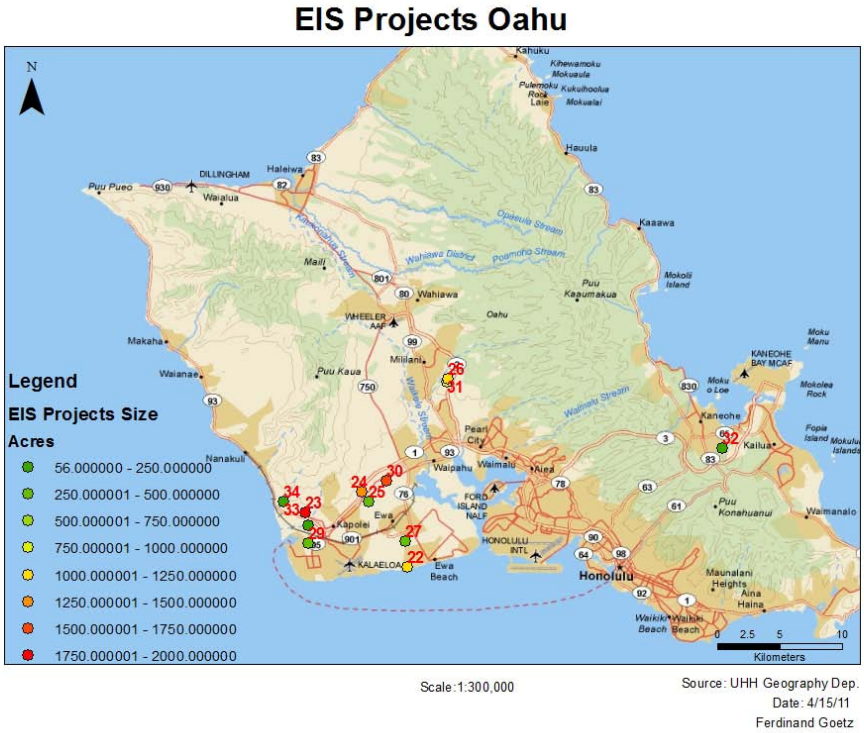


Figure 19. Location by Project Size- Maui

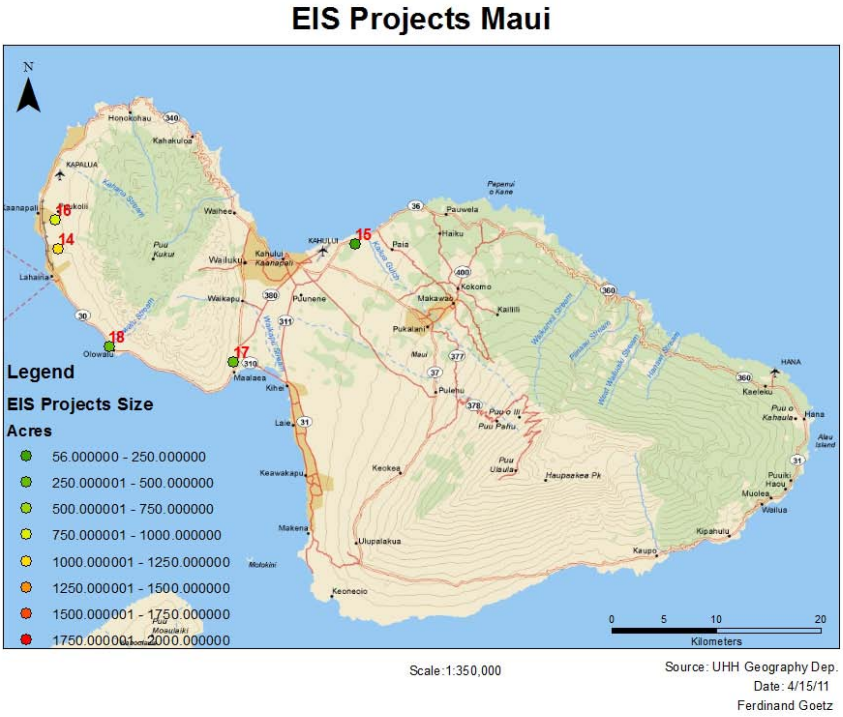


Figure 20. Location by Project Size- Hawaii

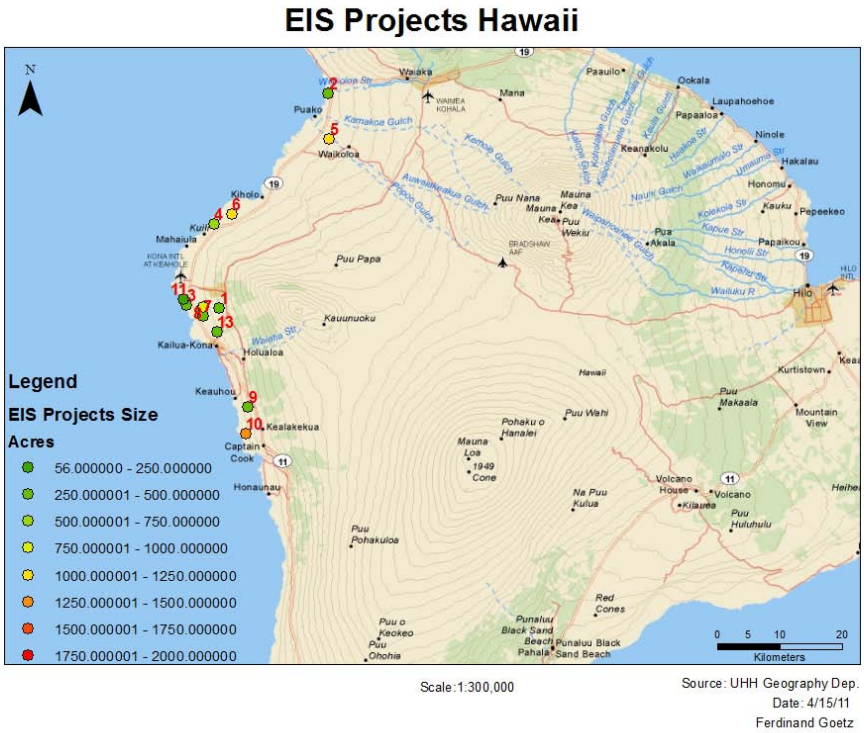


Table 4. Projects Sorted by Date

Document Date	ID	Petitioner	Island	Total
1981	1	Y-O Limited Partnership	Hawaii	1
1984	2	Mauna Kea Properties, Inc (Mauna Kea Resort)	Hawaii	1
1986	3	Kona Beach Development Venture (Kohanaiki)	Hawaii	1
	4	Huehue Ranch	Hawaii	1
1987	5	Bridge Aina Lea, LLC (Villages at Aina Lea)	Hawaii	1
	34	Dept of Env Serv, C&C of Hon (Waimanalo Gulch Landfill)	Oahu	1
1989	14	Hawaii Finance and Development Corp (Villages of Leialii)	Maui	1
	22	Haseko (Ewa Marine)	Oahu	1
1992	23	Estate of James Campbell (Makaiwa Hills)	Oahu	1
1993	6	(Kaupulehu Development)	Hawaii	1
	19	Kukui'ula Development Company, Inc.	Kauai	1
1998	15	A&B Properties, Inc.(Spreckelsville Mauka)	Maui	1
1999	24	State of Hawaii, HCDCH (East Kapolei Master Plan)	Oahu	1
	25	University of Hawaii, West Oahu	Oahu	1
2000	7	Lanihau Properties, LLC (Kaloko-Honokohau Business Park)	Hawaii	1
	8	TSA International, Ltd. (Kaloko Commercial Center)	Hawaii	1
	20	Destination Villages Kauai, LLC (Kapalawai Resort)	Kauai	1
	26	Castle & Cooke Hawaii, Inc./Pacific Health Community (Koa Ridge)	Oahu	1
2003	27	Gentry Investment Properties (Ewa Makai)	Oahu	1
2004	9	Kamehameha Investment Corp. (Keauhou Subdivision)	Hawaii	1
	28	Aina Nui Corporation (Kapolei West)	Oahu	1
2005	16	Kaanapali Development Corp.	Maui	1
	21	Eric A Knudsen Trust	Kauai	1
2006	10	1250 Oceanside Partners (Hokulia)	Hawaii	1
	17	Maalaea Properties, LLC; Lodi Development, Inc.(Maalaea Mauka)	Maui	1
	29	Kapolei Property Development, LLC	Oahu	1
	30	DR Horton - Schuler Homes, LLC (Hoopili)	Oahu	1
2007	11	North Kona Village, LLC (O'oma Beachside Village)	Hawaii	1
	12	SCD Kaloko Makai, LLC (Kaloko Makai)	Hawaii	1
	31	Castle & Cooke Homes Hawaii, Inc.(Koa Ridge (Makai & Waiawa)	Oahu	1
	32	Hawaiian Memorial Park, LTD (Hawaiian Memorial Park Expansion)	Oahu	1
2008	33	Dept of Env Serv, C&C of Hon (Waimanalo Gulch Landfill)	Oahu	1
2010	13	Forest City (Kamakana)	Hawaii	1
	18	Olowalu Town LLC and Olowalu Ekolu LLC	Maui	1

