WAIOPILI DITCH SANITARY SURVEY, KAUAI PART I

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Mahaulepu Watershed-Waiopili Ditch Sanitary Survey, Kauai Part 1

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Table of Contents

Executive Summary 8
1.0. Background 12
2.0. Introduction 16
2.1. Sanitary Survey Requirements 16
2.2. Objectives 16
2.3. Conduct of the Study 17
2.4 Sanitary Survey Methods 17
2.5. Report Organization 18
2.6. Limitations of this Study 18
3.0. Land Use and Natural Setting 19
3.1. Watershed 22
3.1.1. Land Use 24
3.1.2. Land Use Commission, Important Agricultural Lands 27
3.1.3. Past Land Use 27
3.1.4. Current Land Use 28
3.2. Natural Setting 29
3.3. Existing Hydrological Resources 30
4.0. Potential Contaminant Sources 37
4.1. Wastewater 37
4.2. Wastewater Discharges and Collection Systems 37
4.3. Septic Tank Systems and Cesspools 38
4.4. Reclaimed Water 39
4.5. Urban Runoff and Industrial Area Runoff 40
4.6. Agricultural Crop Land Use 41
4.7. Grazing Animals 41
4.8. Concentrated Animal Feeding Operation (CAFO) 41
4.9. Source Water Assessment Program (SWAP) 41
4.10. Pesticides and Herbicide Use 43
4.11. Wildlife 44
4.12. Solid and Hazardous Waste Disposal Facilities 44
4.13. Logging 45

4.14. Recreational Use 45
4.15. Unauthorized Activity 45
4.16. Traffic Accidents/Spills 46
4.17. Groundwater Influencing Surface Water Quality 46
4.18. Geologic Hazards 46
4.19. Fires 48
4.20. Significance of Potential Contamination Sources 48
4.21. Anticipated Growth and Projected Changes in Contaminant Sources 51
5.0. Watershed Control and Management Practices MVSW 52
5.1. Management Practices in the Mahaulepu Valley Sub-Watershed 52
5.1.1. Lease Agreements 53
5.2. Other Agencies with Watershed Control Authority 53
5.2.1. County General Plan Policies 54
5.2.2. Federal Agency Plans and Policies 54
5.2.3. Wastewater Discharge Requirements 54
5.2.4. Storm Water and NPDES Regulations 55
5.2.5. Mines/Mining Reclamation 56
5.2.6. Open Space Policies 56
5.2.7. Erosion Control/Soil Management Policies 57
5.2.8. Fire Management 58
5.3. Agency-Organization Coordination Measures 59
6.0 Water Quality 62
6.1. Water Quality Indicators 62
6.1.1. Recreational Use Regulations 63
6.1.2. Constituents of Concern 69
6.2. Existing Water Quality 72
6.2.1. Monitoring Program DOH Data 73
6.2.2. Evaluation of Monitoring Data 75
6.2.2. Monitoring Data, Molecular Source Tracking 82
6.3. Additional WQ Monitoring in Progress 84
6.3.1. USGS 84
6.3.2. UC Berkeley PhyloChip 84

7.0. Conclusions 86
8.0. References 89

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List of Figures

Figure 1. Mahaulepu and Adjacent Watersheds 20
Figure 2. Aerial View of Mahaulepu 21
Figure 3. Mount Haupu 22
Figure 4. National Park Service Survey 23
Figure 5. Land Use Designations for South-Central Kauai 24
Figure 6. Mahaulepu Farm Postings 26
Figure 7. Warner Dam (Site #11c, just over weir) 31
Figure 8. Waiopili Ditch (heavy canopy at cave entrance) 33
Figure 9. North Cave Entrance (note cave entrance is gated) 34
Figure 10. Current Map Showing the Waiopili Ditch 35
Figure 11. 1912 U.S. Geological Survey Map 36
Figure 12. Injection Wells, OSDS in Poipu/Koloa (Waikomo) and Mahaulepu Watersheds 38
Figure 13. Facility Permits 39
Figure 14. Koloa Wells, Capture Zone, and Site of Proposed Hawaii Dairy Farm LLC 43
Figure 15. Groundwater Flow Paths to the Makauwahi Cave, Southern Kauai 48
Figure 16. Time of Travel from Two Injection Well Sites 50
Figure 17. Sources of Enterococci 66
Figure 18. DOH Sampling Sites in Mahaulepu 75
Figure 19. Enterococci and Clostridum perfringens Geometric Mean 79
Figure 20. Site 11c 80
Figure 21. Site 11b 81
Figure 22. Waiopili Ditch Mouth and Beach 82
Figure 23. Landscape View of Waiopili Ditch Mouth 88

List of Tables

Table 1. Enterococci Levels in Mahaulepu Valley Sub-Watershed 77
Table 2. Clostridium perfringens Levels in Mahaulepu Valley Sub-Watershed 78
Table 3. Waiopili Ditch Sediment Sampling Results 80

Attachments

1. Species of the Genus Enterococci in Their Known Habitats
2. Enterococci in Extra-Enteric Habitats
3. Study Area Landowners
4. Koloa-Poipu-Kalaheo Planning District Land Use Map
5. Mahaulepu Map
6. Aerial Photos of Study Area
7. Historical Kapunakea Pond and Waiopili Spring
8. List of Injection Wells Poipu-Koloa and Mahaulepu Watersheds
9. Kauai Hydraulic Conductivity Map
10. Concentration of Indicator Bacteria in Animal Feces
11. Microbial Source Tracking Data

Acronyms

AWQC	Ambient Water Quality Criteria BAV Beach Action Value
BEACH Act	Beaches Environmental Assessment and Coastal Health Act of 2000
BMP	Best Management Practice
BPW	Buffered Peptone Water
CFU	Colony Forming Units
CWA	Clean Water Act
CWB	Clean Water Branch
DOH	Department of Health
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FIB	Fecal Indicator Bacteria
GI	Gastrointestinal
GM	Geometric Mean
HDF	Hawaii Dairy Farms
IAL	Important Agricultural Lands
LUC	Land Use Commission
MCR	Makauwahi Cave Reserve
mL	milliliters
MPN	Most Probable Number
MST	Molecular Source Tracking
MVSW	Mahaulepu Valley Sub Watershed
MW	Mahaulepu Watershed

