DRAFT

SCOPING REPORT
KAELEPULU STREAM
TOTAL MAXIMUM DAILY LOADS

Prepared for: State of Hawaii
Department of Health
Environmental Planning Office

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In Association with
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TABLE OF CONTENTS

PAGE

EXECUTIVE SUMMARY ES-1
1.0 INTRODUCTION 1-1
1.1 BACKGROUND 1-1
1.2 PROJECT SETTING 1-2
1.3 REGULATORY BACKGROUND 1-3
1.4 PROJECT OBJECTIVES 1-4
1.5 AUTHORIZATION 1-5
2.0 SUMMARY OF AVAILABLE DATA 2-1
2.1 LAND USE AND OWNERSHIP 2-1
2.2 WATERBODY USES 2-1
2.3 WATERSHED HYDROLOGY 2-1
2.4 POLLUTANTS 2-2
2.4.1 Sediment 2-2
2.4.1.1 Turbidity 2-3
2.4.1.2 Total Suspended Solids 2-3
2.4.2 Enterococci 2-3
2.4.3 Escherichia coli (E. coli) 2-3
2.4.4 Clostridium perfingens (C. perfingens) 2-4
2.4.5 Nutrients 2-4
2.4.5.1 Nitrogen 2-4
2.4.5.2 Phosphorus 2-4
2.4.6 Chlorophyll a 2-4
2.5 Pollutant Sources 2-5
2.5.1 Wastewater Facilities 2-5
2.5.2 Storm Drains 2-5
2.5.3 Agriculture 2-6
2.5.4 Wildlife 2-6
2.5.5 Groundwater 2-6
2.6 WATER QUALITY 2-6
2.6.1 University of Hawaii Studies 2-6
2.6.2 Independent Data Sources 2-7
3.0 IDENTIFIED DATA GAPS 3-1
4.0 REFERENCES 4-1

TABLES

Table 1-1 Kaelepulu Watershed Impairments
Table 1-2 Sampling Objectives
Table 1-3 Water Quality Standards for Streams
Table 1-4 Water Quality Standards for Estuaries (Excluding Pearl Harbor)
Table 2-1 Recorded Wastewater Spills

FIGURES

Figure 1-1 Site Map
Figure 2-1 Land Use Zoning
Figure 2-2 Government Owned Lands
Figure 2-3 Kaelepulu Bird Survey
Figure 2-4 Existing and Proposed Watershed Boundaries
Figure 2-5 Turbidity Data
Figure 2-6 Total Suspended Solids Data
Figure 2-7 Enterococci Data
Figure 2-8 E. coli Data
Figure 2-9 C. perfingens Data
Figure 2-10 Total Nitrogen Data
Figure 2-11 Nitrate + Nitrite Data
Figure 2-12 Phosphorus Data
Figure 2-13 Chlorophyll a Data
Figure 2-14 Location of Wastewater Spills
Figure 2-15 Location of Wastewater Facilities
Figure 2-16 Location of Storm Drains
Figure 2-17 Agriculturally Zoned Areas

APPENDICES

Appendix A Dredging of Kaeleplu Estuary for Non Point Source Pollution Control and Protection of Endangered Species Habitat
Appendix B Sampling Data Summaries
Appendix C 2 January 2004 Sampling Synopsis

EXECUTIVE SUMMARY

To be completed after review of first draft

1.0 INTRODUCTION

1.1 BACKGROUND

Section 303(d) of the 1972 Clean Water Act (CWA) directs each State to develop a list of water bodies that do not meet State water quality standards. In Hawaii, the Department of Health, Environmental Planning Office (DOH) has been tasked with this responsibility. Water bodies that are so listed do not meet water quality standards for specific constituents and thereby inhibit beneficial uses of the water body, such as for recreational uses or for supporting fresh water or marine wildlife.

In 1998, DOH issued its initial list of impaired water bodies. This list was updated in 2001 and again in 2004. The 2004 list includes Kaelepulu Stream and three receiving areas that may be impacted by the stream – Lanikai Beach Station, Kailua Beach Station and Oneawa Beach Station. The constituents for each site are listed in Table 1-1.

Table 1-1. Kaelepulu Watershed Impairments

WATERBODY	GEOGRAPHIC SCOPE	POLLUTANTS
Kaelepulu Stream	Kaelepulu Stream/Enchanted Lakes	nutrients turbidity
Kaelepulu Stream	Kaelepulu Stream station	enterococci nitrogen phosphorus turbidity chlorophyll a
Lanikai Beach	Lanikai Beach station	enterococci
Kailua Beach	Kailua Beach Park station	enterococci nitrogen phosphorus chlorophyll a
Kailua Beach	Oneawa Beach station	nitrogen phosphorus turbidity chlorophyll a

In order to develop Total Maxmimum Daily Loads (TMDLs) for the impaired portions of the Kaelepulu watershed, DOH has recommended that sampling data be collected for the areas listed in Table 1-2.

Table 1-2. Sampling Objectives

WATERBODY	POLLUTANTS
Kaelepulu Stream	nitrogen phosphorus sediment enterococci
Hamakua Stream (headwaters of Hamakua wetlands)	nitrogen phosphorus sediment enterococci
Kaelepulu Estuary	nitrogen phosphorus sediment enterococci chlorophyll a

DOH has chosen to approach the TMDL process in two phases. In the first (current) phase, the University of Hawaii has been retained to review existing data, recommend sampling locations, and to determine how the project should proceed in the second phase. The second phase would consist of collecting samples and analyzing the data to apportion pollutant loads to the various sources. This would enable the calculation of how much pollutants would need to be cut back in order to preserve the intended beneficial uses.

1.2 PROJECT SETTING

Kaelepulu Stream is located on the windward side of Oahu in the Kailua neighborhood. The watershed that feeds the Kaelepulu Stream covers 3,450 acres of mixed uses including residential (2,043 acres), preservation (1,122 acres), agricultural (275 acres), and industrial (12 acres) zoned areas. See Figure 1-1.