Document Date	ID	Petitioner	Island	Total
Grand Total				34

Figure 21. Location by Date- Kauai

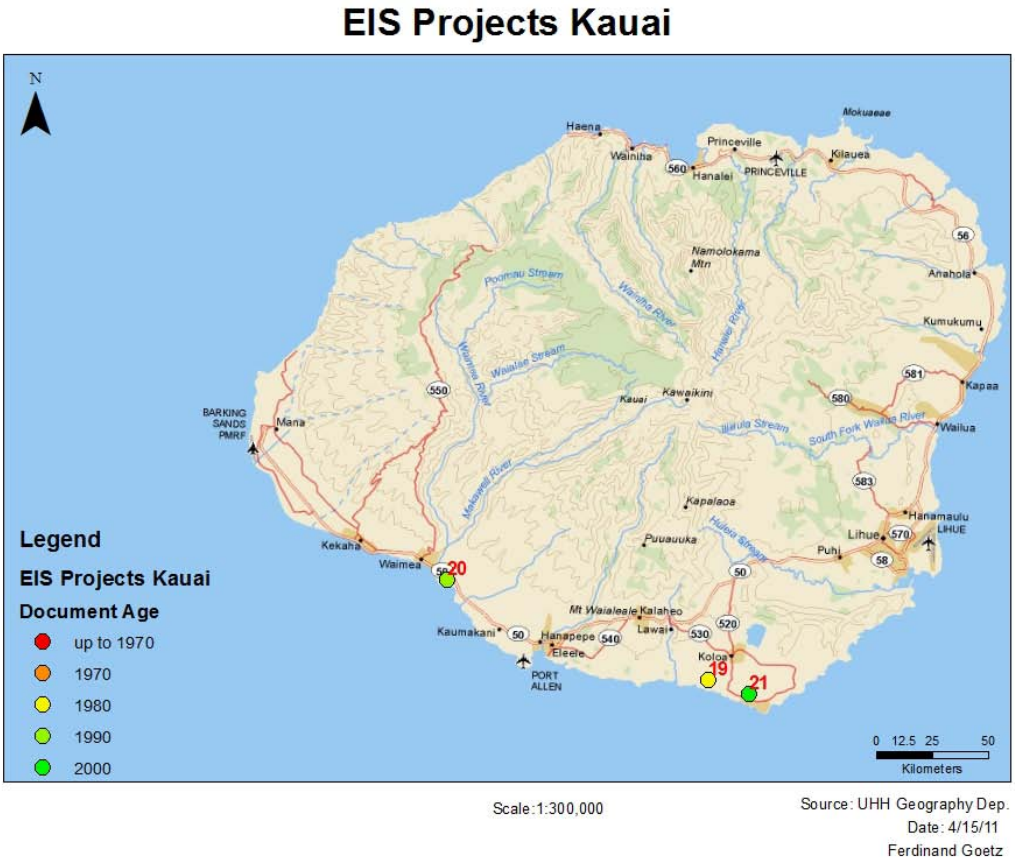


Figure 22. Location by Date- Oahu

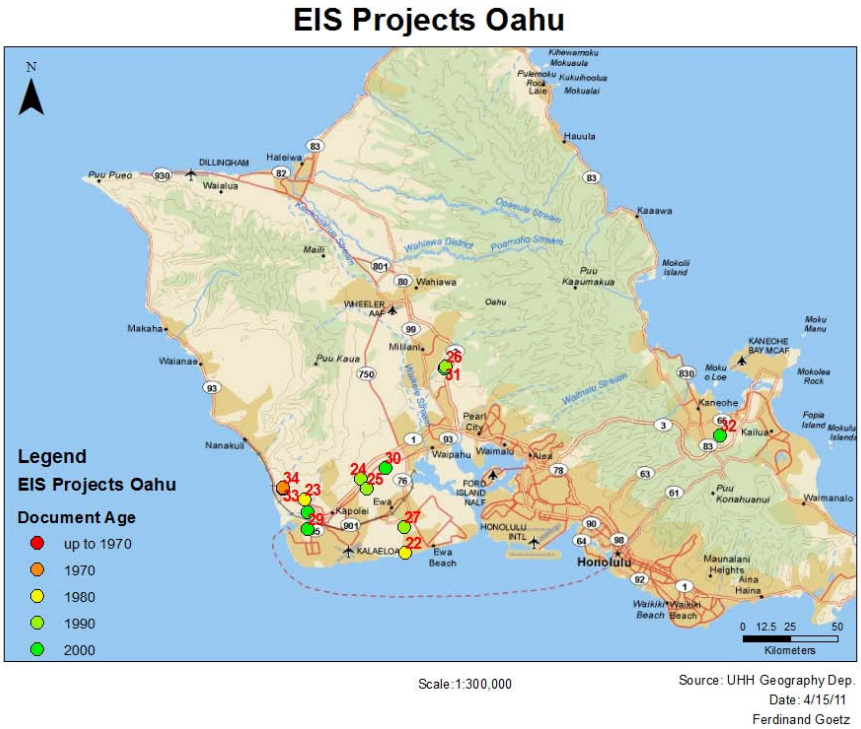


Figure 23. Location by Date- Maui

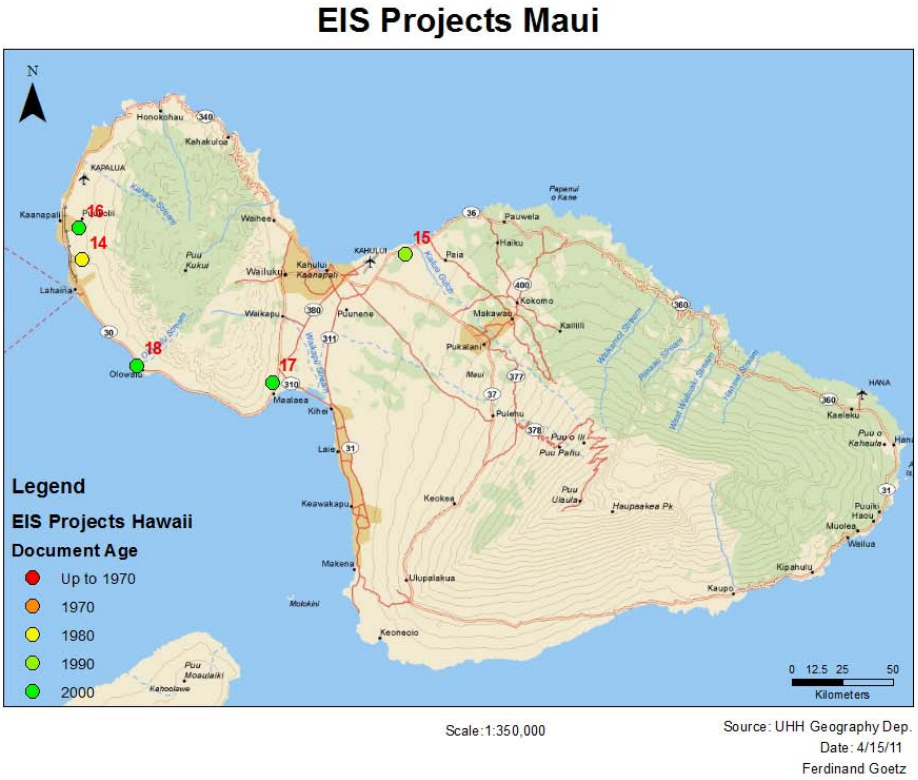


Figure 24. Location by Date- Hawaii

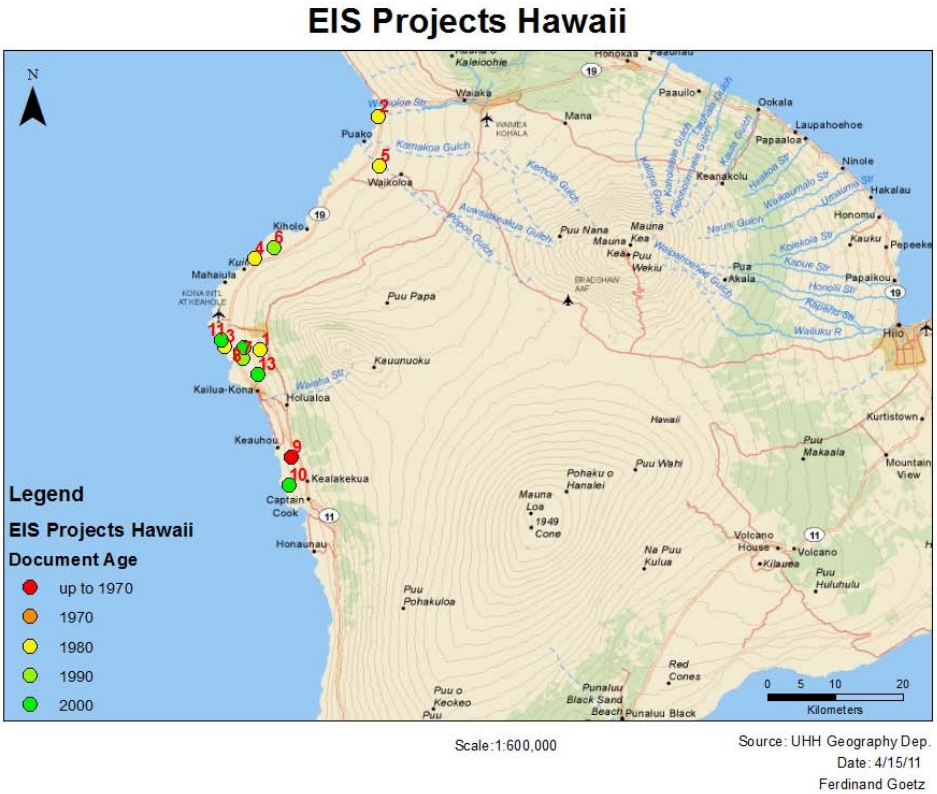


Table 5. Evaluation of Sample EISs

ID	Island	Docket #	Petitioner	Location	Documents Reviewed*	Annual Rainfall (in)	Rainfall intensity (in/hr)	Rainfall impact/ mitigation	slope (%)	soil type	erodibility	erosion impact (construct)	erosion impact (built)	erosion mitigation	stream[¥]	flood zones (FIRM)[†]	stormwater impact/mitigation	Cumulative Stormwater (code)[‡]	LUC stormwater conditions
1	Hawai i	A81-525	Y-O Limited Partnership	North Kona	LUC	-	-	-	6 – 20	stony peat, rocky peat	low	-	-	-	no	C	-	-	no
2	Hawai i	A84-574-2	Mauna Kea Properties, Inc (Mauna Kea Resort)	Hapuna	FEIS, LUC	5 – 20	-	no	6 – 12	stony very fine sand loam	moderate	no	no	no	no	C	yes	6A	no
3	Hawai i	A86-599	Kona Beach Development Venture (Kohanaiki)	Kohanaiki	FEIS, LUC	25	-	no	0 – 5	young lava and extremely rocky peat	low	no	no	no	no	C	yes	1B	yes
4	Hawai i	A86-603	Huehue Ranch	North Kona	FEIS, LUC	7 – 8	-	no	0 – 20	young lava and thin ash	low	yes	no	yes	no	C	yes	1B	no
5	Hawai i	A87-617	Bridge Aina Lea, LLC (Villages at Aina Lea)	Waikoloa	FEIS, LUC	9	-	no	6 – 20	young lava and stony fine sandy loam	moderate	yes	yes	yes	yes	X	yes	2A	no

ID	Island	Docket #	Petitioner	Location	Documents Reviewed*	Annual Rainfall (in)	Rainfall intensity (in/hr)	Rainfall impact/ mitigation	slope (%)	soil type	erodibility	erosion impact (construct)	erosion impact (built)	erosion mitigation	stream[¥]	flood zones (FIRM)[†]	stormwater impact/mitigation	Cumulative Stormwater (code)[‡]	LUC stormwater conditions
6	Hawai i	A93-701	(Kaupulehu Development)	Kona	FEIS, LUC	<20	-	no	4	young lava	low	no	no	no	no	X	yes	2B	yes
7	Hawai i	A00-730	Lanihau Properties, LLC (Kaloko-Honokohau Business Park)	Honokohau	FEIS, LUC	15 – 20	-	no	5 – 8	young lava	low	yes	no	no	no	X	yes	2B	yes
8	Hawai i	A00-732	TSA International, Ltd. (Kaloko Commercial Center)	Honokohau	FEIS, LUC	25	-	no	5 – 8	young lava	low	yes	no	yes	no	X	yes	2A	yes
9	Hawai i	A04-747	Kamehameha Investment Corp. (Keauhou Subdivision)	Keauhou	LUC	45	-	-	2 – 20	stony silty clay loam and rocky peat	-	-	no	yes	no	X	yes	-	yes
10	Hawai i	A06-769	1250 Oceanside Partners (Hokulia)	N/S Kona	FEIS, LUC	35	-	yes	13	lava, stony peat, cinder, silty clay loam	low	yes	no	yes (construct)	no	X	yes	1B	-
11	Hawai i	A07-774	North Kona Village, LLC	Ooma, North Kona	FEIS, LUC	25	-	no	0 – 5	young lava, beac	low	yes	no	yes	no	X	yes	6A	-

ID	Island	Docket #	Petitioner	Location	Documents Reviewed*	Annual Rainfall (in)	Rainfall intensity (in/hr)	Rainfall impact/ mitigation	slope (%)	soil type	erodibility	erosion impact (construct)	erosion impact (built)	erosion mitigation	stream[¥]	flood zones (FIRM)[†]	stormwater impact/mitigation	Cumulative Stormwater (code)[‡]	LUC stormwater conditions
			(O'oma Beachside Village)							h sand									
12	Hawai i	A07-778	SCD Kaloko Makai, LLC (Kaloko Makai)	Kaloko, N. Kona	EISPN, LUC	25	-	-	5 – 8	young lava, stony peat	low	yes	no	yes	no	X	yes	1A	no
13	Hawai i	A10-785	Forest City (Kamakana)	Kaohulou	FEIS, LUC	20 – 40	-	no	5 – 15	young lava, rocky peat	low	yes	no	yes	no	X	yes	1A	-
14	Maui	A89-652	Hawaii Finance and Development Corp (Villages of Leialii)	Lahaina	DEIS, LUC	30	-	no	6 – 12	silty clay	moderate	yes	no	yes	near	X	yes	6A	yes
15	Maui	A98-725	A&B Properties, Inc.(Spreckelsville Mauka)	Spreckelsville	LUC	2.5	-	-	0 – 7	silty clay loam	moderate	yes	no	yes	near	C	yes	1A	yes
16	Maui	A05-756	Kaanapali Development Corp.	Kaanapali	EISPN	20	-	-	6	silty clay	-	-	-	-	yes	C	-	-	-
17	Maui	A06-765	Maalaea Properties, LLC; Lodi Development,	Maalaea	DEIS, LUC	14 – 16	2.9-4.5	no	0 – 15	silty clay, clay loam, ston	low	yes	-	yes (construct)	yes	C	yes	1B	-

ID	Island	Docket #	Petitioner	Location	Documents Reviewed*	Annual Rainfall (in)	Rainfall intensity (in/hr)	Rainfall impact/ mitigation	slope (%)	soil type	erodibility	erosion impact (construct)	erosion impact (built)	erosion mitigation	stream[¥]	flood zones (FIRM)[†]	stormwater impact/mitigation	Cumulative Stormwater (code)[‡]	LUC stormwater conditions
			Inc.(Maalaea Mauka)							y alluvial land									
18	Maui	A10-786	Olowalu Town LLC and Olowalu Ekolu LLC	Olowalu	EISPN, LUC	15	-	no	0 – 4	cobbly clay loam, stony silty clay	low-moderate	yes	no	yes	yes	A, AE, AO, X	yes	1B	-
19	Kauai	A93-696	Kukui'ula Development Company, Inc.	Koloa	FEIS, LUC	70	-	no	0 – 15	stony silty clay	low-severe	yes	yes	yes	yes	X, AE	yes	1B	yes
20	Kauai	A00-731	Destination Villages Kauai, LLC (Kapalawai Resort)	Makaweli	FEIS, LUC	21	-	no	1 – 4	fill land, loamy fine sand, silty clay loam	low-moderate	yes	yes	yes	yes	A, AE, X	yes	1B	yes
21	Kauai	A05-761	Eric A Knudsen Trust	Poipu	FEIS	40 – 45	1.7-3.4	no	2	rocky silty clay	low	yes	yes	yes	no	X	yes	6A	-
22	Oahu	A89-651	Haseko (Ewa Marine)	Ewa	FEIS, FSEIS, LUC	-	-	no	0 – 1	coral outcrop, fill land, silty clay	low	yes	no	yes	no	A, AE, D	yes	1A	yes