ND	Non-Detect
NF	No Flow
OSDS	Onsite Disposal Systems
ODGWN	Onsite (Disposal System) Derived Groundwater Nitrogen
PKW	Poipu Koloa Watershed
POTW	Publicly Owned (sewage) Treatment Works
QA/QC	Quality Assurance/Quality Control
QMRA	Quantitative Microbial Risk Assessment
qPCR	quantitative Polymerase Chain Reaction
RWQC	Recreational Water Quality Criteria
SD	Standard Deviation
SDWB	Safe Drinking Water Branch
STV	Statistical Threshold Value
TMK	Tax Map Key
UH	University of Hawaii
USDA	U.S. Department of Agriculture
UV	Ultraviolet (light)
WHO	World Health Organization (United Nations)
WRRC	Water Resources Research Center
WWB	Wastewater Branch
WWRF	Wastewater Reclamation Facility
WWTP	Wastewater Treatment Plant

Executive Summary

High enterococci bacteria levels have been measured in the Waiopili Ditch. In response to a complaint, the DOH conducted a sanitary survey to investigate the sources of these enterococci bacteria. This sanitary survey gathered facts, reviewed historical documents, reviewed past and present land use, gathered geological and hydrological information, examined hydraulic conductivity, located sources of human contamination (injection wells, septic systems, cesspools, discharge wells), identified animal sources, and conducted bacteria monitoring of surface waters of Mahaulepu Valley to establish a bacteria baseline.

What some call Waiopili Stream is actually a man-made drainage ditch at the terminus of the Mahaulepu Valley irrigation system which was constructed to drain the former Kapunakea Pond and connects to the Mahaulepu Drain. The stream also handles rainfall flow off the Haupu Mountain Range and carries irrigation water from Mahaulepu Valley and Waita Reservoir into the Mahaulepu sub-watershed area. No sewer lines, injection wells or cesspools discharge directly into Waiopili Ditch; however, a healthy population of feral pigs, chickens, ducks, and sheep were observed in the area. Waiopili Ditch is lined with vegetation along its length, which is fairly dense in certain areas, and is heavily canopied along its lower end. Waiopili Ditch is on private land with limited public access and there was no evidence of recreational activity occurring within the Waiopili Ditch.

The construction of a dairy farm is proposed in the area surrounding the Waiopili Ditch (within the Mahaulepu sub-watershed). An irrigation system and water troughs have been installed and grass has been planted in the area of the proposed dairy farm. No significant grading, grubbing, or facility construction activity has occurred recently at the proposed dairy site and no cattle currently exists on the site. There is no point source discharge of pollutants into Waiopili Ditch and the proposed construction area receives a significant amount of solar radiation throughout the day. Currently, there is no significant impact to the Waiopili Ditch from any activity that can be attributed to the proposed dairy.

Enterococci has traditionally been used to indicate sewage contamination. Studies have shown positive correlations between elevated concentrations of enterococci and the risk of humans contracting gastroenteritis while engaging in recreational activities in which ingestion of the water is highly likely, particularly when the area is contaminated by point source pollution (human sewage). However, these studies were mainly conducted in areas where recreational waters were directly impacted by a point source discharge of human sewage. As a result, the use of enterococci as a fecal indicator has drawn criticism, especially in areas where

populations of enterococci have been shown to exist in soil and sediment without a source of human sewage. The existence of these endogenous populations has confounded water quality assessments in areas in which elevated enterococci levels cannot be directly attributable to human sewage contamination. In addition to inhabiting the gastrointestinal tract of mammals and some insects, enterococci has been shown to exist in environmental reservoirs that serve as sources and sinks for these organisms. Enterococci are opportunistic organisms with the ability to exploit a variety of environmental conditions where sufficient nutrients are available, including such extra-enteric habitats as soils, sediment, sand, aquatic and terrestrial vegetation, and ambient waters, especially in tropical environments. For this reason, the use of enterococci as an indicator of human fecal contamination has drawn controversy. The detection of high levels of enterococci alone may not necessarily indicate a significant human health risk to users of the water in Hawaii.

The U.S. Environmental Protection Agency (EPA) recommends the use of enterococci as a fecal indicator bacteria (FIB). Because the Department of Health (DOH) is aware of the shortcomings of enterococci as a fecal indicator, the DOH uses a secondary tracer bacteria, *Clostridium perfringens* for routine monitoring of ambient surface waters, in addition to enterococci. In instances where further information is needed, the DOH uses a "toolbox" approach in which additional EPA-recommended tests are used to help determine human health risks. Because enterococci may be found in many extra-enteric secondary habitats, it is very important to understand the phylogeny of enterococci and the ecology of the group. Not understanding this and acting on enterococci concentration alone may often lead to erroneous decisions and unnecessary expenditures of limited resources that could be better utilized elsewhere. This is particularly relevant to the tropical environment of Hawaii, where favorable growth conditions exist year-round.

Animal fecal contamination of Waiopili Ditch could be a source of concern. DOH has turned to studies conducted by EPA on the health effects of recreation in waters impacted by agricultural animal fecal contamination using a technique known as Quantitative Microbial Risk Assessment (QMRA), where the risk of infection by microbial agents due to environmental pollution are defined as a statistical probability. Of particular interest to DOH was EPA's study on the effect of recreating in waters directly impacted by fecal contamination by agricultural animals. In the study, EPA has concluded that:

- The predicted median risk of illness from recreational exposure to the cattle-impacted waterbody is 25- to 150-times lower than the risk of illness associated with human sources of contamination;

- The predicted median risk of illness from recreational exposure to the pig-impacted waterbody is approximately 30-times lower than the risk of illness associated with human sources of contamination; and
- The predicted median risk of illness from recreational exposure to the chicken-impacted waterbody is approximately 20- to 5000-times lower than the risk of illness associated with human sources of contamination.