The stream system is actually quite complex. Most of the time, the stream mouth is closed resulting in the accumulation of constituents in the stream and estuary. The stream mouth is opened by City staff allowing the stream and estuary to drain for a couple of days per month. The stream system is subject to tidal influences, particularly at the mouth of the stream. It is suspected that groundwater may also influence the quality of the stream and estuary, but the extent has not been documented. Wastewater facilities, including cesspools, pump stations, and collection systems, and domesticated and wild animal droppings may contribute to the pollutant load in addition to stormwater runoff.

1.3 REGULATORY BACKGROUND

As defined in the Hawaii Administrative Rules, Title 11, Chapter 54, the Kaelepulu watershed can be classified into freshwater stream and estuary segments. As further defined in this chapter, there are specific water quality goals for both streams (Table 1-3) and estuaries (Table1-4).

Table 1-3. Water Quality Standards for Streams[2]

Parameter	Geometric Mean Not to Exceed the Given Value (wet/dry season)[1]	Not to Exceed the Given Value More Than 10% of the Time (wet/dry season)[1]	Not to Exceed the Given Value More Than 2% of the Time (wet/dry season)[1]
Total Nitrogen (ug N/L)	250.0/180.0	520.0/380.0	800.0/600.0
Nitrate + Nitrite Nitrogen (ug [NO_3 + NO_2]-N/L)	70.0/30.0	180.0/90.0	300.0/170.0
Total Phosphorus (ug P/L)	50.0/30.0	100.0/60.0	150.0/80.0
Total Suspended Solids (mg/L)	20.0/10.0	50.0/30.0	80.0/55.0
Turbidity (Nephelometric turbidity units)	5.0/2.0	15.0/5.5	25.0/10.0

Notes:
[1]Wet season = November 1 to April 30, dry season = May 1 to October 31.
[2]Additional requirements for pH, dissolved oxygen, temperature, specific conductance and bottom criteria for streams are also included in HAR 11-54, but are not listed here.

Table 1-4. Water Quality Standards for Estuaries (excluding Pearl Harbor)

Parameter	Geometric Mean Not to Exceed the Given Value	Not to Exceed the Given Value More Than 10% of the Time	Not to Exceed the Given Value More Than 2% of the Time
Total Nitrogen (ug N/L)	200.00	350.00	500.00
Ammonia Nitrogen (ug NH_4/L)	6.00	10.00	20.00
Nitrate + Nitrite Nitrogen (ug N/L)	8.00	25.00	35.00
Total Phosphorus (ug P/L)	25.00	50.00	75.00
Chlorophyll a (ug/L)	2.00	5.00	10.00
Turbidity	1.5	3.00	5.00

Table 1-4. Water Quality Standards for Estuaries (excluding Pearl Harbor)

Parameter	Geometric Mean Not to Exceed the Given Value	Not to Exceed the Given Value More Than 10% of the Time	Not to Exceed the Given Value More Than 2% of the Time
(Nephelometric turbidity units)			
Notes: [1]Additional requirements for pH, dissolved oxygen, temperature, salinity, oxidation-reduction potential are also included in HAR 11-54, but are not listed here.			

1.4 PROJECT OBJECTIVES

This report is intended to lay the ground work for development of the TMDLs for Kaelepulu Stream. There were two specific objectives for this project:

- Develop a Scoping Report which:
  - Summarizes existing background information on land use, water body conditions, water body uses, watershed hydrology, pollutant sources, and water quality in Kaelepulu Stream and in the receiving waters of Kailua Bay.
  - Coordinates and assembles available data in ArcGIS and Microsoft Access.
  - Develops a detailed problem statement identifying numeric water quality targets for the system.
- Develop a Project Sampling and Analysis Plan which includes:
  - A field sampling plan
  - Data quality objectives (objectives, indicators, data review, validation and management)
  - Sampling rationale (water, sediment, biological, and habitat)
  - Field methods and procedures (equipment and procedures, including sample containers, preservation methods, and storage)
  - Sample documentation procedures (field notes, labeling, packing for transport, and chain of custody)
  - Analytical methods and quality control
  - Field health and safety procedures

1.5 AUTHORIZATION

This report is authorized by the Department of Health, Environmental Planning Office…

2.0 SUMMARY OF AVAILABLE DATA

2.1 LAND USE AND OWNERSHIP

The area within the Kaelepulu watershed which is tributary to the stream and estuary is primarily zoned residential with small pockets of commercial, open space, and public infrastructure. See Figure 2–1.

Ownership of the land varies within the watershed, with the vast majority being private owners, however there are also various governmental organizations (federal, state, and county agencies) and the Department of Hawaiian Home Lands. Ownership of the Estuary area primarily falls to the Enchanted Lakes Residential Association (TMK 4-2-002:003), but the upper end of the estuary is owned by Hugo DeVries (TMK 4-2-002:050). Figure 2-2 shows the ownership of the parcels associated with the stream and estuary.

2.2 WATERBODY USES

Kaelepulu Stream and Estuary support a diverse range of wildlife. Fish and birds are the predominant species. Figure 2-3 is a sample of a bird count conducted by Ronald Walker and Hugo DeVries on January 21, 2005.

In addition to wildlife, the stream and estuary are used for recreational activities. Canoes and kayaks are used to navigate the stream. Due to the amount of sedimentation that has occurred, the use of larger watercraft is not practical. Fishing and crabbing in the lake have also been observed.

The stream empties into Kailua Bay near Kailua Beach Park. The stream mouth is usually closed by tidal forces that build up sand bars. This results in stagnant water within the stream ecosystem. The City and County opens up the mouth of the stream during the second week of each month. The opening usually occurs between Monday and Wednesday to allow bacterial counts to drop to acceptable levels by the weekend when beach usage peaks. The mouth is open for only a day or two as tidal forces rapidly close the breach.