ID	Island	Docket #	Petitioner	Location	Documents Reviewed*	Annual Rainfall (in)	Rainfall intensity (in/hr)	Rainfall impact/ mitigation	slope (%)	soil type	erodibility	erosion impact (construct)	erosion impact (built)	erosion mitigation	stream¥	flood zones (FIRM)†	stormwater impact/mitigation	Cumulative Stormwater (code)‡	LUC stormwater conditions
23	Oahu	A92-687	Estate of James Campbell (Makaiwa Hills)	Ewa	FEIS, LUC	20 – 30	1.9-2.4	no	0 – 50	stony steep land, stily clay, silty clay loam, stony clay	-	yes	yes (reduced)	yes	no	D	yes	5A	yes
24	Oahu	A99-728	State of Hawaii, HCDCH (East Kapolei Master Plan)	Ewa	FEIS, LUC	20	-	no	0.7 – 2	silty clay	low	yes	yes (reduced)	yes	no	X	yes	1A	yes
25	Oahu	A99-728(a)	University of Hawaii, West Oahu	Ewa	FEIS, LUC	20	-	no	1 – 2	clay, silty clay, silty clay loam	low	yes	yes (reduced)	yes	no	D	yes	3A	yes
26	Oahu	A03-738	Gentry Investment Properties (Ewa Makai)	Ewa	FEIS, LUC	20	-	no	1	silty clay loam	low	no	no	yes	no	D, X	yes	1A	yes
27	Oahu	A04-753	Aina Nui Corporation (Kapolei West)	Honouliuli	FEIS, LUC	21	1.9-2.3	no	1 – 25	coral outcrop, silty clay loam	low	no	yes (reduced)	yes	no	D	yes	1A	yes

ID	Island	Docket #	Petitioner	Location	Documents Reviewed*	Annual Rainfall (in)	Rainfall intensity (in/hr)	Rainfall impact/ mitigation	slope (%)	soil type	erodibility	erosion impact (construct)	erosion impact (built)	erosion mitigation	stream[¥]	flood zones (FIRM)[†]	stormwater impact/mitigation	Cumulative Stormwater (code)[‡]	LUC stormwater conditions
28	Oahu	A06-763	Kapolei Property Development, LLC	Honouliuli	FEIS, LUC	21	1.9-2.7	no	0.5 – 5	coral outcrop, silty clay loam	low	yes	no	yes	no	D	yes	2A	yes
29	Oahu	A06-771	DR Horton - Schuler Homes, LLC (Hoopili)	Ewa	FEIS	20	1.75 -2.5	no	1.1 – 3.9	clay, silty clay, silty clay loam	low-severe	yes	yes (reduced)	yes	no	D, C	yes	4A	-
30	Oahu	A07-775	Castle & Cooke Homes Hawaii, Inc.(Koa Ridge (Makai & Waiawa)	Waipio & Waiawa	FEIS, LUC	50	-	no	≈3	silty clays, clay loams	low-severe	no	no	yes	yes	D	yes	2A	-
31	Oahu	A07-777	Hawaiian Memorial Park, LTD (Hawaiian Memorial Park Expansion)	Kaneohe	FEIS, LUC	59 – 79	2.5	no	0 – 30+	silty clay	Moderate-severe	yes	yes	yes	vicinity	D, X	yes	3B	-
32	Oahu	A08-780	Dept of Env Serv, C&C of Hon (Waimanalo Gulch Landfill)	Honouliuli	FEIS, SFEIS, LUC	20 – 30	-	no	0 – 18	rock land, stony steep land	Low-moderate	yes	yes	yes	no	D	no	3B	-
ID	**Island**	**Docket #**	**Petitioner**	**Location**	**Documents Revie**	**Annual Rainfal**	**Rainfall intensit**	**Rainfall impact/**	**slope (%)**	**soil type**	**erodibility**	**erosion impact**	**erosion impact**	**erosion mitig**	**stream**	**flood zones (FIRM)**	**stormwater impact/m**	**Cumulative Storm water**	**LUC storm water condi**

ID	Island	Docket #	Petitioner	Location	Documents Reviewed*	Annual Rainfall (in)	Rainfall intensity (in/hr)	Rainfall impact/ mitigation	slope (%)	soil type	erodibility	erosion impact (construct)	erosion impact (built)	erosion mitigation	stream[¥]	flood zones (FIRM)[†]	stormwater impact/mitigation	Cumulative Stormwater (code)[‡]	LUC stormwater conditions
					wed*	**l (in)**	**y (in/hr)**	**mitigation**				**(construct)**	**(built)**	**ation**		**†**	**itigation**	**(code)[‡]**	**tions**

Appendix B: Water Quality Standards Maps

Source: http://hawaii.gov/health/environmental/water/cleanwater/wqsmaps/index.html

The GIS layer for Water Quality Classes show the marine waters AA and A. The following maps also show the classes for inland waters and benthic communities.