The DOH has concluded that the high bacteria levels are attributable to sources other than human sewage, since there are very few human sewage sources in Mahaulepu Valley. Feral and domesticated animals, decaying organic matter, avian wildlife, vegetation, soils, and insects are all believed to contribute to the enterococci loading of Waiopili Ditch. High enterococci levels have been found in the sediment of Waiopili Ditch. This enterococci-laden sediment is believed to act as a persistent reservoir for enterococci regrowth and distribution. The heavy canopy over portions of the ditch prevents sunlight (ultraviolet radiation) from penetrating the water and subsequently inactivating the bacteria in the water column and sediment. The turbidity of the water also prevents sunlight from inactivating bacteria in the surface layer of the sediment, and the particles that cause turbidity help to transport enterococci downstream. These appear to be the main reasons for the high enterococci levels in Waiopili Ditch, particularly, the lower end near the estuary.

Although DOH believes that Waiopili's high enterococci levels are mainly due to extra-enteric sources, additional testing using EPA-recommended tests was conducted to determine whether the possible sources of the FIB in Waiopili Ditch could be identified, including water from adjacent watersheds. These tests are highly advanced and just a few laboratories possess the required competency to perform them. Each test was contracted to a laboratory with specialized capabilities and equipment for that particular test.

This sanitary survey found that there are 120 injection wells in the adjacent Poipu/Koloa (Waikomo) watershed, most of which are for wastewater, some are for drainage and one is for industrial use. There are approximately 2,200 on-site disposal systems (OSDS) in the same adjacent watershed, about 1600 of which are cesspools. The geological and hydrological composition of the watershed indicate that these facilities may contribute to the high levels of enterococci detected in the Waiopili Ditch via the groundwater. Groundwater velocity under the proposed dairy is 1.2 feet per day. Most of Poipu/Koloa watershed has an average groundwater velocity of 10 feet per day with the rates increasing as it nears the ocean. This groundwater may carry wastewater contaminants from the Poipu/Koloa watershed which may impact the waters of the Mahaulepu watershed, including the Waiopili Ditch.

DOH is concerned that the large number of injection wells and cesspools in the adjacent Poipu/Koloa watershed may adversely impact the waters of the Waiopili Ditch. The hydrologic information obtained during the fact-finding and data review portions of this sanitary survey indicate that groundwater from the Poipu/Koloa watershed may impact the Mahaulepu watershed by carrying wastewater contaminants which may later be detectable in the Waiopili Ditch. A portion of the injection wells and cesspools in the Poipu/Koloa watershed are located very close to the ocean, further leading to concerns that the beach fronting the Mahaulepu watershed may also be adversely impacted by the adjacent watershed. The EPA-recommended tests used to evaluate the waters of Waiopili Ditch were also used to compare and evaluate waters of Waiopili and the Poipu/Koloa watershed to determine whether latter impacts or influences the former. Some of the tests are currently in progress and results will not be available in time for this report. This report will be amended when the final data becomes available.

Testing in Progress

Testing to determine whether wastewater from the adjacent watershed is impacting the Waiopili Ditch is currently underway. DOH/CWB and U.S. Geological Service, Pacific Islands Water Science Center staff collected water samples from selected sites in the Mahaulepu and Poipu/Koloa Watershed. Samples were collected for pharmaceutical and wastewater indicator compounds, nutrients, stable isotopes of hydrogen and oxygen in water, and stable isotopes of nitrogen and oxygen in nitrate. DOH has received preliminary data from USGS but does not expect to receive the final results until mid to late 2016.

EPA Region 9 has suggested that DOH/CWB look into the application of the University of California, Berkeley Laboratory's proprietary PhloChip as a microbial source tracking diagnostic tool. While current state of the art microbial source tracking uses qPCR for single organism identification of fecal contamination, the PhyloChip tracks thousands of high resolution source detections with statistical confidence. When sampling begins, 150 samples will be collected from both the Mahaulepu and Poipu/Koloa watersheds and analyzed by the Berkeley Laboratory. These results are not expected to be available until late 2016.

1.0. Background

The Department of Health (DOH), Clean Water Branch (CWB) received a complaint of high fecal indicator bacteria (enterococci) levels in Waiopili Ditch and was asked to post warning signs along the stream. Waiopili Ditch receives surface water flow from the Waita and Mahaulepu Reservoirs, intermittent flow from the Haupu Mountain range, and ground water from Mahaulepu Valley where the construction of a dairy is being proposed. CWB conducted additional water testing along Waiopili Ditch and found levels of enterococci that exceeded state water quality standards, as well as elevated levels of *Clostridium perfringens* (CP). Initial assessment of the area revealed no obvious human sources that could be attributable to the high indicator bacteria levels. There are no sewer lines, cesspools, or injection wells near the stream. A vacation beach rental (Gillin's House) is located approximately 200 yards east and somewhat down gradient from the sampling stations.

DOH also received complaints from people citing potential ground water contamination, cattle manure discharge into State waters, odor, flies, and improper location of the proposed Hawaii Dairy Farms LLC (HDF) dairy. There is a claim that HDF has already contaminated Waiopili Ditch, which is also in the same sub-watershed as the proposed farm. Currently, there are no dairy cattle on property. Several people have requested that HDF obtain a National Pollutant Discharge Elimination System (NPDES) permit and that the farm prepare an Environmental Impact Statement (EIS). An NPDES Permit is currently not a requirement for their proposed operation. However, HDF is presently working on a Voluntary EIS.

The fecal indicator bacteria currently used in Hawaii raises concern since the detection of high levels may not necessarily indicate recent contamination with human fecal material or sewage. The current fecal indicator has been shown to grow well in tropical environments even in the absence of human fecal contamination. Hawaii's economic and cultural dependence on water recreation makes accurate detection of sewage contamination essential and a balance should be struck between actual health risks and false-alarms. New and emerging technologies are being used in conjunction with traditional indicators to help assess the risk associated with recreating in waters with elevated levels of fecal indicators without a defined source of contamination. In addition to risk assessments, techniques are being used to trace the fecal indicator back to its source (animal or human fecal material) as well as technologies to help demonstrate a causal connection between the origin of the contamination and its point of detection (e.g., underground connections between sewage discharge sources and surface waters). In Hawaii, the Department of Health (DOH), Clean Water Branch (CWB) is tasked with

monitoring the ambient water for pollutants that threaten the existing and beneficial uses of the waterbody.