Research conducted by the University of Hawaii between 1990 and 1991 indicate that Kaelepulu Stream does impact the water quality in Kailua Bay (Roll, B.M. and R.S. Fujioka 1993). When the mouth of Kaelepulu Stream is closed, samples taken in Kailua Bay were always below State and Federal Water Quality limits. When Kaelepulu Stream was open it exceeded the State standard 80 percent of the time and the Federal standard 60 percent of the time.

2.3 WATERSHED HYDROLOGY

The State has defined watershed boundaries for each of the major islands, but these are based on elevation contours and do not consider channelized or hard piped flows that may be conveyed into the watershed. A review of the elevations in conjunction with storm drain facilities indicate that the watershed actually extends to the north, encompassing the residential area adjacent to the Hamakua Stream. Figure 2-4 shows the existing and proposed watershed boundaries.

2.4 POLLUTANTS

As discussed in Section 1-3, there are a number of constituents that contribute to the pollutant load. This section discusses the various pollutants of concern.

2.4.1 Sediment

HAR 11-54 includes very detailed standards for sediment loads to water bodies. Sediment loads can degrade water bodies from an aesthetic standpoint (i.e., murky or "dirty" water), but they can also endanger the stream ecosystem by filling in the steam or covering up aquatic habitat. In the case of sediment loads for streams, the regulations prescribe the following bottom criteria:

- Episodic deposits of flood-borne soil sediment shall not occur in quantities exceeding an equivalent thickness of five millimeters (0.20 inch) over hard bottoms twenty-four hours after a heavy rainstorm.

- Episodic deposits of flood-borne soil sediment shall not occur in quantities exceeding an equivalent thickness of ten millimeters (0.40 inch) over soft bottoms twenty-four hours after a heavy rainstorm.

- In soft bottom material in pool sections of streams, oxidation-reduction potential (EH) in the top ten centimeters (four inches) shall not be less than +100 millivolts.

- In soft bottom material in pool section of streams, no more than fifty percent of the grain size distribution of sediment shall be smaller than 0.125 millimeter (0.005 inch) in diameter.

- The director shall prescribe the appropriate parameters, measures, and criteria for monitoring stream bottom biological communities including their habitat, which may be affected by proposed actions. Permanent benchmark stations may be required where necessary for monitoring purposes. The water quality criteria for this subsection shall be deemed to be met if time series surveys of benchmark stations indicate no relative changes in the relevant biological communities, as noted by biological community indicators or by indicator organisms which may be applicable to the specific site.

The impact of sediment loads to the Kaelepulu Stream and Estuary has manifested itself in the siltation of these waterbodies. The problem has become such an issue that the City and County of Honolulu's Department of Design and Construction has proposed dredging the stream and installing sediment traps and BMPs at several inlets.

The estimated cost of this is $1.6 million. A summary of the proposed project is contained in Appendix A.

Measurements of these natures are difficult because they are predicated upon sampling directly after storm events or for very involved parameters. Two other constituents typically serve as surrogates for sediment loading – turbidity and total suspended solids and each are described below.

2.4.1.1 Turbidity

Turbidity is a measure of suspended matter in a water matrix. The suspended matter can be inorganic or organic in nature. Turbidity has been used a surrogate for sediment measurements because it is a simple process that can be conducted in the field. Turbidity is measured in Nephelometric turbidity units (NTUs). Figure 2-5 shows data for turbidity at various sampling points in the watershed.

2.4.1.2 Total Suspended Solids

Total suspended solids (TSS) is a typical measure of wastewater strength. TSS consists of the solids retained on a filter disc after drying at 103 to 105 °C. TSS is not specific to sewage contamination, but it presents a general indication of the amount of solids that are present. Since most pathogenic organisms tend to associate with particulate matter, the general trending is not without basis, but the results must be interpreted in conjunction with other analyses. Figure 2-6 shows data for total suspended solids at various sampling points in the watershed.

2.4.2 Enterococci

Enterococci is a subgroup of the fecal streptococci bacteria and serve as an indicator of fecal contamination. The State guidelines for enterococci are as follows:

- Inland recreational waters: Geometric mean of 33 per 100 mL in not less than five samples covering a period of 25 to 30 days. No single sample exceeding 89 CFU per 100 mL or the site specific one-sided 82 percent confidence limit.

- Marine recreational waters: Geometric mean of 7 per 100 mL in not less than five samples covering a period of 25 to 30 days. No single sample exceeding 100 CFU per 100 mL or the site specific one-sided 75 percent confidence limit.

The State is considering revising its marine recreational waters limit to 35 per 100 mL to fall in line with the Federal standard, but this has not been formally adopted yet. Figure 2-7 shows data for enterococci at various sampling points in the watershed.

2.4.3 Escherichia coli (E. coli)

E. coli is a pathogenic bacteria found in large quantities in human feces. Infection by E. coli typically manifests itself in some gastro-intestinal disorder. Although E. coli is recognized by the Federal government as an indicator of water quality, there have been several studies that indicate that E. coli is also present in native soils and is not necessarily indicative of fecal

contamination. DOH has primarily relied on enterococcus as the primary microbial indicator. Figure 2-8 shows data for E. coli at various sampling points in the watershed.

2.4.4 Clostridium perfingens (C. perfingens)

C. perfingens is another bacteria that has been suggested as an alternative indicator. Like E. coli, C. perfingens is also found in native soils. However, C. perfingens is an anerobe and would not reproduce in recreational waters. Therefore, proponents believe that it would be more reflective of sewage contamination than other microbial indicators. Figure 2-9 shows data for E. coli at various sampling points in the watershed.

2.4.5 Nutrients

Many types of nutrients are needed to maintain a stable ecosystem. The two most prevalent nutrients are nitrogen and phosphorus, which are described below.

2.4.5.1 Nitrogen

Nitrogen exists in numerous forms in the environment – nitrogen gas, nitrate, nitrite, and ammonia are some of the more common forms. Nitrogen is essential to plant growth, but excessive levels can be detrimental. In the early days of sanitary engineering, levels of the relative species of nitrogen were used to determine if fecal contamination had occurred. This methodology has since been replaced with enumeration techniques for pathogenic organisms and/or indicator organisms. Figures 2-10 and 2-11 show data for total nitrogen and nitrate plus nitrite levels at various sampling points in the watershed.