Figure 25. Water Quality Standards Map- Kauai & Niihau

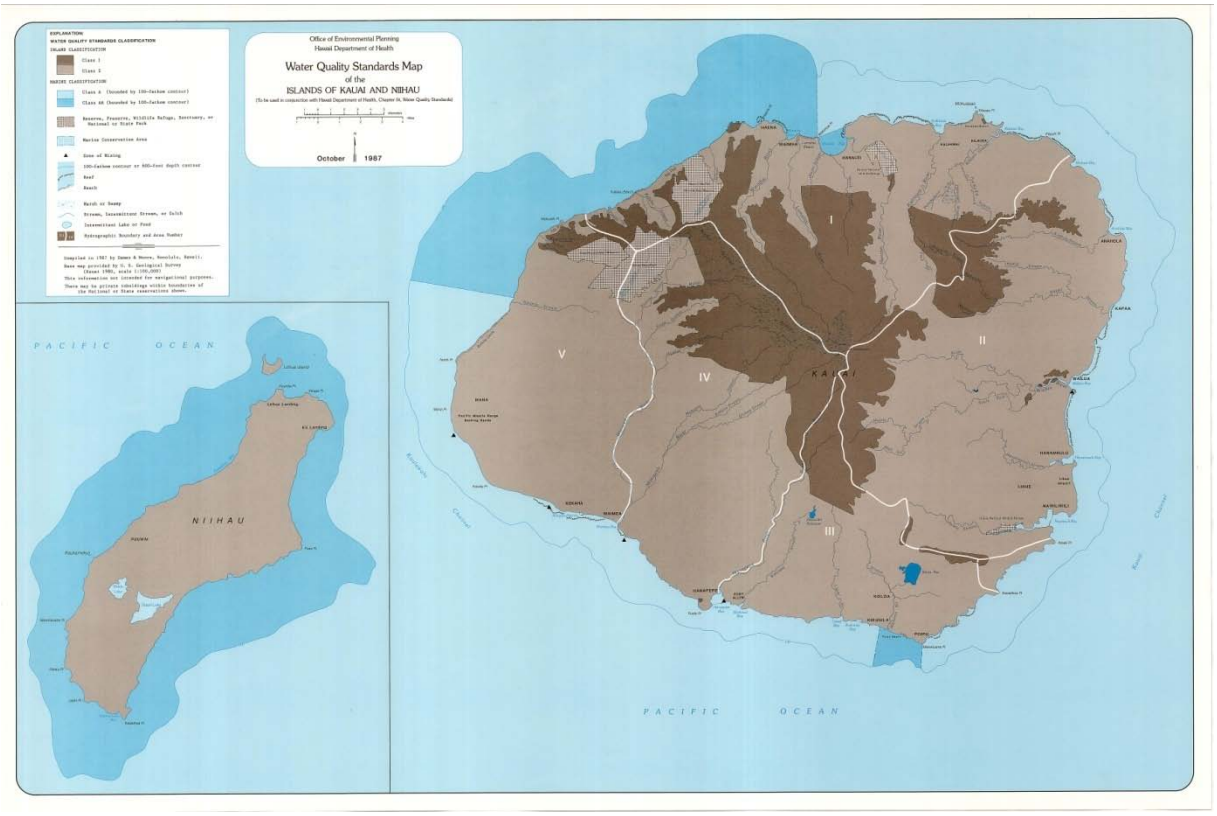


Figure 26. Water Quality Standards Map- Oahu

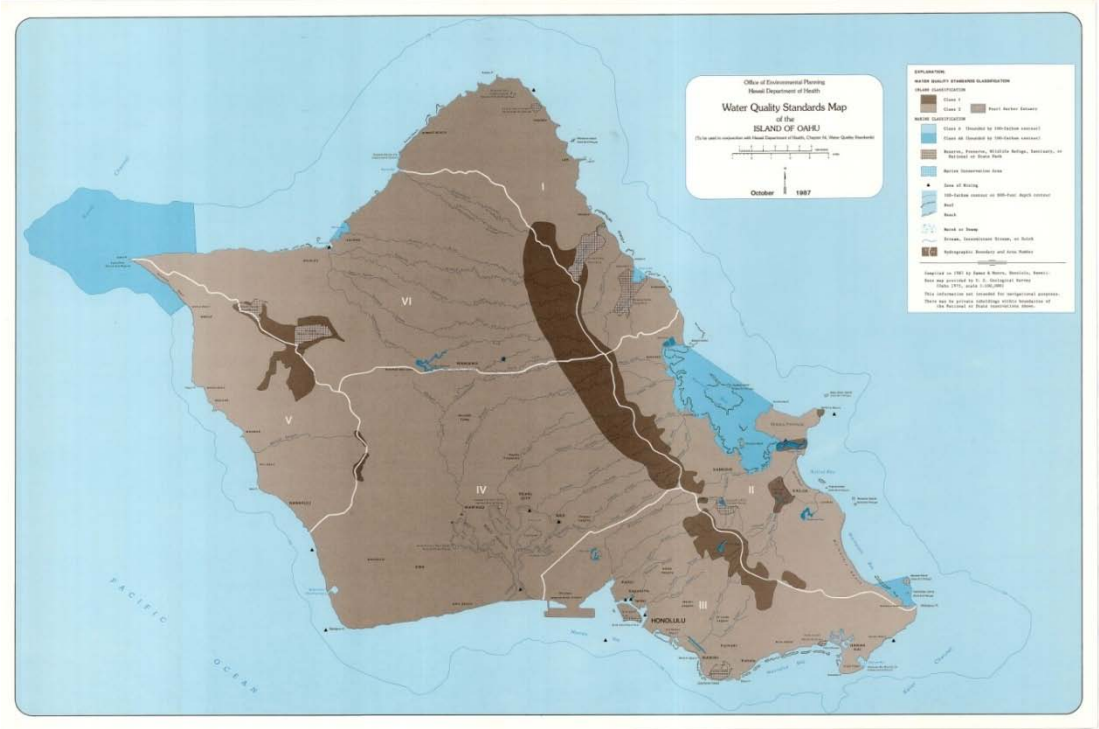


Figure 27. Water Quality Standards Map- Maui

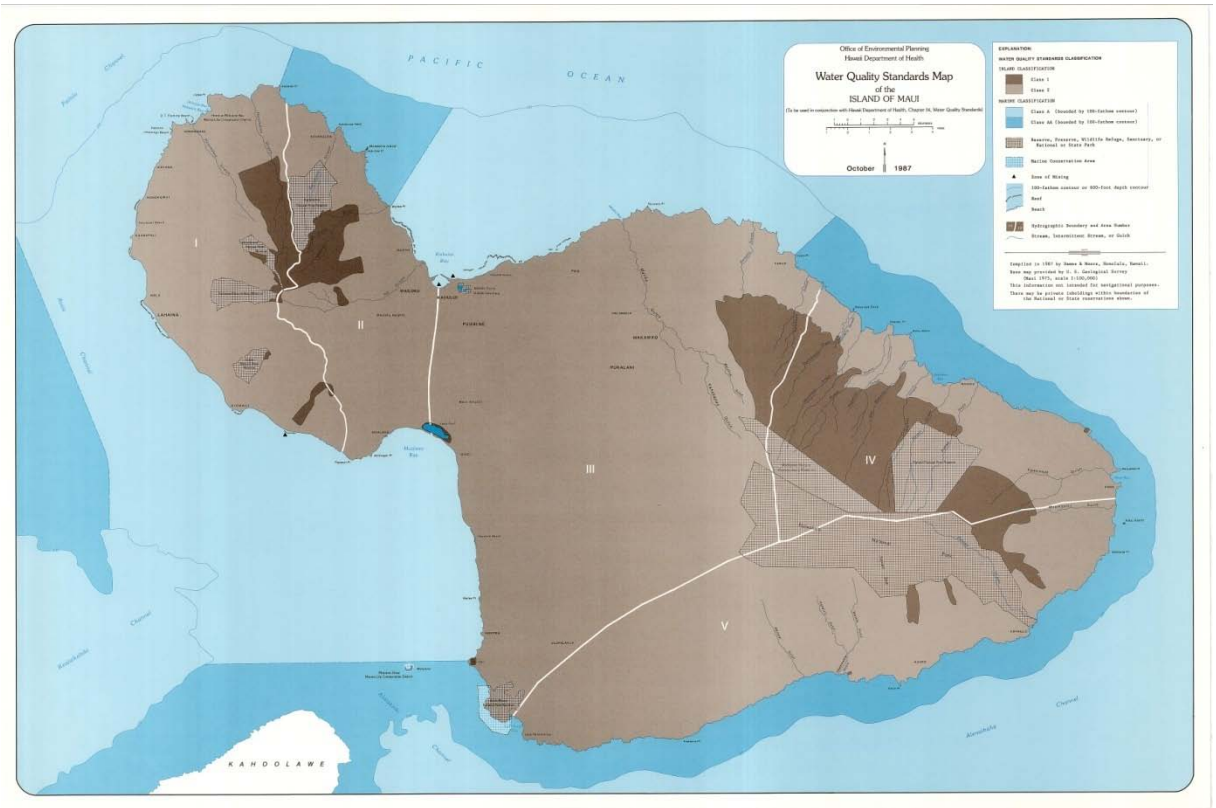


Figure 28. Water Quality Standards Map- Molokai, Lanai, Kahoolawe

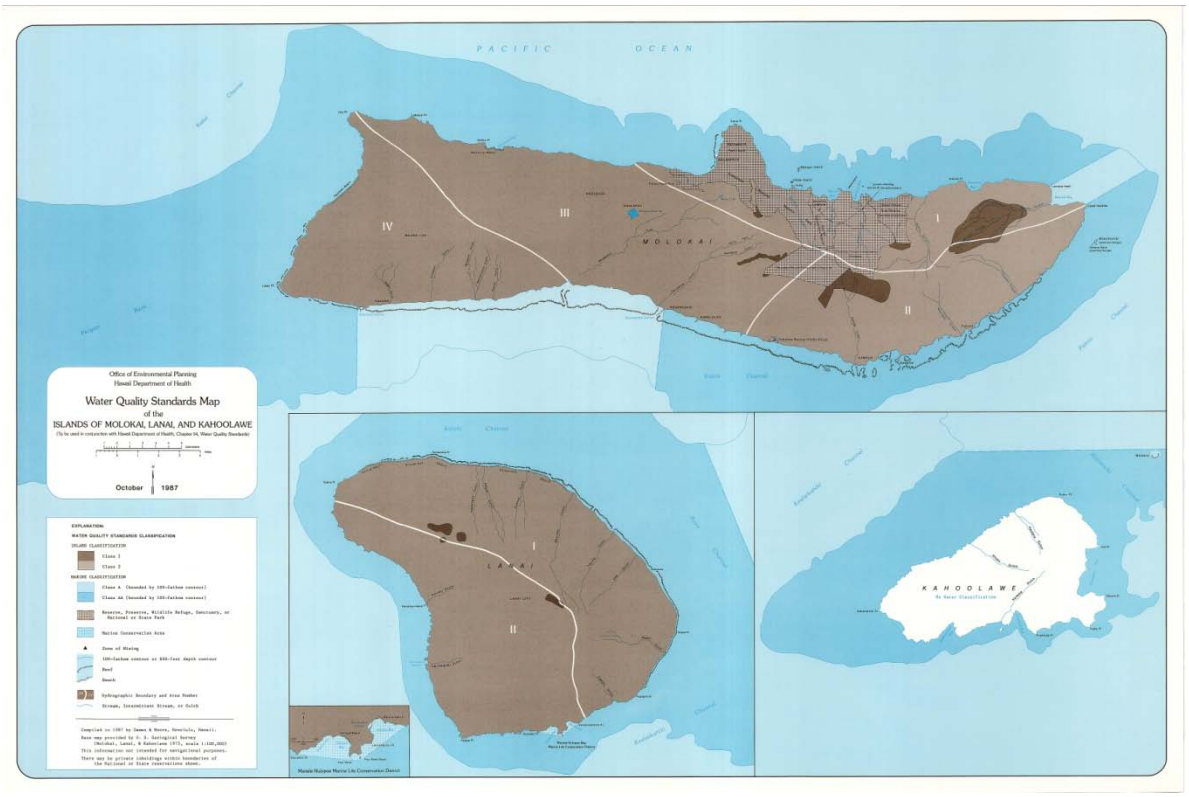
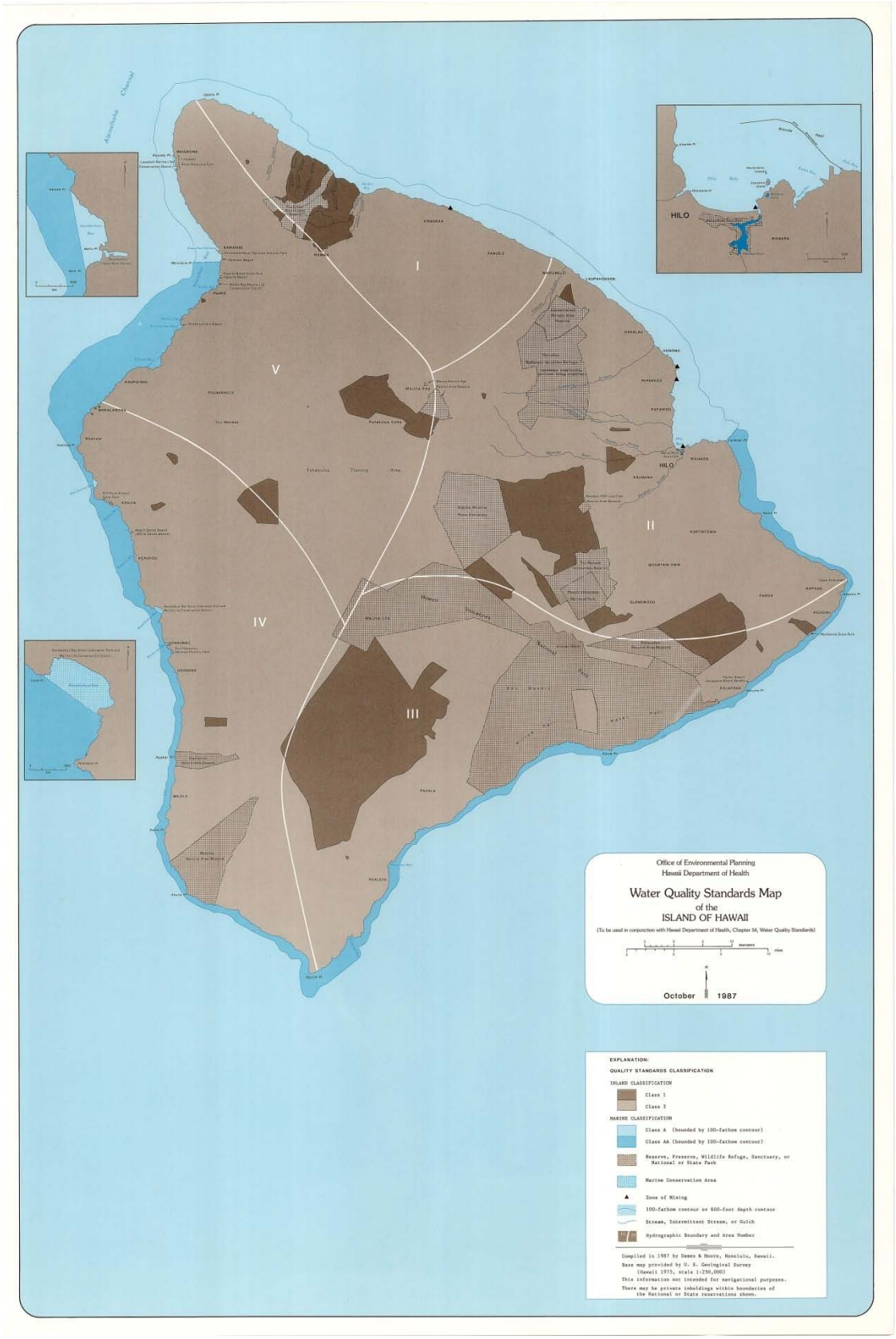


Figure 29. Water Quality Standards Map- Hawaii


Office of Environmental Planning
Hawaii Department of Health
Water Quality Standards Map
of the
ISLAND OF HAWAII
(To be used in conjunction with Hawaii Department of Health, Chapter 54, Water Quality Standards)
October 1987
EXPLANATION:
QUALITY STANDARDS CLASSIFICATION
INLAND CLASSIFICATION
Class 1
Class 2
MARINE CLASSIFICATION
Class A (bounded by 100-fathom contour)
Class AA (bounded by 100-fathom contour)
Reserve, Preserve, Wildlife Refuge, Sanctuary, or National or State Park
Marine Conservation Area
Zone of Mixing
100-fathom contour or 600-foot depth contour
Stream, Intermittent Stream, or Gulch
Hydrographic Boundary and Area Number
Compiled in 1987 by Dames & Moore, Honolulu, Hawaii.
Base map provided by U. S. Geological Survey
(Hawaii 1975, scale 1:250,000)
This information not intended for navigational purposes.
There may be private inholdings within boundaries of the National or State reservations shown.
HILO
I
II
III
IV
V

Appendix C: Sensitive Watersheds

Watershed Sensitivity Reference

Receiving Waters:	Classification of receiving waters (Dept. of Health Marine Classification
Coral Cover:	Presence of coral cover within 500m of watershed (NOAA benthic habitat maps)
Coastal Reserve:	Presence of coastal reserve, preserve, or park within 500m of watershed
Embayments:	Presence of embayment within receiving waters of watershed
303(d) Streams:	Presence of EPA Hawaii 303(d) Listed Waters within watershed
Watershed Health Index:	Kido's Watershed Health Index, 0 being poor watershed health and 1.0 being excellent (see: Kido, M.H. April 2004. Hawaii Island – Stream Condition Along A Human Disturbance Gradient. Technical Report to the Hawaii Department of Health Environmental Planning Office)
HWPP Restoration:	Hawaii Watershed Prioritization Process ranking 580 State watersheds by their need to receive restoration. Rank 1 = highest priority for restoration. (see: MCS International. June 2009. Hawaii Watershed Prioritization Process. Prepared for NOAA)
HWPP Protection:	Hawaii Watershed Prioritization Process ranking 580 State watersheds by their need to receive protection. Rank 1 = highest priority for protection.

Island	Watershed Name	Receiving Waters (A/AA)	Coral Cover (Yes/No)	Coastal Reserve (Yes/No)	Embay-ment (Yes/No)	EPA 303(d) ImpairedStreams (Yes/No)	Watershed Health Index (poor 0 -	HWPP Restoration Rank (1-580)	HWPP Protection Rank (1-580)
Hawaii	Aamakao	A	No	No	No	**Yes**	0.611	**187**	411
Hawaii	Aamanu	A	No	No	No	No	**0.498**	385	506
Hawaii	Ahole	A	No	No	No	No	0.693	541	514
Hawaii	Alakahi	A	**Yes**	No	No	No	**0.276**	**181**	289
Hawaii	Aleamai	A	**Yes**	No	No	No	**0.349**	**130**	296
Hawaii	Alia	A	**Yes**	No	No	No	**0.346**	**79**	**185**
Hawaii	Alilipali	A	No	No	No	No	**0.480**	372	489
Hawaii	Haakoa	A	No	No	No	No	0.921	574	572
Hawaii	Hakalau	A	**Yes**	No	No	**Yes**	0.709	**182**	410
Hawaii	Halawa	A	No	No	No	No	**0.465**	**40**	250
Hawaii	Halelua	A	No	No	No	No	**0.421**	**159**	370
Hawaii	Haloa	A	No	No	No	No	**0.391**	414	498
Hawaii	Hanaula	A	No	No	No	No	**0.415**	234	395
Hawaii	Hanawi	A	**Yes**	No	No	No	0.701	445	416
Hawaii	Hapahapai	A	No	No	No	No	**0.425**	**164**	368
Hawaii	Hilea	AA	**Yes**	No	No	No	0.823	386	254
Hawaii	Honokaia	A	No	No	No	No	**0.465**	468	552
Hawaii	Honokane Iki	A	No	No	No	No	0.866	559	538
Hawaii	Honokane Nui	A	No	**Yes**	No	No	0.915	565	477
Hawaii	Honokea	A	No	**Yes**	No	No	0.843	525	396
Hawaii	Honokohau	AA	**Yes**	**Yes**	**Yes**	No	0.634	**108**	**70**
Hawaii	Honolii	A	No	No	No	**Yes**	0.885	209	436
Hawaii	Honomu	A	**Yes**	No	No	No	0.624	406	359
Hawaii	Honopue	A	No	**Yes**	No	No	0.910	538	398
Hawaii	Hualua	A	No	No	No	No	**0.387**	**174**	375
Hawaii	Kaahakini	AA	**Yes**	**Yes**	No	No	0.791	**126**	**46**