Human fecal contamination (sewage) has long been associated with diseases caused by pathogenic microorganisms. The direct detection of pathogenic microorganisms attributable to human fecal contamination has traditionally been complex, costly, and time consuming, given the large variety of potentially pathogenic microorganisms. In order to make monitoring of ambient water bodies more streamlined and cost effective, the US Environmental Protection Agency (EPA) has identified indicator bacteria that may be used to detect the presence of potentially pathogenic microorganisms found in human fecal matter. In developing these fecal indicators, EPA identified the following to be ideal criteria. The indicator organism should:

- be present whenever enteric pathogens are present, ideally in higher concentrations
- be of fecal origin (i.e., found in the intestines of warm blooded animals)
- be useful in all types of water
- survive in the water for a longer period of time than the hardiest enteric pathogen
- not multiply (grow) in the water
- be relatively easy to detect

Using these criteria, EPA has identified the bacteria *Escherichia coli* (*E. coli*) and the bacterial group Enterococcus, a sub group within the fecal streptococcus group, as the fecal indicator bacteria to be used in ambient water monitoring. None of the fecal indicators currently in use meet all of the criteria listed above; however, cost and efficiency has factored into the decision to use these indicators.

Since the 1960s, fecal indicator bacteria (FIB) have been used to identify the possible presence of human fecal contamination in Hawaii. Contact with contaminated water can lead to ear or skin infections, gastrointestinal ailments, and other more serious pathogenic infections. The pathogens responsible for these diseases can be bacteria, viruses, protozoans, or parasites that live in the gastrointestinal tract and are shed in the feces of warm-blooded animals.

In 1986, EPA published the *Ambient Water Quality Bacteria* guidance document that recommended use of enterococci for the detection of human fecal contamination in marine waters and the use of enterococci or *E. coli* for human fecal contamination in fresh water. DOH has selected enterococci for both marine and freshwater application. However, the use of enterococci as a FIB has resulted in numerous false positive results (elevated FIB concentrations in the absence of an identifiable human source) and a secondary test was needed. CWB with the assistance of the University of Hawaii, Water Resources Research Center (WRRC) developed the use of *Clostridium perfringens* (CP) as a secondary tracer bacteria. In 1994, EPA allowed the

DOH to use CP as a secondary tracer while maintaining enterococci as the primary FIB; CP would be used to supplement the enterococci results to determine further action by the CWB.

The Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000 amended the Clean Water Act and required each State having coastal recreational waters to adopt water quality criteria and standards for coastal recreational waters for those pathogens and pathogen indicators as published in EPA's Ambient Water Quality Criteria for Bacteria 1986. The BEACH Act also required EPA to conduct studies associated with pathogens and human health by October 2003 and to publish new or revised criteria for pathogens and pathogen indicators based on those studies by October 2005. EPA failed to meet these deadlines and was sued in 2006.

The search for new indicators of human fecal contamination has proven to be is a very difficult task; what may work well in temperate climates, may not work in the tropics. There is currently no single indicator that can satisfy all of EPA's criteria for an indicator organism. In 2007, EPA convened an Experts Workshop to obtain input on the type of research that would be needed to develop new criteria. As a result of this input, EPA published its 2012 Recreational Water Quality Criteria (RWQC) with recommendations for protecting human health in all coastal and non-coastal waters designated for primary contact recreation (the RWQC does not address secondary contact recreation). The 2012 RWQC also encourages the use of epidemiological studies, Quantitative Microbial Risk Assessments (QMRA), predictive modeling, new indicators and methods, including rapid molecular methods such as Quantitative Polymerase Chain Reaction (qPCR) and microbial source tracking. The use of enterococci and *E. coli* is still recommended as the FIB; however, the criteria now provides recommendations for the magnitude, duration, and frequency of exceedance of the FIB; no longer is just the detection of FIB an indicator of potential health risk. DOH has adopted the new criteria but continues to use CP as a secondary tracer in its tool box approach.

The use of enterococci and CP as indicators of human fecal pollution is still not a perfect solution because enterococci has been shown to replicate outside the human body and may be found in soil, plants, decaying organic matter, biofilm, sand, and are also shed by animals in their fecal matter. Attachment 1 shows the known habitats of several species of Enterococci, including animals that harbor the organism (they are not unique to humans), and Attachment 2 shows some of the known extra-enteric habitats of enterococci which may serve as reservoirs for these organisms in the environment. CP are also natural inhabitants of the intestinal tract and are also known to be shed by several animal species in their fecal matter (Fujioka, Byappanahalli 1996). Unlike enterococci however, CP does not replicate outside the animal host

but does possess the ability to form spores that are highly stable in the environment, a factor which is believed to contribute to its natural presence in soil and sediment. CP may remain detectable in soil and sediment long after the initial contamination.

Concern has been expressed about the possible fecal transmission of animal disease to humans via waterborne transmission (specifically dairy cattle). At present, the only animals in the Mahaulepu Valley Sub-Watershed (MVSW) are: approximately 85 sheep at Haraguchi's Taro Farm, about 5 sheep at the Makauwahi Cave Reserve (MCR) field, roughly a dozen land tortoises at the MCR native plant project, a healthy population of feral pigs, some feral cats, feral dogs, and beef cattle that are rotated in and out of the slopes of Haupu Mountain Range for forage. The animal density is similar to numerous other agricultural watersheds throughout the State.

Concern has also been expressed about potential ground water contamination at the site. Currently, there are just a few potential ground water contamination sources in the MVSW. Possible ground water contamination sources of MVSW are: two taro fields, a limestone quarry, a banana farm, and a seed farm. In the parent Mahaulepu Watershed (MW), there are structures adjacent to the old Koloa Mill (used by several businesses), and located in the southern portion of the watershed is a rodeo/horse riding stable operation, a green waste facility, a beach rental, and several resort related drainage and waste water wells.