2.4.5.2 Phosphorus

Phosphorus is found in numerous forms in an aqueous state - orthophosphates, polyphosphates, and organic phosphates. Typical phosphorus levels in raw wastewater range from 4 to 16 mg/L as P. Phosphorus can be a limiting constituent in the biological treatment of wastewater and its presence in natural water bodies can lead to alga blooms. Figure 2-12 show data for phosphorus levels at various sampling points in the watershed.

2.4.6 Chlorophyll a

Chlorophyll is the pigment that allows for photosynthesis or the process that allows plants to convert sunlight into organic compounds. Chlorophyll a is the predominant type found in algae and cyanobacteria (blue-green algae), and its relative quantities are a good indicator of the amount of algae present. Excessive quantities of chlorophyll *a* can indicate the presence of algae blooms. These usually consist of a single species of algae, one typically that fish and other predators do not consume. Unconsumed algae sink to the bottom and decays, using up the oxygen required by plants and other organisms to survive. The presence of other nutrients, such as nitrogen and phosphorus, can result in algal blooms which reduce water clarity.

Chlorophyll a can also reducing the amount of light available to plants in shallow-water habitats. This directly impacts the ability of underwater bay grasses to thrive. Figure 2-13 show data for chlorophyll a levels at various sampling points in the watershed.

2.5 Pollutant Sources

A variety of sources contribute to the pollutant load to the Kaelepulu Stream and Estuary. This section describes each of these sources.

2.5.1 Wastewater Facilities

Untreated wastewater represents an obvious source of pollution. Wastewater would be expected to contribute to the loading of nutrients (nitrogen and phosphorus), turbidity, and microbial organisms. Spills from permitted facilities are reported to the Department of Health who maintains spill records. Based on a search of records from 2000 to 2004, four spills were recorded within the Kaelepulu watershed. Three of the spills appear to be related to the Kalaheo sewer project which is still ongoing. Table 2-1 presents some information on these spills and Figure 2- 14 shows the physical location of these spills.

Table 2-1. Recorded Wastewater Spills

Date	Location	Cause	Quantity (gallons)
7/4/03	Kailua Road Pump Station (Kawainui Marsh)	Sink hole, 18-inch forcemain break	100
2/26/04	394 Wana'ao Road (Kaelepulu Stream – Kailua Beach)	Heavy rain and pump failure at the Kalaheo bypass project.	984,700
3/2/04	394 Wana'ao Road (Kaelepulu Stream – Kailua Beach)	Heavy rain caused surcharge	108,000
11/6/04	429 Wana'ao Road (Kaelepulu Stream – Kailua Beach)	Heavy rain	5,000
Source: Department of Health			

In addition to visible wastewater spills there could be other discharges of wastewater that are unseen. Cesspools, septic tanks, exfiltration or leakage from collection system pipes, and wastewater pump stations also represent potential sources of pollutants. Figure 2-15 shows the location of these facilities within the watershed.

2.5.2 Storm Drains

Storm drains are used to convey runoff from storm events to a discharge point. It was previously thought that storm water runoff was fairly clean, but as areas have become more urbanized this has been shown not to be the case. Runoff can pick up a wide variety of pollutants depending on the land use – nutrients from recently fertilized lawns, oil from carports, sediment from construction sites, etc. Two sets of storm drains

systems exist within the watershed – City and County of Honolulu's Environmental Services Department and the State of Hawaii's, Department of Transportation. Figure 2-16 shows the location of their respective drainage systems.

2.5.3 Agriculture

Within the Kaelepulu watershed, there is a small segment of land that is zoned Ag-2 by the City and County. Ag-2 zoning means that the land may be used for raising agriculture and animals. The lots are on steeply graded land which discharges to storm drains that cross Kalanianiole Highway. The nature of these lots makes this source potentially significant. Agriculture would be expected to contribute nutrients (nitrogen and phosphorus) and turbidity. Figure 2-17 shows the location of the agriculturally zoned areas.

2.5.4 Wildlife

As was previously mentioned, the stream and estuary support a diverse number of wildlife. However, these animals generate wastewater which contributes nutrients and bacterial pollutants to the water body. Duck feces and sewer discharges were identified as having the highest concentration of indicator bacteria in a University of Hawaii study (Roll and Fujioka). Assessing this natural input into the watershed will be difficult due to the transient nature of the wildlife.

2.5.5 Groundwater

Although groundwater is typically thought of more as a victim of pollution rather than a source of pollution, it is possible for this to happen if the groundwater quality were significantly degraded. In most cases, the constituent of concern Is typically nitrogen. Groundwater quality can be impacted by In the case of the Kaelepulu watershed, groundwater quality is not generally known. Monitoring, if any is available, is probably limited to water wells. Monitoring downgradient of suspected pollutant sources such as cesspools

2.6 WATER QUALITY

Several studies and ongoing monitoring programs have helped to characterize the baseline water quality. Both the Department of Environmental Services (City) and the Clean Water Branch (State Department of Health), conduct regular monitoring at various locations in the watershed. Appendix B contains summary data for each of the pollutants from these sources. Two specialized studies are described below.

2.6.1 University of Hawaii Studies

The University of Hawaii conducted a series of studies that examined water quality in Kailua Bay (Ahuna and Fujioka, 1993; Roll and Fujioka, 1993; Moravcik and Heitz,

1993; Krock and Fujioka, 1993; Krock and Sundararaghavan, 1993; and Fujioka, Wu, and Fujioka, 1993). Of these studies, two either touched upon or directly dealt with Kaelepulu Stream. The studies reached the following conclusions:

- The salinity of Kaelepulu stream is subject to tidal influence and rainfall and should be considered a marine or brackish water system.