Island	Watershed Name	Receiving Waters (A/AA)	Coral Cover (Yes/No)	Coastal Reserve (Yes/No)	Embay-ment (Yes/No)	EPA 303(d) ImpairedStreams (Yes/No)	Watershed Health Index (poor 0 -	HWPP Restoration Rank (1-580)	HWPP Protection Rank (1-580)
Hawaii	Kaaheiki	A	No	No	No	No	**0.430**	455	517
Hawaii	Kaala	A	No	No	No	No	0.600	550	560
Hawaii	Kaapoko	A	**Yes**	No	No	No	**0.216**	**61**	**182**
Hawaii	Kaawalii	A	No	**Yes**	No	No	0.868	555	481
Hawaii	Kahaupu	A	No	No	No	No	**0.480**	526	568
Hawaii	Kahawailiili	A	No	No	No	No	0.526	427	513
Hawaii	Kahoopuu	A	No	**Yes**	No	No	0.678	396	270
Hawaii	Kaieie	A	**Yes**	No	No	**Yes**	**0.496**	**60**	222
Hawaii	Kailikaula	A	No	**Yes**	No	No	0.817	535	406
Hawaii	Kaimu	A	No	**Yes**	No	No	0.891	566	444
Hawaii	Kainapahoa	A	No	No	No	No	0.531	473	543
Hawaii	Kaiwiki	A	No	No	No	No	0.839	575	559
Hawaii	Kaiwilahilahi	A	No	No	No	No	0.892	570	570
Hawaii	Kalaoa	A	**Yes**	No	No	No	**0.357**	**111**	264
Hawaii	Kalapahapuu	A	No	No	No	No	0.582	505	544
Hawaii	Kalele	A	No	No	No	No	0.633	494	511
Hawaii	Kalopa	A	No	No	No	No	0.623	380	539
Hawaii	Kaluahine Falls	A	No	No	No	No	0.536	299	418
Hawaii	Kaohaoha	A	No	**Yes**	No	No	**0.440**	291	362
Hawaii	Kapapala	AA	**Yes**	**Yes**	No	No	0.772	202	**53**
Hawaii	Kapehu	A	**Yes**	No	No	**Yes**	**0.377**	**37**	**169**
Hawaii	Kapehu Camp	A	No	No	No	No	**0.441**	417	557
Hawaii	Kapua	A	No	No	No	No	**0.416**	272	480
Hawaii	Kapue	A	**Yes**	No	No	**Yes**	0.869	**115**	242
Hawaii	Kapulena	A	No	No	No	No	0.598	429	551
Hawaii	Kaula	A	No	No	No	No	0.683	461	549
Hawaii	Kaumoali	A	No	No	No	No	0.541	403	499
Hawaii	Kauna	AA	**Yes**	**Yes**	No	No	0.704	**104**	**21**
Hawaii	Kawaihae	A	**Yes**	**Yes**	**Yes**	No	0.565	**134**	**118**
Hawaii	Kawaikalia	A	No	No	No	No	0.637	366	479
Hawaii	Kawainui	A	No	No	No	No	0.822	**4**	**34**
Hawaii	Kawela	A	No	No	No	No	0.592	446	518
Hawaii	Keaakaukau	A	No	No	No	No	0.593	325	422
Hawaii	Keahole	AA	**Yes**	**Yes**	No	No	0.569	**57**	**18**
Hawaii	Keahua	A	No	No	No	No	**0.484**	437	532
Hawaii	Kealahewa	A	No	No	No	No	**0.379**	**192**	379
Hawaii	Kealakaha	A	No	No	No	No	0.603	546	553
Hawaii	Kealakekua	AA	**Yes**	**Yes**	**Yes**	No	0.699	**66**	**16**
Hawaii	Keawanui	AA	**Yes**	**Yes**	No	No	0.509	**95**	**20**
Hawaii	Keehia	A	No	No	No	No	0.543	509	565
Hawaii	Kekualele	A	No	No	No	No	0.538	553	571
Hawaii	Kihalani	A	No	No	No	No	**0.453**	467	530
Hawaii	Kiholo	AA	**Yes**	**Yes**	**Yes**	No	0.724	**176**	**51**
Hawaii	Kiilae	AA	**Yes**	**Yes**	**Yes**	No	0.804	**158**	**54**
Hawaii	Kilau	A	No	No	No	No	0.782	560	578
Hawaii	Kilauea	AA	**Yes**	**Yes**	No	No	0.764	**141**	**45**

Island	Watershed Name	Receiving Waters (A/AA)	Coral Cover (Yes/No)	Coastal Reserve (Yes/No)	Embay-ment (Yes/No)	EPA 303(d) ImpairedStreams (Yes/No)	Watershed Health Index (poor 0 -	HWPP Restoration Rank (1-580)	HWPP Protection Rank (1-580)
Hawaii	Koholalele	A	No	No	No	No	0.651	424	519
Hawaii	Kolealiilii	A	No	**Yes**	No	No	0.916	554	401
Hawaii	Kolekole	A	**Yes**	No	No	No	0.844	479	445
Hawaii	Kukaiau	A	No	No	No	No	0.612	500	541
Hawaii	Kukui	A	No	**Yes**	No	No	0.842	529	354
Hawaii	Kukuilamalamahii	A	No	No	No	No	0.505	390	485
Hawaii	Kulanakii	A	No	No	No	No	0.576	558	577
Hawaii	Kumakua	A	No	No	No	No	**0.419**	261	437
Hawaii	Kupapaulua	A	No	No	No	No	0.779	549	546
Hawaii	Kuwaikahi	A	No	No	No	No	**0.388**	342	488
Hawaii	Laimi	A	**Yes**	No	No	No	**0.446**	360	385
Hawaii	Lamimaumau	A	No	No	No	No	**0.439**	420	534
Hawaii	Lapakahi	AA	**Yes**	**Yes**	No	No	**0.467**	**107**	**27**
Hawaii	Laupahoehoe	A	No	No	No	No	0.730	532	566
Hawaii	Mahukona	A	**Yes**	**Yes**	No	No	**0.437**	**188**	**157**
Hawaii	Maili	A	No	No	No	No	0.610	453	535
Hawaii	Makahanaloa	A	**Yes**	No	No	No	**0.367**	**133**	259
Hawaii	Makea	A	**Yes**	No	No	No	**0.354**	205	353
Hawaii	Malanahae	A	No	No	No	No	0.549	379	487
Hawaii	Manoloa	A	No	No	No	No	0.741	552	524
Hawaii	Manowaiopae	A	No	No	No	No	0.653	489	536
Hawaii	Manuwaikaalio	A	No	**Yes**	No	No	0.951	511	318
Hawaii	Maulua	A	No	No	No	No	0.912	579	575
Hawaii	Nakooko	A	No	**Yes**	No	No	0.969	533	389
Hawaii	Naluea	A	No	**Yes**	No	No	0.762	506	388
Hawaii	Nanue	A	No	No	No	No	0.939	578	569
Hawaii	Nienie	A	No	No	No	No	0.535	466	562
Hawaii	Ninole	A	No	No	No	No	0.737	542	556
Hawaii	Niulii	A	No	No	No	**Yes**	0.670	**185**	452
Hawaii	Ohanaula	A	No	No	No	No	**0.375**	255	460
Hawaii	Ohiahuea	A	No	**Yes**	No	No	0.966	573	450
Hawaii	Onomea	A	**Yes**	No	No	No	**0.360**	249	358
Hawaii	Opea	A	No	No	No	No	0.556	451	449
Hawaii	Ouhi	A	No	No	No	No	0.523	301	474
Hawaii	Paauilo	A	No	No	No	No	0.600	514	558
Hawaii	Pae	A	No	**Yes**	No	No	0.846	495	305
Hawaii	Paeohe	A	No	No	No	No	0.602	465	522
Hawaii	Pahala	AA	**Yes**	**Yes**	No	No	0.796	204	**88**
Hawaii	Pahale	A	No	No	No	No	0.854	569	576
Hawaii	Paheehee	A	**Yes**	No	No	No	**0.495**	375	423
Hawaii	Pahoehoe	A	**Yes**	No	No	No	0.806	462	413
Hawaii	Pali Akamoa	A	No	No	No	No	**0.400**	**172**	374
Hawaii	Paopao S.	A	No	No	No	No	0.872	577	555
Hawaii	Papaikou	A	**Yes**	No	No	No	**0.279**	**53**	198
Hawaii	Papuaa	A	No	No	No	No	**0.482**	313	510
Hawaii	Paukaa	A	No	No	No	No	**0.324**	269	490

Island	Watershed Name	Receiving Waters (A/AA)	Coral Cover (Yes/No)	Coastal Reserve (Yes/No)	Embay-ment (Yes/No)	EPA 303(d) ImpairedStreams (Yes/No)	Watershed Health Index (poor 0 -	HWPP Restoration Rank (1-580)	HWPP Protection Rank (1-580)
Hawaii	Peleau	A	No	No	No	No	**0.355**	332	501
Hawaii	Pohakuhaku	A	No	No	No	No	0.540	443	484
Hawaii	Pohakuloa	AA	**Yes**	**Yes**	**Yes**	No	0.651	**106**	**40**
Hawaii	Pohakupuka	A	No	No	No	No	0.873	580	580
Hawaii	Pololu	A	No	**Yes**	No	No	0.782	476	382
Hawaii	Poupou	A	No	No	No	No	**0.453**	556	573
Hawaii	Pukihae	A	No	No	**Yes**	No	0.556	395	529
Hawaii	Pukoa	A	No	**Yes**	No	No	0.944	534	377
Hawaii	Punalulu	A	No	No	No	No	0.853	571	537
Hawaii	Puumaile	A	No	No	No	No	0.604	508	550
Hawaii	Puuokalepa	A	**Yes**	No	No	No	**0.365**	**103**	202
Hawaii	South Point	AA	**Yes**	No	No	No	0.678	244	204
Hawaii	Umauma	A	No	No	No	No	0.826	545	574
Hawaii	Waiaalala	A	No	No	No	No	0.785	564	523
Hawaii	Waiaama	A	No	No	No	No	0.721	459	483
Hawaii	Waiaha	AA	**Yes**	**Yes**	**Yes**	No	0.741	**98**	**31**
Hawaii	Waialeale	A	No	No	No	No	0.609	434	494
Hawaii	Waiapuka	A	No	**Yes**	No	No	0.921	463	280
Hawaii	Waiehu	A	No	No	No	No	**0.425**	**3**	**50**
Hawaii	Waikaalulu	A	No	No	No	No	**0.489**	457	507
Hawaii	Waikaloa	A	No	**Yes**	No	No	0.967	563	434
Hawaii	Waikama	A	No	No	No	**Yes**	0.707	**114**	369
Hawaii	Waikaumalo	A	No	No	No	No	0.929	528	521
Hawaii	Waikoekoe	A	No	No	No	No	0.507	314	491
Hawaii	Waikoloa	A	No	No	No	No	**0.491**	515	561
Hawaii	Waikoloa/Waiulaula	AA	**Yes**	No	No	No	0.567	**128**	**150**
Hawaii	Waikolu	A	No	No	No	No	**0.427**	**135**	**14**
Hawaii	Wailoa	A	**Yes**	**Yes**	No	**Yes**	0.782	**55**	**144**
Hawaii	Wailoa/Waipio	A	No	**Yes**	No	**Yes**	0.715	207	393
Hawaii	Wailuku	A	No	No	**Yes**	**Yes**	0.818	**146**	424
Hawaii	Waimaauou	A	No	No	No	No	**0.312**	275	527
Hawaii	Waimaile	A	No	**Yes**	No	No	0.851	471	306
Hawaii	Waimanu	A	No	**Yes**	No	No	0.786	523	367
Hawaii	Wainaia	A	No	No	No	**Yes**	**0.423**	**36**	325
Hawaii	Wainaku	A	No	No	**Yes**	No	**0.322**	**163**	381
Hawaii	Waipahi	A	No	No	No	No	0.739	543	545
Hawaii	Waipahoehoe	A	No	**Yes**	No	No	0.651	400	287
Hawaii	Waipunahina	A	No	**Yes**	No	No	0.584	215	284
Hawaii	Waipunahoe	A	No	No	No	No	**0.459**	442	512
Hawaii	Waipunalau	A	No	**Yes**	No	No	0.528	316	320
Hawaii	Waipunalei	A	No	No	No	No	0.499	345	443
Hawaii	Waiulili	A	No	No	No	No	0.566	352	531
Kahoolawe	Ahupu	AA	**Yes**	No	No	No	0.583	281	**111**
Kahoolawe	Ahupuiki	AA	**Yes**	No	No	No	0.557	254	**100**
Kahoolawe	Hakioawa	AA	**Yes**	No	No	No	0.537	278	**110**
Kahoolawe	Honokanaia	AA	**Yes**	No	No	No	**0.461**	252	**103**