2.0. Introduction

This section describes the major tasks, objectives, and conduct of the study and report organization. This sanitary survey focuses on what is currently occurring in the MVSW, MW, and adjacent watersheds. There is much concern that there may be contamination of the MVSW, its groundwater, Waiopili Ditch, and the nearby coastal waters.

The format of this sanitary survey follows the document *Sanitary Surveys in Hawaii: A Framework*, developed by Tetra Tech, Inc., for the US EPA Region IX and the Hawaii Department of Health in 2003 (revised in 2004). The document may be found at: http://health.hawaii.gov/cwb/site-map/clean-water-branch-home-page/water-quality-references/.

2.1. Sanitary Survey Requirements

This sanitary survey requires that DOH CWB staff investigate all possible sources in the MW and adjacent watersheds that may contribute to high FIB levels in the Waiopili Ditch. The following are the tasks that were carried out by CWB for this study:

- Collect, review, and verify all available information on the MW;
- Define and characterize the watershed with respect to geographical location, physical features, topography, geology, soil types, vegetation, hydrology, land use and ownership;
- Identify and characterize natural and human activities within the watershed that affect bacterial water quality;
- Identify all significant or potentially significant sources, quantities and causes of microbial contamination within the watershed that can affect water quality;
- Conduct a detailed QA/QC review of available microbiological water quality data;
- Review past and present land and water management practices applied in the watershed and identify best management practices (BMP) which are implementable;
- Examine adjacent watersheds to determine if there are any other factors that may contribute to high levels of FIB and other contaminants in the MW.

2.2. Objectives

The objectives of this sanitary survey are to determine the source of high fecal indicator bacteria (FIB) levels in Waiopili Ditch, review existing data, gather background water quality data in the MVSW, examine sources of contamination in adjacent watersheds that may impact

the MVSW , and discuss potential surface water impact from animal and bird sources. Where applicable, issues with the proposed HDF will be discussed.

2.3. Conduct of the Study

This sanitary survey of the MW, Waiopili Ditch, and adjacent watersheds was conducted by the CWB staff of the DOH. Officials from Mahaulepu Farm LLC (the land owner) and HDF provided the CWB staff access to the property for assessment and sampling of Mahaulepu Valley Sub Watershed (MVSW). Most samples collected were split with HDF for analysis by their contracted laboratory. CWB bacteria samples were sent to the DOH Kauai lab for analysis. Four-wheel drive vehicles were used to access the sites and surveys were done on foot. Twelve sites were established in the MVSW. At times, additional samples were collected between established sites to provide additional information.

The DOH Safe Drinking Water (SDWB) and the DOH Waste Water Branch (WWB) contributed data and information for this report. Numerous maps and figures were supplied by SDWB.

CWB staff met with HDF and Mahaulepu Farm LLC to gather documents, land use information, and to obtain access to the MW. In addition, information was obtained from: US Department of Agriculture; AQUA Engineering; the National Parks Service; the Kauai Board of Water Supply; the Kauai County Planning Department, the State Land Use Commission, and the Garden Island Newspaper.

Sampling methodologies were prepared by the CWB in collaboration with the U.S. Geological Survey, Pacific Islands Water Science Center; the University of Hawaii Water Resources Research Center; and Stanford University.

A literature review was conducted which included a review of available studies and reports, land use commission documents, and books on Grove Farm, Koloa and Mahaulepu. The major studies, reports, and documents that were reviewed are provided in the list of References at the end of this document.

2.4 Sanitary Survey Methods

Methods for this sanitary survey included: meetings with Mahaulepu Farm LLC (landowner), HDF, community members, Makauwahi Cave Reserve staff, and elected officials. Meetings within DOH were conducted with the Safe Drinking Water Branch, the Wastewater Branch, the State Laboratories Division-Microbiology, and the Environmental Planning Office. Discussions with DOH State Epidemiologist also continued throughout the sanitary survey process. CWB

reviewed aerial and historic photos of the area and Google Earth was utilized extensively for recent activity within the watershed and surrounding areas. Various reports, publications, books, and government documents were reviewed and personal interviews and telephone conversations with past Koloa Plantation employees were conducted. Evidence of wildlife activity, including diggings, tracks, remains, and fecal matter was noted while sampling and during site assessments.

2.5. Report Organization

This report contains seven major sections, and is organized in the following manner:

- Section 1 Background: information on the issues related to using bacteria as indicators of potential human fecal contamination and the need for a better tool to assess impairment.
- Section 2 Introduction: objectives, scope, conduct and limitations of the study.
- Section 3 Land Use and Natural Setting: includes a discussion of the geography, hydrology, geology, soils, vegetation, land use and ownership within the boundaries of the watershed.
- Section 4 Potential Contaminant Sources in the Watershed: includes identification of watershed activities detrimental to water quality and a description and review of potential contaminant sources in the watershed.
- Section 5 Watershed Control and Management Practices: provides a review and evaluation of existing management practices, discussion of best watershed management practices and a summary of recommended short- term and long-term management plans.
- Section 6 Water Quality: assessment of bacterial contaminant concentrations in surficial waters of the MVSW and a discussion of how they compare to relevant water quality criteria.
- Section 7 Conclusions: provides a discussion of the key conclusions drawn from the sanitary survey.
- Section 8 References