- Recreational water standards for Kaelepulu Stream were exceeded at almost all sampling locations. Indicator bacteria levels decline as the stream draws closer to the ocean.

- Nutrient loading was suspected in the Hamakua canal, at the storm drain canal near St. John Viannery School, and at the storm drain canal adjacent to the Akumu sewage pump station. (Note: The sampling in Hamakua canal may no longer be valid since the Army Corps of Engineers installed a berm at the headwaters of the canal adjacent to the outlet for the Kawainui Marsh.

- Recreational water standards for Kailua Bay were exceeded when the Kaelepulu Stream mouth was open.

- The major sources of indicator bacteria were sewage discharges, duck feces, source waters, soil and storm drain runoff, with sewage discharges and duck feces being the highest.

2.6.2 Independent Data Sources

Kailua is a very dynamic community and its residents take an active part in monitoring the health of its environment. The Kailua Bay Advisory Council (KBAC) has been active in developing watershed based programs to enhance their community. Individual residents have taken it upon themselves to monitor various parameter and collected water samples to document the state of Kaelepulu Stream and Estuary. A sample of the effort undertaken by its residents is enclosed in Appendix C which recounts estimated sediment loads for a rainfall event on 2 January 2004. This testing is not performed on behalf of any of the affected agencies, and may not follow requisite sampling procedures; therefore it is not considered primary data in the TMDL process. However, it does provide an indication of how the stream system responds to rainfall events.

3.0 IDENTIFIED DATA GAPS

The available data provides a reasonable basis for developing a sampling and analysis plan, but there are additional pieces of information that may be beneficial to review in the context of the existing data. The following are recommendations for increasing our knowledge of the watershed to help in the development of TMDLs.

1. Develop a database of local area rainfall. This will be useful in determining typical loading scenarios and reviewing historical water quality sampling in the context of wet and dry conditions.
2. Review water level data. Dr. Floyd McCoy of Windward Community College has been recording water level data and it may be necessary to correlate water levels in the estuary with the breaching of the stream mouth to better understand how pollutant levels vary over time.
3. Measure conductivity at the stream mouth and at various positions along the stream. Accounting for tidal influences will be difficult, but monitoring of this sort will provide a basic understanding of how the system operates.
4. Establish a clear definition of the watershed boundaries in the vicinity of the State Correctional facilities. Although the current watershed boundaries seem correct based on elevation information, there are a number of DOT inlets in that area. If these inlets allow water to go under Kalanianiole Highway, then areas southwest of that area may need to be included in the analysis. A review of DOT storm drain drawings is recommended to decide whether this is in fact the case.
5. It is possible to determine the tributary area associated with each inlet, but this will require significant effort. To the extent that record drawings and design calculations exist, these can be readily digitized and used. An example of this is presented in Figure 3-1. In areas where record drawings do not exist, it will be necessary to locate topographical information to estimate the tributary area.

   The Kaelepulu estuary is somewhat unique in comparison to the other waterbodies that DOH has established TMDLs for. To a large extent, the estuary acts as a sink with pollutant loads accumulating (and exacerbated by evaporative losses) until City forces open the mouth of the stream and allow the accumulated water to flow into Kailua Bay. If the mouth of the stream were to be permanently opened, then it might be possible to use the same approach as was used for other waterbodies in Hawaii. However, since it is unlikely that this would happen, it is necessary to consider other means to establish numerical objectives. This will be addressed in detail in the Sampling and Analysis Plan.