Island	Watershed Name	Receiving Waters (A/AA)	Coral Cover (Yes/No)	Coastal Reserve (Yes/No)	Embay-ment (Yes/No)	EPA 303(d) ImpairedStreams (Yes/No)	Watershed Health Index (poor 0 -	HWPP Restoration Rank (1-580)	HWPP Protection Rank (1-580)
Kahoolawe	Honokoa	AA	**Yes**	No	No	No	0.552	369	**147**
Kahoolawe	Kamohio	AA	No	No	No	No	0.543	421	291
Kahoolawe	Kanaloa	AA	No	No	No	No	0.515	411	274
Kahoolawe	Kaukamaka	AA	No	No	No	No	0.529	433	300
Kahoolawe	Kaukamoku	AA	**Yes**	No	No	No	0.590	294	**124**
Kahoolawe	Kaulana	AA	**Yes**	No	No	No	0.584	378	195
Kahoolawe	Kealia Luna	AA	**Yes**	No	No	No	0.518	263	**108**
Kahoolawe	Kuheeia	AA	**Yes**	No	No	No	0.572	398	197
Kahoolawe	Lae o Kaka	AA	No	No	No	No	**0.493**	423	279
Kahoolawe	Lae Paki	AA	**Yes**	No	No	No	0.573	307	**116**
Kahoolawe	Makaalae	AA	**Yes**	No	No	No	0.582	343	**149**
Kahoolawe	Moaulaiki	AA	**Yes**	No	No	No	0.577	235	**97**
Kahoolawe	Oawawahie	AA	**Yes**	No	No	No	0.519	253	**106**
Kahoolawe	Olohia	AA	**Yes**	No	No	No	0.551	286	**132**
Kahoolawe	Pali o Kalapakea	AA	No	No	No	No	0.529	490	386
Kahoolawe	Papakaiki	AA	**Yes**	No	No	No	0.579	320	**161**
Kahoolawe	Papakanui	AA	No	No	No	No	0.557	504	384
Kahoolawe	Waaiki	AA	**Yes**	No	No	No	0.612	298	**104**
Kahoolawe	Wai Honu	AA	**Yes**	No	No	No	0.528	336	**166**
Kahoolawe	Waikahalulu	AA	No	No	No	No	0.529	404	298
Kauai	Aakukui	A	No	No	No	No	0.557	322	463
Kauai	Aepo	AA	No	No	**Yes**	No	**0.450**	**131**	243
Kauai	Aliomanu	A	**Yes**	No	No	No	0.533	323	333
Kauai	Anahola	A	No	No	No	**Yes**	0.627	**147**	500
Kauai	Anini	A	**Yes**	No	No	No	**0.421**	265	322
Kauai	Awaawapuhi	AA	No	**Yes**	No	No	0.959	493	281
Kauai	Haeleele	A	No	**Yes**	No	No	0.860	450	347
Kauai	Hanakapiai	AA	**Yes**	**Yes**	No	No	0.923	297	**41**
Kauai	Hanakoa	AA	**Yes**	**Yes**	No	No	1.000	280	**36**
Kauai	Hanalei	AA	**Yes**	No	**Yes**	**Yes**	0.860	**42**	**55**
Kauai	Hanamaulu	A	**Yes**	**Yes**	**Yes**	**Yes**	**0.343**	**15**	**120**
Kauai	Hanapepe	A	No	No	**Yes**	**Yes**	0.746	**193**	508
Kauai	Hikimoe	AA	**Yes**	**Yes**	No	No	0.898	351	**96**
Kauai	Hoea	A	No	**Yes**	No	No	0.610	213	299
Kauai	Honopu	AA	**Yes**	**Yes**	No	No	0.918	**102**	**28**
Kauai	Hoolulu	AA	**Yes**	**Yes**	No	No	0.740	270	**72**
Kauai	Huleia	A	**Yes**	**Yes**	**Yes**	**Yes**	0.568	**23**	**91**
Kauai	Kaawaloa	A	No	**Yes**	No	No	0.550	309	407
Kauai	Kaaweiki	AA	**Yes**	**Yes**	No	No	0.838	**177**	**29**
Kauai	Kalaheo	A	**Yes**	No	No	No	**0.334**	**112**	238
Kauai	Kalalau	AA	**Yes**	**Yes**	No	No	0.919	293	**80**
Kauai	Kalihikai Center	A	No	No	No	No	0.525	324	466
Kauai	Kalihikai East	A	**Yes**	No	No	No	**0.462**	250	247
Kauai	Kalihikai West	A	**Yes**	No	No	No	0.528	350	334
Kauai	Kalihiwai	A	**Yes**	No	No	No	0.796	326	251
Kauai	Kapaa	A	No	No	No	**Yes**	0.705	236	547

Island	Watershed Name	Receiving Waters (A/AA)	Coral Cover (Yes/No)	Coastal Reserve (Yes/No)	Embay-ment (Yes/No)	EPA 303(d) ImpairedStreams (Yes/No)	Watershed Health Index (poor 0 -	HWPP Restoration Rank (1-580)	HWPP Protection Rank (1-580)
Kauai	Kapilimao	A	No	**Yes**	**Yes**	No	**0.401**	**150**	311
Kauai	Kauapea	A	**Yes**	**Yes**	No	No	**0.358**	**45**	**60**
Kauai	Kauhao	AA	**Yes**	**Yes**	No	No	0.822	**142**	**23**
Kauai	Kaulaula	A	No	**Yes**	No	No	0.823	401	332
Kauai	Kaumakani	A	No	**Yes**	No	No	**0.274**	**171**	339
Kauai	Kawailoa	A	No	**Yes**	No	**Yes**	**0.384**	**13**	**148**
Kauai	Kilauea	A	**Yes**	**Yes**	No	**Yes**	0.635	**33**	**83**
Kauai	Kipu Kai	A	**Yes**	No	No	No	0.703	431	327
Kauai	Kukamahu	A	No	No	**Yes**	No	**0.243**	**166**	421
Kauai	Kulihaili	A	**Yes**	No	No	No	**0.413**	**186**	229
Kauai	Kumukumu	A	No	No	No	No	**0.286**	251	496
Kauai	Lawai	A	No	No	No	**Yes**	**0.490**	**62**	412
Kauai	Lihue Airport	A	**Yes**	No	No	No	**0.453**	**124**	228
Kauai	Limahuli	AA	**Yes**	**Yes**	No	**Yes**	0.858	**39**	**17**
Kauai	Lumahai	AA	**Yes**	No	No	No	0.987	436	213
Kauai	Mahaulepu	AA	**Yes**	No	No	**Yes**	0.575	**14**	**59**
Kauai	Mahinauli	A	No	No	No	No	**0.473**	330	525
Kauai	Makaha	AA	**Yes**	**Yes**	No	No	0.854	258	**93**
Kauai	Manoa	AA	**Yes**	No	No	**Yes**	0.776	**18**	**62**
Kauai	Maunapuluo	AA	**Yes**	**Yes**	No	No	0.740	276	**47**
Kauai	Milolii	AA	**Yes**	**Yes**	No	No	0.950	245	**67**
Kauai	Moikeha	A	No	No	No	No	**0.260**	344	540
Kauai	Moloaa	A	**Yes**	No	No	**Yes**	0.679	**154**	342
Kauai	Nahomalu	A	**Yes**	**Yes**	No	No	0.662	**137**	**141**
Kauai	Nakeikionaiwi	AA	**Yes**	**Yes**	No	No	0.856	346	**64**
Kauai	Nawiliwili	A	**Yes**	No	**Yes**	**Yes**	**0.312**	**16**	212
Kauai	Niu	A	No	**Yes**	No	No	**0.422**	**109**	207
Kauai	Nualolo	AA	**Yes**	**Yes**	No	No	0.949	306	**68**
Kauai	Papaa	A	**Yes**	No	No	**Yes**	0.639	**89**	330
Kauai	Paua	A	No	No	No	No	**0.448**	222	428
Kauai	Pilaa	A	**Yes**	No	No	No	**0.445**	**180**	302
Kauai	Pohakuao	AA	No	**Yes**	No	No	0.961	440	223
Kauai	Puali	A	No	No	**Yes**	**Yes**	**0.303**	**46**	392
Kauai	Puukumu	A	**Yes**	No	No	No	**0.297**	**167**	265
Kauai	Wahiawa	A	**Yes**	No	**Yes**	**Yes**	0.599	**24**	**172**
Kauai	Waiahuakua	AA	No	**Yes**	No	No	0.956	536	309
Kauai	Waikaea	A	No	No	No	No	**0.360**	303	495
Kauai	Waikoko	AA	**Yes**	No	**Yes**	No	0.576	206	**179**
Kauai	Waikomo	AA	No	No	No	**Yes**	**0.388**	**11**	**138**
Kauai	Waileia	AA	**Yes**	No	**Yes**	No	**0.307**	**90**	**113**
Kauai	Wailua	A	No	**Yes**	No	**Yes**	0.672	**52**	**174**
Kauai	Waimea	A	No	**Yes**	No	**Yes**	0.874	**99**	268
Kauai	Wainiha	AA	**Yes**	No	No	No	0.952	273	**162**
Kauai	Waiolaa	AA	**Yes**	**Yes**	No	No	0.877	377	**109**
Kauai	Waioli	AA	No	No	**Yes**	No	0.824	331	269
Kauai	Waipa	AA	No	No	**Yes**	**Yes**	0.821	216	397

Island	Watershed Name	Receiving Waters (A/AA)	Coral Cover (Yes/No)	Coastal Reserve (Yes/No)	Embay-ment (Yes/No)	EPA 303(d) ImpairedStreams (Yes/No)	Watershed Health Index (poor 0 -	HWPP Restoration Rank (1-580)	HWPP Protection Rank (1-580)
Kauai	Waipake	A	**Yes**	No	No	No	**0.480**	310	335
Kauai	Waipao	A	No	No	No	No	0.587	285	430
Lanai	Anapuka	AA	**Yes**	No	No	No	**0.472**	**169**	**86**
Lanai	Awehi	AA	**Yes**	No	No	No	0.622	230	**140**
Lanai	Halulu	AA	**Yes**	**Yes**	No	No	0.600	292	**105**
Lanai	Haua	AA	**Yes**	No	No	No	0.678	233	**127**
Lanai	Hauola	AA	**Yes**	No	No	No	0.694	356	216
Lanai	Hawaiilanui	AA	No	**Yes**	No	No	0.707	319	215
Lanai	Honopu	AA	**Yes**	**Yes**	No	No	0.526	318	**63**
Lanai	Kaa	AA	**Yes**	No	No	No	0.659	**153**	**32**
Lanai	Kaapahu	AA	**Yes**	**Yes**	No	No	**0.490**	**68**	**19**
Lanai	Kahea	A	**Yes**	No	No	No	0.593	338	266
Lanai	Kahua	AA	No	**Yes**	No	No	0.649	428	**193**
Lanai	Kalamaiki	AA	**Yes**	**Yes**	No	No	**0.380**	**73**	**15**
Lanai	Kalamanui	AA	**Yes**	**Yes**	No	No	**0.407**	199	**44**
Lanai	Kapoho	AA	**Yes**	No	No	No	0.586	262	**173**
Lanai	Kapua	AA	**Yes**	No	No	No	0.557	194	**121**
Lanai	Kaumalapau	AA	**Yes**	**Yes**	**Yes**	No	**0.408**	**51**	**8**
Lanai	Kawaiu	AA	**Yes**	No	No	No	0.538	**139**	**76**
Lanai	Kuahua	AA	**Yes**	**Yes**	No	No	0.685	220	**43**
Lanai	Lapaiki	AA	No	**Yes**	No	No	0.623	**132**	**90**
Lanai	Lopa	AA	**Yes**	No	No	No	0.643	259	**129**
Lanai	Mahanalua	AA	**Yes**	No	No	No	0.686	200	**95**
Lanai	Manele	AA	**Yes**	No	No	No	0.535	**170**	**85**
Lanai	Maunalei	AA	**Yes**	**Yes**	No	No	0.699	247	**38**
Lanai	Naha	AA	**Yes**	No	No	No	**0.495**	**65**	**74**
Lanai	Nahoko	AA	**Yes**	No	No	No	0.612	334	**125**
Lanai	Palawai Basin	AA	No	No	No	No	0.500	210	272
Lanai	Paliamano	AA	**Yes**	**Yes**	No	No	**0.458**	**20**	**3**
Lanai	Poaiwa	AA	**Yes**	**Yes**	No	No	0.542	**162**	**30**
Lanai	Puumaiekahi	AA	**Yes**	**Yes**	No	No	0.517	**156**	**65**
Lanai	Ulaula	AA	**Yes**	No	No	No	**0.428**	**93**	**82**
Lanai	Wahane	AA	**Yes**	No	No	No	0.604	**175**	**145**
Lanai	Waiopa	AA	**Yes**	No	No	No	0.719	241	**139**
Maui	Ahihi Kinau	AA	**Yes**	**Yes**	No	No	0.632	**173**	**35**
Maui	Alaalaula	AA	**Yes**	No	No	No	0.697	349	210
Maui	Alelele	AA	No	**Yes**	No	No	0.870	510	275
Maui	Anakaluahine	AA	**Yes**	**Yes**	No	No	0.569	**67**	**24**
Maui	E. Wailuaiki	AA	No	**Yes**	No	No	0.996	472	235
Maui	Hahalawe	AA	No	No	No	No	0.748	501	426
Maui	Haipuaena	AA	No	**Yes**	No	No	0.862	374	**122**
Maui	Hanawana	AA	**Yes**	No	No	No	**0.432**	274	221
Maui	Hanawi	AA	No	No	No	No	0.937	567	467
Maui	Hanehoi	AA	**Yes**	No	No	No	**0.470**	196	**159**
Maui	Haneoo	AA	**Yes**	No	No	No	0.645	394	249
Maui	Hapapa	A	**Yes**	No	No	No	0.604	217	328