2.6. Limitations of this Study

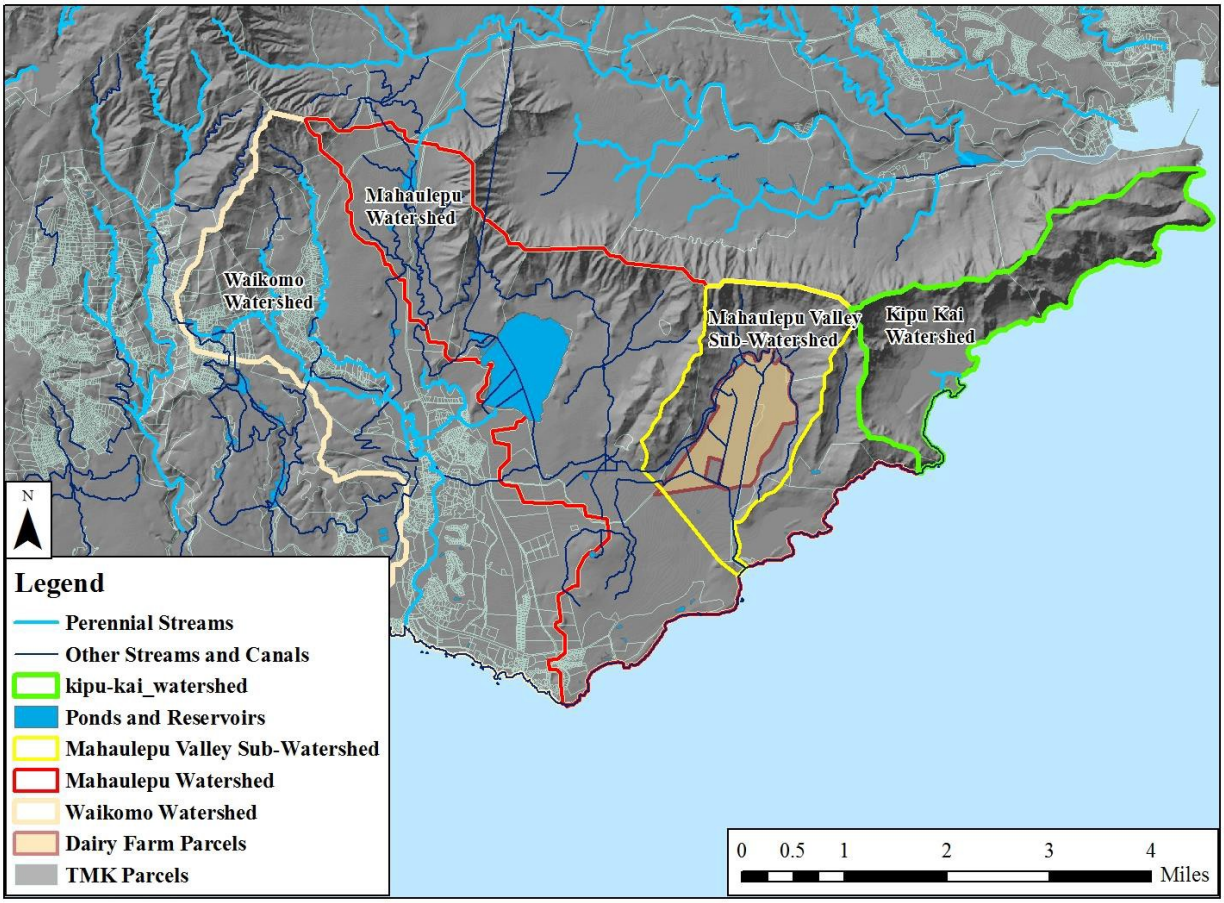
In regards to the injection wells and OSDS in the PKW, CWB will identify the sources, provide location, and amount of discharge information. Quality of the discharge, and negative impacts to endangered species in not part of this sanitary survey. However, DOH will review discharge quality and follow up with U.S. Fish and Wildlife Service with the endangered species after completion of this Sanitary Survey.

3.0. Land Use and Natural Setting

This section describes the physical and ecological environment of MW with emphasis placed on environmental aspects that could affect the water quality with respect to bacterial contamination and its potential risk to public health. Figure 1 shows the Mahaulepu and adjacent watersheds. The MW is highlighted in red and the MVSW, a small non-descript area and the area of concern, is highlighted in yellow. To the west of MW is the Poipu/Koloa watershed (PKW) (highlighted in beige) and to the East is the Kipu Kai watershed highlighted in green. Attachment 4 shows the Koloa-Poipu-Kalaheo Planning District Land Use Designation Map showing the designated land use for the MW and adjacent watersheds. Attachment 4 shows that the MW is mainly used for agriculture whereas the adjacent PKW is designated for resort, residential as well as agricultural uses. Attachment 5 shows several points of interest in the Mahaulepu and adjacent watersheds.

State Geographical Information System (GIS) refers to the watershed west of MW as "Waikomo" watershed. For the sake of familiarity, we will refer to Waikomo watershed as "Poipu/Koloa" watershed (PKW) in this sanitary survey.

Figure 1. Mahaulepu and Adjacent Watersheds



Source: DOH, SDWB 2015

In the adjacent, highly urbanized Poipu/Koloa Watershed (PKW), there are about 120 injection wells (waste water, drainage, and industrial), and about 2,200 on site disposal systems (OSDS), of which about 1,600 are cesspools. Complicating the situation is a known karst/pseudo-karst lava tube system in Koloa (Koloa lava tubes) that possibly could be connected to the karst Makauwahi Cave/Sinkhole adjacent to the Waiopili Ditch in the MVSW. The Koloa Lava tubes and the Makauwahi Cave/Sinkhole are known habitats of two endangered insect species found nowhere else in the world.

To the east of MW is the Kipu Kai Watershed (KKW), a privately owned watershed used primarily as a cattle ranch in past. Kipu Kai, is a 1,117-acre coastal valley owned by the long-time heirs of Jack Waterhouse, and is legally slated to be turned over to the state as a wilderness park upon their passing. Its scenic setting has served as a movie location, and until 2006, a cattle ranch. Today resident caretakers live on site, and the Waterhouse family and friends vacation in the old Waterhouse home.

Aerial views of the area of interest in the MW are shown in Figure 2. The path that Waiopili Ditch takes from the area of the proposed dairy farm (upper middle portion of the image) to the ocean can clearly be seen by the green vegetation growing along its banks. The Makauwahi Cave/Sinkhole can be seen towards the bottom of the image near the densely canopied terminus of the Waiopili Ditch. Additional aerial photos of the area are shown in Attachment 6.