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APPENDIX A

APPENDIX B

ENTEROCOCCI

Data Source	Site	Data Timeframe	Constituent	Units	Season[1]	Count	Min	Median	Geo Mean	Max
UH Microbial Assessment	KSKB	1990-1991	Enterococci	CFU/100 mL	D	14	0	0	9	48
UH Microbial Assessment	KSKB	1990-1991	Enterococci	CFU/100 mL	W	15	0	4	18	1800
UH Microbial Assessment	KS1	1990-1991	Enterococci	CFU/100 mL	D	14	0	20	40	312
UH Microbial Assessment	KS1	1990-1991	Enterococci	CFU/100 mL	W	15	8	44	78	3600
UH Microbial Assessment	KS7	1990-1991	Enterococci	CFU/100 mL	D	14	4	33	43	500
UH Microbial Assessment	KS7	1990-1991	Enterococci	CFU/100 mL	W	15	8	44	78	3600
UH Microbial Assessment	KS8	1990-1991	Enterococci	CFU/100 mL	D	14	16	104	151	2320
UH Microbial Assessment	KS8	1990-1991	Enterococci	CFU/100 mL	W	14	116	802	980	37200
UH Microbial Assessment	KS9	1990-1991	Enterococci	CFU/100 mL	D	13	31	84	101	900
UH Microbial Assessment	KS9	1990-1991	Enterococci	CFU/100 mL	W	15	48	196	361	59200
UH Microbial Assessment	KS10	1990-1991	Enterococci	CFU/100 mL	D	13	16	136	169	2520
UH Microbial Assessment	KS10	1990-1991	Enterococci	CFU/100 mL	W	14	56	296	455	40400
UH Microbial Assessment	KS11	1990-1991	Enterococci	CFU/100 mL	D	13	84	156	462	8560
UH Microbial Assessment	KS11	1990-1991	Enterococci	CFU/100 mL	W	16	136	1420	1520	30000
UH Microbial Assessment	KS12	1990-1991	Enterococci	CFU/100 mL	D	13	24	236	464	6320
UH Microbial Assessment	KS12	1990-1991	Enterococci	CFU/100 mL	W	17	52	2280	2264	510000
UH Microbial Assessment	KS13	1990-1991	Enterococci	CFU/100 mL	D	14	8	538	393	3760
UH Microbial Assessment	KS13	1990-1991	Enterococci	CFU/100 mL	W	17	20	1240	1358	110000
DOH	Kaelepulu Stream	1987-1995	Enterococci	CFU/100 mL	D	110	0.5	8	10	11550
DOH	Kaelepulu Stream	1986-1995	Enterococci	CFU/100 mL	W	113	0.5	27	33	70000
ENV	Kaelepulu Stream	1998-2000	Enterococci	CFU/100 mL	D	35	7	40	34	200
ENV	Kaelepulu Stream	1998-2000	Enterococci	CFU/100 mL	W	59	1	61	68	13000
ENV	Kailua Beach Park	1998-2002	Enterococci	CFU/100 mL	D	115	1	2	3	84
ENV	Kailua Beach Park	1998-2002	Enterococci	CFU/100 mL	W	121	1	5	7	930
ENV	Kalama Beach	1998-2002	Enterococci	CFU/100 mL	D	115	1	1	2	150
ENV	Kalama Beach	1998-2002	Enterococci	CFU/100 mL	W	121	1	3	5	240
ENV	Oneawa Beach	1998-2002	Enterococci	CFU/100 mL	D	115	1	1	2	790
ENV	Oneawa Beach	1998-2002	Enterococci	CFU/100 mL	W	121	1	4	4	170
DOH	Kalama Beach	1988-1995	Enterococci	CFU/100 mL	D	101	0.5	1	1	156
DOH	Kalama Beach	1989-1995	Enterococci	CFU/100 mL	W	97	0.5	2	3	420
DOH	Kalama Beach	1988-1998	Enterococci	CFU/100 mL	D	106	0.5	1	2	796
DOH	Kalama Beach	1989-1998	Enterococci	CFU/100 mL	W	98	0.3	2	3	5500
DOH	Lanikai Beach	1990-1999	Enterococci	CFU/100 mL	D	142	0.3	2	3	450
DOH	Lanikai Beach	1990-1999	Enterococci	CFU/100 mL	W	124	0.3	5.1	6	3000
DOH	Kailua Beach Park	1987-2003	Enterococci	CFU/100 mL	D	339	0.3	1.3	2	1100
DOH	Kailua Beach Park	1987-2003	Enterococci	CFU/100 mL	W	302	0.3	5	6	8800
MS4 Surface	???	1998-2002	Enterococci	CFU/100 mL	D	115	1	3	5	410
MS4 Surface	???	1998-2002	Enterococci	CFU/100 mL	W	115	1	13	13	3800
DOH	Kaelepulu 1	2004	Enterococci	CFU/100 mL	D	4	700	2,075	1,662	3,300
DOH	Kaelepulu 2	2004	Enterococci	CFU/100 mL	D	4	120	1,515	555	4,900
DOH	Kaelepulu 3	2004	Enterococci	CFU/100 mL	D	4	2,600	8,600	5,806	23,000
DOH	Kaelepulu 4	2004	Enterococci	CFU/100 mL	D	4	15	1,063	121	4,100
DOH	Kaelepulu 5	2004	Enterococci	CFU/100 mL	D	4	71	777	222	2,800
DOH	Kaelepulu 6	2004	Enterococci	CFU/100 mL	D	4	9	39	26	71

Notes:

[1]Dry season (D) = 1 May to 31 October, wet season (W) = 1 November to 30 April

ESCHERICHIA COLI (E. coli)

Data Source	Site	Data Timeframe	Constituent	Units	Season[1]	Count	Min	Median	Geo Mean	Max
UH Microbial Assessment	KSKB	1990-1991	E. coli	CFU/100 mL	D	14	0	0	4	8
UH Microbial Assessment	KSKB	1990-1991	E. coli	CFU/100 mL	W	15	0	0	12	700
UH Microbial Assessment	KS1	1990-1991	E. coli	CFU/100 mL	D	14	0	0	24	276
UH Microbial Assessment	KS1	1990-1991	E. coli	CFU/100 mL	W	15	0	11	31	4400
UH Microbial Assessment	KS7	1990-1991	E. coli	CFU/100 mL	D	14	0	12.5	26	400
UH Microbial Assessment	KS7	1990-1991	E. coli	CFU/100 mL	W	15	0	11	31	4400
UH Microbial Assessment	KS8	1990-1991	E. coli	CFU/100 mL	D	14	8	68	94	5120
UH Microbial Assessment	KS8	1990-1991	E. coli	CFU/100 mL	W	14	76	228	447	28000
UH Microbial Assessment	KS9	1990-1991	E. coli	CFU/100 mL	D	13	16	32	45	1320
UH Microbial Assessment	KS9	1990-1991	E. coli	CFU/100 mL	W	15	0	84	219	35200
UH Microbial Assessment	KS10	1990-1991	E. coli	CFU/100 mL	D	14	0	60	130	2210
UH Microbial Assessment	KS10	1990-1991	E. coli	CFU/100 mL	W	14	36	122	221	29200
UH Microbial Assessment	KS11	1990-1991	E. coli	CFU/100 mL	D	13	4	76	214	6280
UH Microbial Assessment	KS11	1990-1991	E. coli	CFU/100 mL	W	16	28	766	791	20400
UH Microbial Assessment	KS12	1990-1991	E. coli	CFU/100 mL	D	13	12	112	187	4480
UH Microbial Assessment	KS12	1990-1991	E. coli	CFU/100 mL	W	17	0	1160	1249	470000
UH Microbial Assessment	KS13	1990-1991	E. coli	CFU/100 mL	D	14	0	210	241	5800
UH Microbial Assessment	KS13	1990-1991	E. coli	CFU/100 mL	W	17	0	960	1081	46000

Notes:

[1]Dry season (D) = 1 May to 31 October, wet season (W) = 1 November to 30 April

CLOSTRIDIUM PERFINGENS (C. perfingens)