Island	Watershed Name	Receiving Waters (A/AA)	Coral Cover (Yes/No)	Coastal Reserve (Yes/No)	Embay-ment (Yes/No)	EPA 303(d) ImpairedStreams (Yes/No)	Watershed Health Index (poor 0 -	HWPP Restoration Rank (1-580)	HWPP Protection Rank (1-580)
Maui	Heleleikeoha	AA	No	No	No	No	0.876	557	415
Maui	Hoalua	AA	**Yes**	No	No	No	0.543	368	**184**
Maui	Honanana	AA	No	**Yes**	No	No	0.646	315	201
Maui	Honokahua	AA	No	No	No	No	**0.493**	260	352
Maui	Honokohau	AA	**Yes**	No	No	No	0.760	**143**	**102**
Maui	Honokowai	A	**Yes**	No	No	**Yes**	0.526	**26**	203
Maui	Honolewa	AA	**Yes**	No	No	No	0.695	337	217
Maui	Honolua	AA	**Yes**	**Yes**	No	No	0.656	**145**	**78**
Maui	Honomaele	AA	No	**Yes**	No	No	0.655	425	261
Maui	Honomanu	AA	No	**Yes**	No	No	0.938	464	245
Maui	Honopou	A	No	No	No	No	**0.457**	393	462
Maui	Hoolawa	A	No	No	No	No	0.546	391	502
Maui	Iao	A	**Yes**	**Yes**	**Yes**	**Yes**	**0.434**	**5**	**73**
Maui	Kaaiea	AA	No	No	No	No	0.828	537	453
Maui	Kaapahu	AA	No	**Yes**	No	No	0.808	475	220
Maui	Kahakuloa	AA	No	**Yes**	No	No	0.858	340	194
Maui	Kahana	A	**Yes**	No	No	**Yes**	**0.397**	**1**	**1**
Maui	Kahawaihapapa	AA	No	No	No	No	0.856	572	472
Maui	Kahoma	A	**Yes**	No	No	**Yes**	0.565	**63**	283
Maui	Kailua	AA	**Yes**	No	No	No	0.877	447	232
Maui	Kailua Gulch	A	**Yes**	No	No	No	**0.314**	**165**	345
Maui	Kakipi	A	No	No	No	No	0.605	522	567
Maui	Kakiweka	AA	No	No	No	No	0.758	539	439
Maui	Kalena	AA	No	No	No	No	0.721	478	435
Maui	Kalepa	AA	No	**Yes**	No	No	0.626	289	**119**
Maui	Kalialinui	A	No	**Yes**	No	No	**0.388**	**138**	310
Maui	Kanaio	AA	**Yes**	**Yes**	No	No	0.658	**58**	**7**
Maui	Kapaula	AA	No	No	No	No	0.760	519	456
Maui	Kapia	AA	**Yes**	No	No	No	0.861	492	255
Maui	Kauaula	A	**Yes**	No	**Yes**	No	0.597	257	348
Maui	Kaupakulua	A	**Yes**	No	No	No	**0.441**	**127**	206
Maui	Kaupo	AA	**Yes**	No	No	No	0.665	227	**165**
Maui	Kawaipapa	AA	**Yes**	**Yes**	No	No	0.718	267	**87**
Maui	Kawakoe	AA	No	No	No	No	0.844	568	454
Maui	Keaaiki	AA	No	No	No	No	0.647	548	455
Maui	Kealii	A	No	No	No	No	**0.332**	317	478
Maui	Kipapa	AA	**Yes**	No	No	No	0.626	**152**	**142**
Maui	Kolea	AA	No	No	No	No	0.564	496	405
Maui	Kopiliula	AA	No	**Yes**	No	No	0.963	397	**180**
Maui	Koukouai	AA	No	No	No	No	0.896	497	399
Maui	Kuhiwa	AA	No	No	No	No	0.845	562	468
Maui	Kuiaha	A	**Yes**	No	No	No	**0.321**	**148**	343
Maui	Kukuiula	AA	No	**Yes**	No	No	0.672	456	256
Maui	Lanikele	AA	No	No	No	No	**0.487**	416	402
Maui	Launiupoko	A	**Yes**	No	No	No	0.618	231	240
Maui	Lelekea	AA	No	**Yes**	No	No	0.773	512	277

Island	Watershed Name	Receiving Waters (A/AA)	Coral Cover (Yes/No)	Coastal Reserve (Yes/No)	Embay-ment (Yes/No)	EPA 303(d) ImpairedStreams (Yes/No)	Watershed Health Index (poor 0 -	HWPP Restoration Rank (1-580)	HWPP Protection Rank (1-580)
Maui	Makamakaole	AA	**Yes**	No	No	**Yes**	0.585	**59**	**152**
Maui	Makapipi	AA	No	No	No	No	0.720	547	475
Maui	Maliko	A	**Yes**	No	No	**Yes**	**0.380**	**22**	205
Maui	Manawaiiao	A	**Yes**	No	No	No	**0.316**	221	373
Maui	Manawaikeae	AA	No	No	No	No	**0.469**	469	408
Maui	Manawainui	AA	**Yes**	No	No	No	0.675	409	542
Maui	Manawainui Gulch	AA	No	No	No	No	0.654	392	341
Maui	Mooloa	AA	**Yes**	**Yes**	No	No	0.652	**97**	**22**
Maui	Moomoonui	AA	**Yes**	No	No	No	0.601	388	246
Maui	Nailiilihaele	AA	**Yes**	No	No	No	0.791	507	301
Maui	Nuaailua	AA	No	**Yes**	No	No	0.721	376	224
Maui	Nuanuaaloa	AA	**Yes**	No	No	No	0.528	197	**160**
Maui	Nuu	AA	No	No	No	No	0.646	405	315
Maui	Oheo	AA	No	**Yes**	No	No	0.865	408	248
Maui	Ohia	AA	No	**Yes**	No	No	**0.458**	373	252
Maui	Olowalu	A	**Yes**	No	No	No	0.692	432	446
Maui	Oopuola	AA	No	No	No	No	0.677	488	391
Maui	Opelu	AA	No	No	No	No	0.584	367	337
Maui	Paakea	AA	No	**Yes**	No	No	0.847	517	257
Maui	Pahihi	AA	No	No	No	No	0.637	487	431
Maui	Papahawahawa	AA	**Yes**	No	No	No	0.693	402	262
Maui	Papalaua	A	**Yes**	**Yes**	No	No	0.703	237	**186**
Maui	Piinaau	AA	No	**Yes**	No	No	0.809	240	**192**
Maui	Poelua	AA	No	**Yes**	No	No	0.543	203	**143**
Maui	Pohakea	A	**Yes**	**Yes**	**Yes**	No	0.517	**64**	**81**
Maui	Poopoo	AA	No	No	No	No	0.520	430	371
Maui	Puaaluu	AA	No	**Yes**	No	No	**0.424**	**87**	**153**
Maui	Puehu	AA	No	No	No	No	**0.485**	358	304
Maui	Punalau	AA	No	**Yes**	No	No	0.735	362	**133**
Maui	Puohokamoa	AA	No	No	No	No	0.843	540	409
Maui	Uaoa	A	No	No	No	No	**0.333**	300	493
Maui	Ukumehame	A	**Yes**	**Yes**	No	**Yes**	0.675	**54**	**115**
Maui	W. Wailuaiki	AA	No	**Yes**	No	No	0.955	482	241
Maui	Wahikuli	A	**Yes**	No	No	No	**0.385**	**129**	253
Maui	Wahinepee	AA	No	No	No	No	0.910	551	486
Maui	Waiaaka	AA	No	No	No	No	0.541	371	331
Maui	Waiakoa	A	**Yes**	**Yes**	No	No	**0.478**	**86**	**126**
Maui	Waiehu	AA	**Yes**	No	No	**Yes**	**0.492**	389	503
Maui	Waieli	AA	No	No	No	No	0.634	288	292
Maui	Waihee	AA	**Yes**	No	No	**Yes**	0.818	**29**	**66**
Maui	Waihole	AA	No	No	No	No	0.805	513	321
Maui	Waikamoi	AA	No	No	No	No	0.641	518	427
Maui	Waikapu	A	**Yes**	**Yes**	No	**Yes**	**0.442**	**10**	**98**
Maui	Wailea	AA	**Yes**	**Yes**	No	No	0.564	**56**	**12**
Maui	Wailua	AA	**Yes**	No	No	No	0.674	460	263
Maui	Wailuanui	AA	No	**Yes**	No	No	0.820	382	226

Island	Watershed Name	Receiving Waters (A/AA)	Coral Cover (Yes/No)	Coastal Reserve (Yes/No)	Embay-ment (Yes/No)	EPA 303(d) ImpairedStreams (Yes/No)	Watershed Health Index (poor 0 -	HWPP Restoration Rank (1-580)	HWPP Protection Rank (1-580)
Maui	Waiohonu	AA	**Yes**	No	No	No	0.904	448	208
Maui	Waiohue	AA	No	**Yes**	No	No	0.781	477	260
Maui	Waiokamilo	AA	No	**Yes**	No	No	0.800	242	**92**
Maui	Waiolai	AA	No	No	No	No	**0.433**	282	356
Maui	Waioni	AA	No	No	No	No	0.563	491	380
Maui	Waiopai	AA	No	No	No	No	0.668	438	376
Maui	Waipili	AA	No	No	No	No	0.519	295	324
Maui	Waipio	A	**Yes**	No	No	**Yes**	**0.451**	**94**	295
Molokai	Ahaino	AA	**Yes**	No	No	No	0.681	266	211
Molokai	Anapuhi	AA	No	**Yes**	No	No	0.899	527	314
Molokai	Hakina	AA	**Yes**	No	No	No	0.610	268	**176**
Molokai	Halawa	AA	No	No	No	No	0.784	279	403
Molokai	Haloku	AA	No	**Yes**	No	No	0.926	410	**154**
Molokai	Honomuni	AA	**Yes**	No	No	No	0.757	225	**146**
Molokai	Honoulimaloo	AA	**Yes**	No	No	No	0.790	348	**189**
Molokai	Honouliwai	AA	**Yes**	No	No	No	0.753	239	**107**
Molokai	Honowewe	AA	No	No	No	No	**0.476**	312	273
Molokai	Kaa	AA	**Yes**	**Yes**	No	No	0.518	264	**168**
Molokai	Kahananui	AA	No	No	No	No	0.801	444	414
Molokai	Kahiwa	AA	No	No	No	No	0.818	516	378
Molokai	Kailiili	AA	No	**Yes**	No	No	0.779	383	**167**
Molokai	Kainalu	AA	**Yes**	No	No	No	0.778	347	199
Molokai	Kalaemilo	AA	No	No	No	No	0.844	524	433
Molokai	Kalamaula	A	No	No	No	No	0.573	480	526
Molokai	Kaluaaha	AA	No	No	No	No	0.781	329	290
Molokai	Kaluapeelua	A	No	No	No	No	**0.486**	454	563
Molokai	Kamalo	AA	**Yes**	**Yes**	No	No	0.715	**69**	**11**
Molokai	Kamiloloa	AA	**Yes**	No	No	No	0.647	**168**	**177**
Molokai	Kaunakakai	AA	**Yes**	No	**Yes**	No	0.620	**189**	**135**
Molokai	Kaunala	AA	**Yes**	No	No	No	0.557	**100**	**75**
Molokai	Kawainui	AA	No	No	No	No	0.869	561	564
Molokai	Kawela	AA	**Yes**	No	No	No	0.779	357	219
Molokai	Keawanui	AA	No	**Yes**	No	No	0.682	243	**94**
Molokai	Kolo	AA	**Yes**	No	No	No	0.675	**178**	**128**
Molokai	Manawainui	A	No	No	No	No	0.539	287	**171**
Molokai	Maneopapa	AA	**Yes**	**Yes**	No	No	**0.458**	**71**	**13**
Molokai	Mapulehu	AA	**Yes**	No	No	No	0.740	**190**	**155**
Molokai	Moomomi	AA	**Yes**	**Yes**	No	No	0.583	**118**	**26**
Molokai	Ohia	AA	**Yes**	No	No	No	0.772	219	**151**
Molokai	Oloupena	AA	No	**Yes**	No	No	0.979	412	**131**
Molokai	Papio	AA	No	No	No	No	0.647	381	394
Molokai	Papohaku	AA	**Yes**	No	No	No	0.554	**125**	**101**
Molokai	Pelekunu	AA	No	**Yes**	No	No	0.914	361	236
Molokai	Pipiwai	AA	No	No	No	No	0.726	435	286
Molokai	Pohakupili	AA	No	No	No	No	0.611	413	390
Molokai	Puukaoku	AA	No	**Yes**	No	No	0.965	502	218