Figure 2. Aerial View of Mahaulepu



Source: Kauai County Planning Department, 2015

3.1. Watershed

The MW is located on the southeast portion of Kauai, the oldest and western most of the main Hawaiian Islands. Figure 4 (inset) shows the location of the study area relative to the island of Kauai. The Haupu mountain range forms the northern boundary with ridges coming off the mountain range forming sub-watersheds. One of these sub-watersheds, Mahaulepu Valley Sub-Watershed (MVSW) is the focus of this report. MVSW is formed by a ridge coming off of Mount Haupu (Figure 3), the highest point of Haupu Mountain Range and another ridge to the west. The U shape valley floor is gridded with irrigation ditches that were used to irrigate sugar cane that was grown in the past. There are no perennial streams inside the MVSW. MW has perennial streams but only in the far northwest portion outside the MVSW.

Figure 3. Mount Haupu



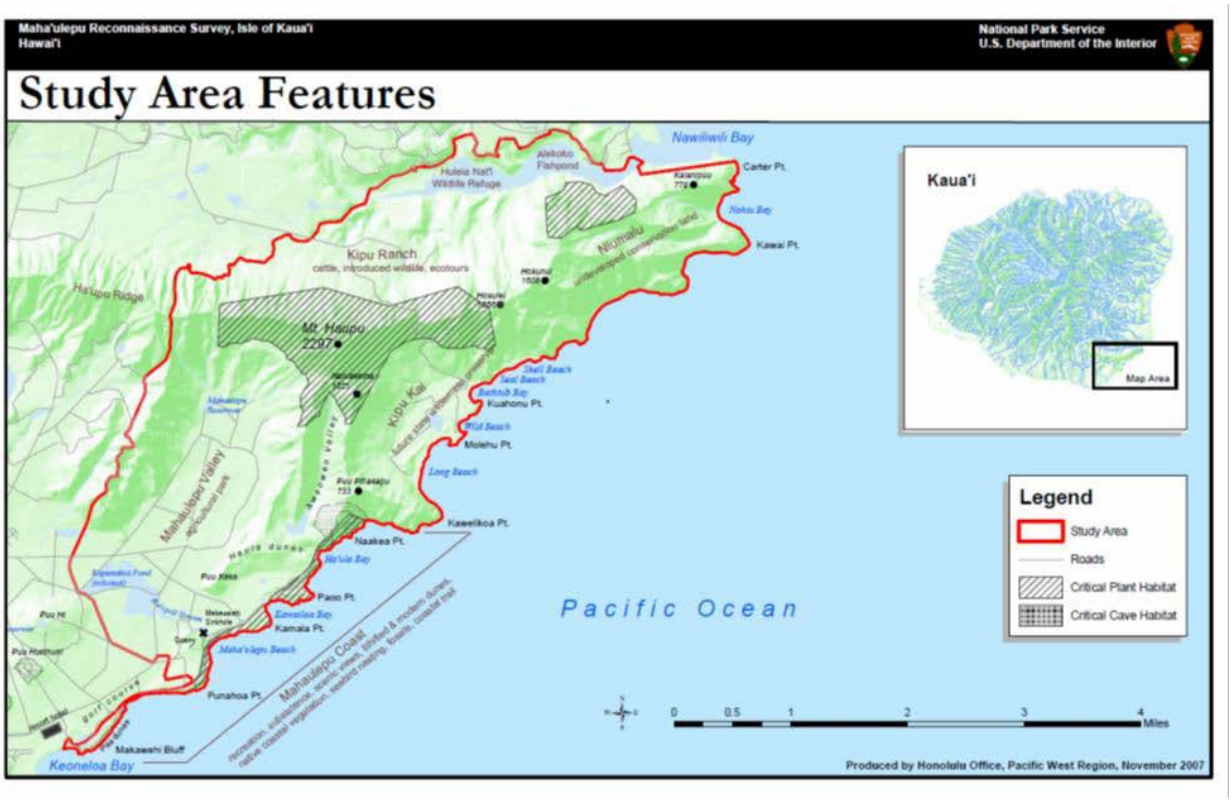
Source: DOH, CWB 2014

The southeast border of the MW has significant natural, historical, and cultural resources (Figure 4). At the request of Senator Daniel K. Inouye, in 2006 the National Park Service agreed to conduct a reconnaissance survey of Mahaulepu and nearby areas on the island of Kauai, as background material for Senator Inouye as he considered whether to seek Congressional authorization for a full-fledged study of resource protection alternatives for Mahaulepu and surrounding areas. Critical plant and cave habitats were identified, as were a historical battle

ground, the Makauwahi Sink Hole, and a relictual representation of Kapunakea Pond and the flow path of Waiopili Ditch. See: http://www.nps.gov/pwr/upload/mahaulepu_final.pdf
The Mahaulepu and Kipu Kai shorelines have long served as secluded recreational areas for local residents. While access to Kipu Kai is restricted, the Mahaulepu shoreline can be accessed by way of a pot-holed crushed coral road. Lately a growing tourist presence has added to the mix; over one-third of the petition-signers in a community initiative to protect Mahaulepu's shoreline resources identified themselves as visitors to the island (NPS 2008).

The Mahaulepu shoreline is also accessible at its south end via a footpath leading from Keoneloa Bay and the Hyatt hotel, past the Pokia Bay Golf Course and along the Makawehi/Paa dunes. Businesses and community groups jointly prepared an interpretive guide for this trail and sponsor occasional guided walks from the hotel to Punahoa Point. However, there are no public restrooms in the area.