Data Source	Site	Data Timeframe	Constituent	Units	Season[1]	Count	Min	Median	Geo Mean	Max
UH Microbial Assessment	KSKB	1990-1991	C. perfingens	CFU/100 mL	D	14	0	0	4	8
UH Microbial Assessment	KSKB	1990-1991	C. perfingens	CFU/100 mL	W	15	0	0	6	50
UH Microbial Assessment	KS1	1990-1991	C. perfingens	CFU/100 mL	D	14	0	1	3	8
UH Microbial Assessment	KS1	1990-1991	C. perfingens	CFU/100 mL	W	15	0	5	9	80
UH Microbial Assessment	KS7	1990-1991	C. perfingens	CFU/100 mL	D	14	0	2	6	43
UH Microbial Assessment	KS7	1990-1991	C. perfingens	CFU/100 mL	W	15	0	5	9	80
UH Microbial Assessment	KS8	1990-1991	C. perfingens	CFU/100 mL	D	14	2	12	10	124
UH Microbial Assessment	KS8	1990-1991	C. perfingens	CFU/100 mL	W	14	10	38	41	480
UH Microbial Assessment	KS9	1990-1991	C. perfingens	CFU/100 mL	D	13	0	4	7	84
UH Microbial Assessment	KS9	1990-1991	C. perfingens	CFU/100 mL	W	15	3	17	25	520
UH Microbial Assessment	KS10	1990-1991	C. perfingens	CFU/100 mL	D	14	0	8	10	295
UH Microbial Assessment	KS10	1990-1991	C. perfingens	CFU/100 mL	W	14	3	26	29	4000
UH Microbial Assessment	KS11	1990-1991	C. perfingens	CFU/100 mL	D	13	4	32	36	612
UH Microbial Assessment	KS11	1990-1991	C. perfingens	CFU/100 mL	W	17	7	192	155	1320
UH Microbial Assessment	KS12	1990-1991	C. perfingens	CFU/100 mL	D	13	4	20	32	272
UH Microbial Assessment	KS12	1990-1991	C. perfingens	CFU/100 mL	W	17	2	68	98	5700
UH Microbial Assessment	KS13	1990-1991	C. perfingens	CFU/100 mL	D	14	0	11	13	136
UH Microbial Assessment	KS13	1990-1991	C. perfingens	CFU/100 mL	W	17	0	33	50	7000
DOH	Kaelepulu Stream	1993-1995	C. perfingens	CFU/100 mL	D	24	1	6	6	35
DOH	Kaelepulu Stream	1992-1995	C. perfingens	CFU/100 mL	W	33	2	10	12	690
DOH	Lanikai Beach	1997-1999	C. perfingens	CFU/100 mL	D	35	0.3	2	1.8	12.6
DOH	Lanikai Beach	1997-1999	C. perfingens	CFU/100 mL	W	29	0.3	1.5	2.9	220
DOH	Kailua Beach Park	1996-2003	C. perfingens	CFU/100 mL	D	181	0.2	1.3	1.4	146
DOH	Kailua Beach Park	1996-2003	C. perfingens	CFU/100 mL	W	156	0.2	1.5	2	138

Notes:

[1]Dry season (D) = 1 May to 31 October, wet season (W) = 1 November to 30 April

NITRATE + NITRITE - NITROGEN

Data Source	Site	Data Timeframe	Constituent	Units	Season[1]	Count	Min	Median	Geo Mean	Max
DOH	Kaelepulu Stream	1984-1995	NO2 + NO3 - N	mg/L	D	37	10	10	12	160
DOH	Kaelepulu Stream	1989-1995	NO2 + NO3 - N	mg/L	W	33	10	10	20	740
DOH	Keolu Bridge	1976-1977	NO2 + NO3 - N	mg/L	D	6	10	60	49	600
DOH	Keolu Bridge	1976-1977	NO2 + NO3 - N	mg/L	W	2	100	105	105	110
DOH	Oneawa Beach	1988-1990	NO2 + NO3 - N	mg/L	D	35	10	10	11	300
DOH	Oneawa Beach	1988-1995	NO2 + NO3 - N	mg/L	W	29	10	10	12	30
DOH	Lanikai Beach	1984	NO2 + NO3 - N	mg/L	W	1	6	6	6	6
DOH	Kailua Beach Park	1973-1994	NO2 + NO3 - N	mg/L	D	66	10	10	17	100
DOH	Kailua Beach Park	1973-1995	NO2 + NO3 - N	mg/L	W	59	3.5	10	19	300

Notes:

[1]Dry season (D) = 1 May to 31 October, wet season (W) = 1 November to 30 April

TOTAL SUSPENDED SOLIDS (TSS)

Data Source	Site	Data Timeframe	Constituent	Units	Season[1]	Count	Min	Median	Geo Mean	Max
DOH	Kaelepulu Stream	1984-1995	TSS	mg/L	D	37	2	16	16	60
DOH	Kaelepulu Stream	1989-1995	TSS	mg/L	W	32	2	17	17	90
DOH	Kaelepulu Stream	1988-1994	TSS	mg/L	D	35	7	27	25	58
DOH	Oneawa Beach	1989-1995	TSS	mg/L	W	28	12	30	30	60
DOH	Lanikai Beach	1984	TSS	mg/L	W	1	31	31	31	31
DOH	Kailua Beach Park	1982-1994	TSS	mg/L	D	47	3	28	28	257
DOH	Kailua Beach Park	1982-1995	TSS	mg/L	W	38	4	28	27	136

Notes:

[1]Dry season (D) = 1 May to 31 October, wet season (W) = 1 November to 30 April

CHLOROPHYLL A

Data Source	Site	Data Timeframe	Constituent	Units	Season[1]	Count	Min	Median	Geo Mean	Max
DOH	Kaelepulu Stream	1984-1995	Chlorophyll a	ug/L	D	35	22	174	180	1540
DOH	Kaelepulu Stream	1989-1995	Chlorophyll a	ug/L	W	32	3	134	101	1624
DOH	Oneawa Beach	1988-1994	Chlorophyll a	ug/L	D	33	3	12	14	171
DOH	Oneawa Beach	1989-1995	Chlorophyll a	ug/L	W	29	3	5	11	247
DOH	Kailua Beach Park	1982-1994	Chlorophyll a	ug/L	D	44	2.5	2.8	6	308
DOH	Kailua Beach Park	1982-1995	Chlorophyll a	ug/L	W	38	2.5	5	8	100