Island	Watershed Name	Receiving Waters (A/AA)	Coral Cover (Yes/No)	Coastal Reserve (Yes/No)	Embay-ment (Yes/No)	EPA 303(d) ImpairedStreams (Yes/No)	Watershed Health Index (poor 0 -	HWPP Restoration Rank (1-580)	HWPP Protection Rank (1-580)
Molokai	Waiahewahewa	A	No	No	No	No	0.658	498	459
Molokai	Waiahookalo	AA	No	No	No	No	0.881	530	355
Molokai	Waialeia	AA	**Yes**	**Yes**	No	No	0.729	**179**	**56**
Molokai	Waialua	AA	**Yes**	No	No	**Yes**	0.782	**35**	**79**
Molokai	Waihanau	AA	**Yes**	**Yes**	No	No	0.671	**77**	**42**
Molokai	Waikolu	AA	**Yes**	**Yes**	No	No	0.886	407	482
Molokai	Wailau	AA	No	**Yes**	No	No	0.932	**136**	**69**
Molokai	Wailele	AA	No	**Yes**	No	No	0.968	426	**190**
Molokai	Wainene	AA	No	**Yes**	No	No	0.903	277	**112**
Molokai	Waiohookalo	AA	No	**Yes**	No	No	0.925	335	**181**
Molokai	Waipu	AA	No	**Yes**	No	No	0.868	384	**191**
Molokai	Wawaia	AA	**Yes**	No	No	No	0.766	271	209
Niihau	Halalii	AA	**Yes**	No	No	No	**0.497**	**157**	**84**
Niihau	Honuaula	AA	**Yes**	No	No	No	**0.497**	359	**170**
Niihau	Kaailana	AA	No	No	No	No	**0.469**	474	351
Niihau	Kaaukuu	AA	No	No	No	No	**0.422**	363	308
Niihau	Kaaukuu	A	No	**Yes**	No	No	**0.489**	341	316
Niihau	Kalaoa	AA	**Yes**	No	No	No	**0.482**	308	**137**
Niihau	Kaumuhonu	AA	No	No	No	No	0.556	452	288
Niihau	Keanauhi	AA	No	No	No	No	0.523	439	338
Niihau	Keawanui	AA	No	No	No	No	**0.467**	364	350
Niihau	Kooeaukani	AA	No	No	No	No	**0.452**	485	340
Niihau	Mauuloa	AA	No	No	No	No	0.504	499	336
Niihau	Nomilu	AA	**Yes**	No	No	No	**0.470**	333	**130**
Niihau	Nonopapa	AA	No	No	No	No	0.511	520	387
Niihau	Puuwai	AA	No	No	No	No	**0.494**	365	282
Oahu	Ahuimanu	A	No	No	No	**Yes**	**0.494**	**101**	497
Oahu	Aiea	A	No	**Yes**	No	**Yes**	**0.200**	**74**	357
Oahu	Ala Wai	AA	**Yes**	**Yes**	**Yes**	**Yes**	**0.000**	**2**	**2**
Oahu	Anahulu	AA	**Yes**	No	**Yes**	**Yes**	**0.439**	**17**	**77**
Oahu	Diamond Head	A	No	**Yes**	No	No	0.656	353	361
Oahu	Haiamoa	AA	No	No	**Yes**	No	**0.364**	**116**	244
Oahu	Hakipuu	AA	No	No	**Yes**	No	**0.493**	354	383
Oahu	Halawa	A	No	No	No	No	**0.078**	481	417
Oahu	Halawa	A	No	**Yes**	No	**Yes**	**0.313**	302	440
Oahu	Halehaa	A	**Yes**	No	No	No	**0.239**	305	372
Oahu	Hanauma	AA	**Yes**	**Yes**	**Yes**	No	0.545	**81**	**9**
Oahu	Heeia	AA	**Yes**	**Yes**	**Yes**	**Yes**	**0.458**	**6**	**6**
Oahu	Helemano	A	No	No	No	**Yes**	0.611	**91**	461
Oahu	Honouliuli	A	No	**Yes**	No	No	**0.422**	218	303
Oahu	Kaaawa	A	**Yes**	No	No	**Yes**	0.537	**49**	227
Oahu	Kaalaea	AA	No	No	**Yes**	**Yes**	0.556	**25**	**187**
Oahu	Kaelepulu	A	**Yes**	No	No	**Yes**	**0.268**	283	258
Oahu	Kaelepulu	A	**Yes**	No	No	No	**0.311**	**27**	271
Oahu	Kaelepulu	A	**Yes**	No	No	No	**0.363**	441	400
Oahu	Kahaluu	A	No	No	No	**Yes**	0.611	**140**	442

Island	Watershed Name	Receiving Waters (A/AA)	Coral Cover (Yes/No)	Coastal Reserve (Yes/No)	Embay-ment (Yes/No)	EPA 303(d) ImpairedStreams (Yes/No)	Watershed Health Index (poor 0 -	HWPP Restoration Rank (1-580)	HWPP Protection Rank (1-580)
Oahu	Kahaluu segment	AA	**Yes**	No	No	**Yes**	**0.273**	**21**	**117**
Oahu	Kahana	AA	**Yes**	**Yes**	No	**Yes**	0.567	**34**	294
Oahu	Kahawai	AA	No	No	No	No	**0.423**	248	313
Oahu	Kahawainui	A	No	**Yes**	No	**Yes**	**0.491**	**38**	**188**
Oahu	Kaipapau	A	**Yes**	**Yes**	No	No	0.611	238	**183**
Oahu	Kalauao	A	No	**Yes**	No	**Yes**	0.529	**32**	196
Oahu	Kalihi	A	No	No	**Yes**	**Yes**	**0.361**	**84**	464
Oahu	Kaloi	A	No	**Yes**	No	No	**0.353**	**151**	234
Oahu	Kaluakauila	AA	**Yes**	**Yes**	No	No	0.576	**161**	**39**
Oahu	Kaluanui	A	**Yes**	**Yes**	No	No	0.716	223	200
Oahu	Kalunawaikaala	AA	**Yes**	**Yes**	No	No	**0.350**	**30**	**5**
Oahu	Kamaileunu	A	No	No	No	No	0.510	449	528
Oahu	Kamiloiki	A	**Yes**	No	**Yes**	No	**0.324**	296	365
Oahu	Kamilonui	A	**Yes**	No	**Yes**	No	**0.439**	290	312
Oahu	Kaneohe	AA	**Yes**	No	**Yes**	**Yes**	**0.398**	**8**	**37**
Oahu	Kapakahi	A	No	**Yes**	No	No	**0.115**	212	293
Oahu	Kapalama	A	No	No	**Yes**	**Yes**	**0.061**	**96**	476
Oahu	Kaukonahua	A	No	No	No	**Yes**	0.555	**78**	432
Oahu	Kaupuni	A	No	No	**Yes**	**Yes**	0.516	**191**	533
Oahu	Kawa	AA	**Yes**	No	**Yes**	**Yes**	**0.270**	**19**	**123**
Oahu	Kawaihapai	AA	No	No	No	No	0.572	226	307
Oahu	Kawaiiki	A	No	No	No	**Yes**	0.831	**149**	469
Oahu	Kawailoa	A	No	No	No	**Yes**	0.583	228	509
Oahu	Kawainui	A	**Yes**	No	No	No	0.576	458	329
Oahu	Kawainui	A	No	No	No	**Yes**	0.804	422	346
Oahu	Kawainui	AA	**Yes**	No	No	**Yes**	**0.447**	**85**	366
Oahu	Kawainui	A	**Yes**	No	No	No	**0.308**	544	492
Oahu	Kawela	A	**Yes**	No	No	No	**0.415**	214	364
Oahu	Keaahala	AA	**Yes**	No	**Yes**	No	0.576	**12**	**57**
Oahu	Keaahala	AA	**Yes**	No	**Yes**	No	0.576	**119**	**71**
Oahu	Keaahala	AA	**Yes**	No	**Yes**	No	0.576	208	**89**
Oahu	Keaahala	AA	**Yes**	No	**Yes**	No	0.576	304	**163**
Oahu	Keaahala	AA	**Yes**	No	**Yes**	**Yes**	**0.209**	415	233
Oahu	Keaau	A	**Yes**	**Yes**	No	No	0.573	198	**178**
Oahu	Keamanea	AA	No	No	No	No	**0.440**	232	344
Oahu	Keehi	A	No	No	**Yes**	No	**0.132**	419	520
Oahu	Kiikii	A	No	No	**Yes**	**Yes**	**0.229**	**110**	451
Oahu	Koko Crater	AA	**Yes**	**Yes**	No	No	**0.478**	**82**	**33**
Oahu	Koloa	A	**Yes**	No	No	No	0.550	**144**	230
Oahu	Kualoa	AA	**Yes**	No	No	No	**0.459**	**122**	**164**
Oahu	Kualoa	A	No	No	No	No	0.576	483	465
Oahu	Kualoa	A	No	No	No	No	0.576	503	470
Oahu	Kuliouou	A	No	**Yes**	**Yes**	No	0.517	521	438
Oahu	Loko Ea	AA	**Yes**	No	**Yes**	No	**0.425**	**88**	**136**
Oahu	Maakua	A	**Yes**	No	No	No	0.725	470	360
Oahu	Mailiili	A	No	No	No	No	**0.458**	387	504

Island	Watershed Name	Receiving Waters (A/AA)	Coral Cover (Yes/No)	Coastal Reserve (Yes/No)	Embay-ment (Yes/No)	EPA 303(d) ImpairedStreams (Yes/No)	Watershed Health Index (poor 0 -	HWPP Restoration Rank (1-580)	HWPP Protection Rank (1-580)
Oahu	Makaha	A	No	No	No	No	0.580	484	554
Oahu	Makaiwa	A	No	No	**Yes**	No	**0.497**	355	505
Oahu	Makaleha	A	**Yes**	No	No	No	0.644	256	323
Oahu	Makapuu	AA	No	**Yes**	No	No	**0.495**	**183**	**158**
Oahu	Makapuu	AA	No	No	No	No	**0.118**	370	349
Oahu	Makapuu	AA	No	No	No	No	**0.427**	531	473
Oahu	Makaua	AA	**Yes**	**Yes**	No	No	0.534	**83**	**25**
Oahu	Makiki	A	No	No	No	**Yes**	**0.201**	**72**	458
Oahu	Makua	A	**Yes**	**Yes**	No	No	0.626	**76**	**58**
Oahu	Malaekahana	A	No	**Yes**	No	No	**0.483**	224	285
Oahu	Manini	AA	**Yes**	**Yes**	No	No	0.596	**120**	**48**
Oahu	Manoa-Palolo	A	No	No	No	**Yes**	**0.416**	**92**	419
Oahu	Manuwai	A	**Yes**	No	**Yes**	No	**0.229**	321	404
Oahu	Moanalua	A	No	No	**Yes**	**Yes**	**0.436**	**113**	448
Oahu	Nanakuli	A	No	No	No	No	0.580	486	548
Oahu	Niu	A	No	No	No	No	0.502	328	425
Oahu	Nuuanu	A	No	**Yes**	**Yes**	No	**0.192**	**9**	**49**
Oahu	Nuuanu	A	**Yes**	**Yes**	**Yes**	**Yes**	**0.304**	**160**	278
Oahu	Oio	A	**Yes**	**Yes**	No	No	**0.452**	**75**	**61**
Oahu	Opaeula	A	No	No	No	**Yes**	0.655	**117**	447
Oahu	Pahole	A	**Yes**	No	No	No	0.633	327	363
Oahu	Pakulena	A	No	No	No	No	**0.428**	284	429
Oahu	Papaakoko	A	**Yes**	No	No	No	**0.308**	311	326
Oahu	Paukauila	AA	No	No	**Yes**	**Yes**	**0.257**	**41**	239
Oahu	Paumalu	A	**Yes**	No	No	No	**0.480**	211	276
Oahu	Poamoho	A	No	No	No	**Yes**	**0.388**	**70**	441
Oahu	Portlock	AA	**Yes**	**Yes**	**Yes**	No	**0.325**	**31**	**4**
Oahu	Punaluu	AA	**Yes**	**Yes**	No	No	0.554	**44**	**10**
Oahu	Puu Hawaiiloa	AA	**Yes**	No	No	**Yes**	**0.266**	**121**	**134**
Oahu	Puu Hawaiiloa	AA	No	No	No	**Yes**	**0.051**	229	297
Oahu	Salt Lake	A	No	No	No	No	**0.148**	339	471
Oahu	Ulehawa	A	No	No	No	No	**0.455**	399	515
Oahu	Waiahole	AA	**Yes**	No	**Yes**	**Yes**	0.558	**7**	**52**
Oahu	Waialaenui	A	**Yes**	**Yes**	No	No	**0.312**	**155**	214
Oahu	Waialua	A	**Yes**	No	No	No	**0.375**	**184**	319
Oahu	Waianu	AA	**Yes**	No	**Yes**	No	**0.442**	195	**156**
Oahu	Waiawa	A	No	**Yes**	No	**Yes**	0.543	**47**	237
Oahu	Waihee	A	No	No	No	**Yes**	0.570	**105**	420
Oahu	Waikane	AA	**Yes**	No	**Yes**	**Yes**	0.554	**28**	**99**
Oahu	Waikele	A	No	No	No	No	0.576	**43**	225
Oahu	Waikele	A	No	**Yes**	No	**Yes**	**0.441**	576	579
Oahu	Wailele	A	**Yes**	**Yes**	No	**Yes**	**0.403**	**80**	**175**
Oahu	Wailupe	A	No	No	No	No	**0.399**	201	457
Oahu	Waimalu	AA	No	No	No	**Yes**	**0.472**	**50**	231
Oahu	Waimanalo	A	**Yes**	No	No	**Yes**	**0.489**	**48**	267
Oahu	Waimea	A	No	**Yes**	No	No	0.660	246	317

Island	Watershed Name	Receiving Waters (A/AA)	Coral Cover (Yes/No)	Coastal Reserve (Yes/No)	Embay-ment (Yes/No)	EPA 303(d) ImpairedStreams (Yes/No)	Watershed Health Index (poor 0 -	HWPP Restoration Rank (1-580)	HWPP Protection Rank (1-580)
Oahu	Waipio	A	No	No	No	No	**0.405**	418	516
Oahu	Waipuhi	A	**Yes**	**Yes**	No	No	**0.436**	**123**	**114**

Appendix D: Useful GIS Sources for Stormwater Analysis

Parameter	GIS Layer/Attribute	Availability
Watershed	Watersheds (wshed_n83.shp)	State GIS website
Rainfall intensity	Use web map	PFDS
Streams	Streams (darstreams.shp)	State GIS website
Watershed Health Index	Watershed scores	Compilation by HWPP
Soil characteristics	Soils (separate shapefiles per island)	State GIS website
Land cover	C-CAP (available for all islands except Hawaii Island)	State GIS website links to NOAA Coastal Services Center
Water Quality Classes	Water Quality Classifications (classwater.zip)	State GIS website
Coastal Reserves	Reserves (reserves.shp)	State GIS website
Coral reefs	Shallow water benthic habitats	NOAA

State GIS website (http://hawaii.gov/dbedt/gis/download.htm)
PFDS (Precipitation Frequency Data Server) (http://hdsc.nws.noaa.gov/hdsc/pfds/)
HWPP (Hawaii Watershed Prioritation Process) consult with Office of Planning
NOAA (http://ccma.nos.noaa.gov/products/biogeography/hawaii_cd_07/data/)