Notes:

[1]Dry season (D) = 1 May to 31 October, wet season (W) = 1 November to 30 April

TURBIDITY

Data Source	Site	Data Timeframe	Constituent	Units	Season[1]	Count	Min	Median	Geo Mean	Max
DOH	Kaelepulu Stream	1984-1995	Turbidity	NTU	D	36	1.3	2.9	3.0	7.1
DOH	Kaelepulu Stream	1989-1995	Turbidity	NTU	W	33	1.0	2.7	2.8	8.5
DOH	Keolu Bridge	1976-1977	Turbidity	NTU	D	6	1.8	2.6	2.7	4.2
DOH	Keolu Bridge	1976-1977	Turbidity	NTU	W	2	1.9	2.4	2.3	2.8
DOH	Oneawa Beach	1988-1994	Turbidity	NTU	D	34	1.1	3.7	3.5	9.8
DOH	Oneawa Beach	1989-1995	Turbidity	NTU	W	29	1.0	3.9	3.8	9.6
DOH	Lanikai Beach	1984	Turbidity	NTU	W	1	4.4	4.4	4.4	4.4
DOH	Kailua Beach Park	1973-2003	Turbidity	NTU	D	75	1.3	4.7	4.7	14
DOH	Kailua Beach Park	1973-2003	Turbidity	NTU	W	64	0.1	5.5	5.5	24
DOH	Kaelepulu 1	2004	Turbidity	NTU	D	4	10.8	13.0	12.9	14.2
DOH	Kaelepulu 2	2004	Turbidity	NTU	D	3	3.4	4.8	4.6	6.1
DOH	Kaelepulu 3	2004	Turbidity	NTU	D	4	5.4	6.5	6.4	7.9
DOH	Kaelepulu 4	2004	Turbidity	NTU	D	4	1.6	3.2	3.0	4.7
DOH	Kaelepulu 5	2004	Turbidity	NTU	D	4	3.0	4.1	4.0	4.8
DOH	Kaelepulu 6	2004	Turbidity	NTU	D	4	2.8	3.8	3.7	4.7

Notes:

[1]Dry season (D) = 1 May to 31 October, wet season (W) = 1 November to 30 April

PHOSPHORUS

Data Source	Site	Data Timeframe	Constituent	Units	Season[1]	Count	Min	Median	Geo Mean	Max
UH Microbial Assessment	KSKB	1990-1991	Phosphorus	mg/L	D	14	0.001	0.007	0.007	0.029
UH Microbial Assessment	KSKB	1990-1991	Phosphorus	mg/L	W	15	0.004	0.009	0.012	0.129
UH Microbial Assessment	KS1	1990-1991	Phosphorus	mg/L	D	14	0.001	0.023	0.019	0.400
UH Microbial Assessment	KS1	1990-1991	Phosphorus	mg/L	W	15	0.004	0.021	0.029	0.251
UH Microbial Assessment	KS7	1990-1991	Phosphorus	mg/L	D	14	0.005	0.049	0.036	0.300
UH Microbial Assessment	KS7	1990-1991	Phosphorus	mg/L	W	15	0.004	0.021	0.029	0.251
UH Microbial Assessment	KS8	1990-1991	Phosphorus	mg/L	D	14	0.009	0.060	0.049	0.247
UH Microbial Assessment	KS8	1990-1991	Phosphorus	mg/L	W	15	0.008	0.116	0.128	0.810
UH Microbial Assessment	KS9	1990-1991	Phosphorus	mg/L	D	13	0.009	0.079	0.051	0.148
UH Microbial Assessment	KS9	1990-1991	Phosphorus	mg/L	W	15	0.015	0.094	0.085	0.610
UH Microbial Assessment	KS10	1990-1991	Phosphorus	mg/L	D	14	0.008	0.095	0.080	0.214
UH Microbial Assessment	KS10	1990-1991	Phosphorus	mg/L	W	14	0.015	0.080	0.089	0.740
UH Microbial Assessment	KS11	1990-1991	Phosphorus	mg/L	D	14	0.047	0.119	0.142	0.548
UH Microbial Assessment	KS11	1990-1991	Phosphorus	mg/L	W	17	0.049	0.119	0.133	0.510
UH Microbial Assessment	KS12	1990-1991	Phosphorus	mg/L	D	14	0.042	0.112	0.107	0.184
UH Microbial Assessment	KS12	1990-1991	Phosphorus	mg/L	W	17	0.042	0.115	0.152	0.804
UH Microbial Assessment	KS13	1990-1991	Phosphorus	mg/L	D	14	0.001	0.045	0.024	0.116
UH Microbial Assessment	KS13	1990-1991	Phosphorus	mg/L	W	17	0.008	0.049	0.060	0.416
DOH	Kaelepulu Stream	1984-1995	Phosphorus	mg/L	D	37	0.010	0.029	0.027	0.058
DOH	Kaelepulu Stream	1989-1995	Phosphorus	mg/L	W	33	0.016	0.034	0.039	0.251
DOH	Keolu Bridge	1976-1977	Phosphorus	mg/L	D	6	0.078	0.103	0.101	0.143
DOH	Keolu Bridge	1976-1977	Phosphorus	mg/L	W	2	0.078	0.127	0.117	0.177
DOH	Oneawa Beach	1988-1990	Phosphorus	mg/L	D	35	0.008	0.016	0.017	0.191
DOH	Oneawa Beach	1988-1995	Phosphorus	mg/L	W	29	0.009	0.019	0.025	0.990
DOH	Lanikai Beach	1984	Phosphorus	mg/L	W	1	20	20	20	20
DOH	Kailua Beach Park	1982-1994	Phosphorus	mg/L	D	67	6	15	18	254
DOH	Kailua Beach Park	1973-1995	Phosphorus	mg/L	W	59	0	21	36	411

Notes:

[1]Dry season (D) = 1 May to 31 October, wet season (W) = 1 November to 30 April

APPENDIX C