Figure 4. National Park Service Survey



Source: U.S Department of the Interior, National Park Service 2008

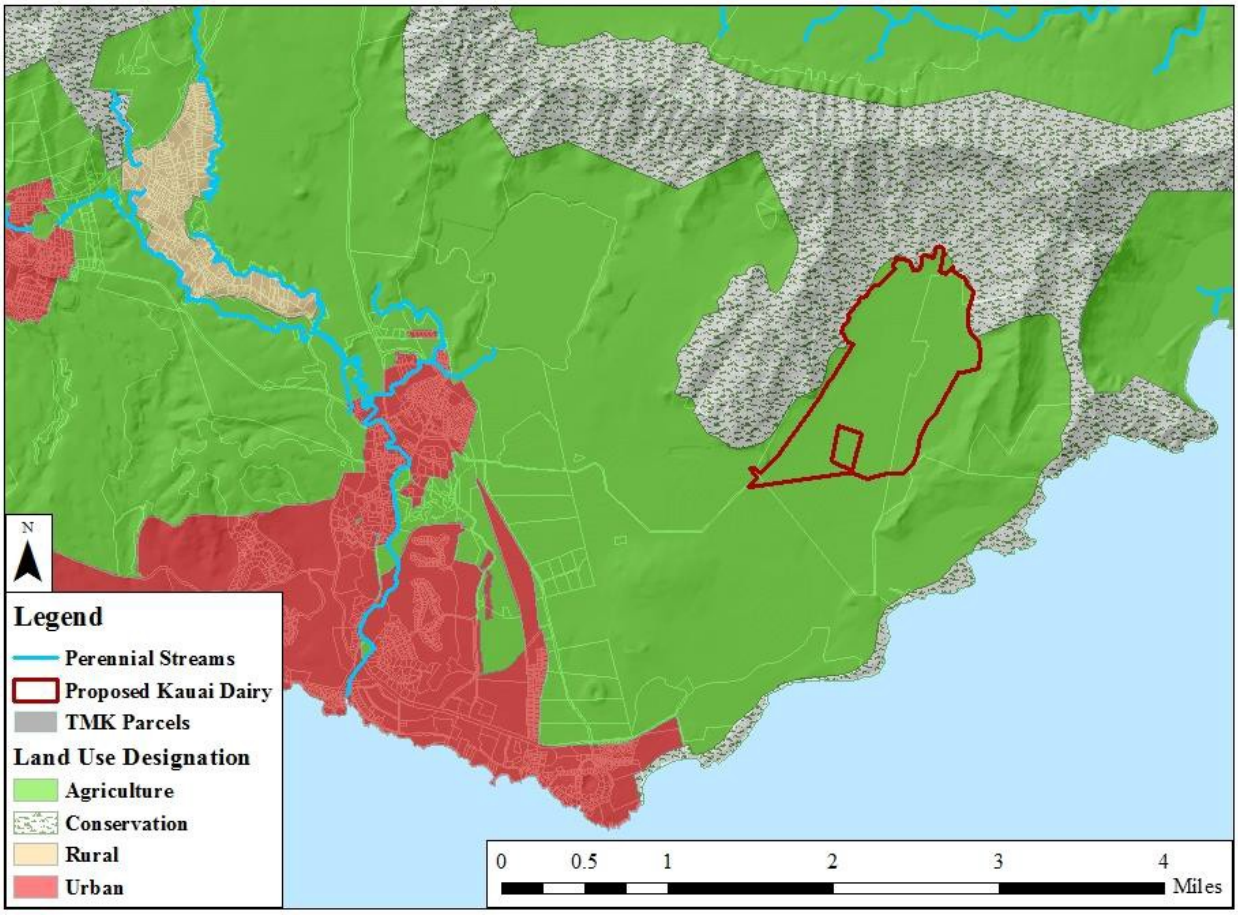
In February 2008, the National Park Service, Pacific Region completed Mahaulepu, Island of Kauai, *Reconnaissance Survey.* Based on the survey evaluations, the National Park Service, Pacific West Region recommended that a Special Resource Study be authorized under the

stipulations of Public Law 105-391, so long as it focuses on non-traditional management alternatives that: a) involve local partners and b) include options for continued farm and ranch operations on private agricultural lands (NPS 2008).

3.1.1. Land Use

The State Land Use Law Chapter 205, Hawaii Revised Statutes, establishes a framework of land use management and regulation in which all lands are classified into one of four land use districts: Conservation, Agricultural, Rural and Urban. Counties establish more detailed designations and zonings, but these conform to the range of allowable uses under each designation by the state. Figure 5 shows the land Use designations for south central Kauai, which includes both the MW and the PKW and shows that the PKW is much more urbanized than the MW, which is mainly zoned for agricultural use with some areas zoned for conservation.

Figure 5. Land Use Designations for South-Central Kauai



Source: DOH, SDWB, based on the DBEDT GIS Layer, 2014

In Hawaii, conservation lands are further designated into subzones according to environmental sensitivity; all subzones place strong limits on use, and most uses must be approved by a permit from the state's Board of Land and Natural Resources. Most of the conservation lands in the survey area fall into the two most restrictive subzones.

Mahaulepu Farm LLC owns most of MVSW. All of the land in the MVSW is designated and zoned for either agriculture or conservation, and except for a few farm structures, it remains undeveloped. The conservation lands are found in a narrow strip along the Mahaulepu coast and across most of Haupu ridge (Figure 5). Broad agricultural lands occur on both sides of the Haupu range and at Kipu Kai to the east. The proposed Hawaii Dairy Farm LLC (HDF) will be situated in an area designated as important agricultural lands in the Mahaulepu Valley (see section 3.1.2).

Grove Farm, one of the largest landowners in the state, was founded in 1864 by George N. Wilcox, who developed the area as one of the first sugar plantations in Hawaii. During the late 20th century focus began shifting towards real estate development and in 1988, the Land Use Commission approved a special use permit for the development of the Poipu Bay Golf Course on agriculture-zoned lands along the southwest boundary of the MW. Sugar production in the MW ended in the 1990s.

In 2000, the Wilcox family sold Grove Farm to Steve Case of America Online, and in January 2011, land within the MW, including the entire land area encompassing the MVSW, was sold to Mahaulepu Farm LLC. Today the corporation is involved in major residential and commercial developments in Lihue. In recent years it has leased portions of its MW land for various individual and business purposes, including farming, pasturage, a commercial stable, a sand quarry, a green waste facility, a nonprofit research and restoration project at Makauwahi Cave, and most recently, Hawaii Dairy Farms, LLC. Mahaulepu Farm LLC allows daytime vehicle access through lower MW by way of a rutted dirt road that parallels the shoreline. This beach access is used by both residents and visitors but there are no public restrooms in the area. The road is closed at 6 pm every night, any cars on the property are towed away (Figure 6 Mahaulepu Farm Postings).

Figure 6. Mahaulepu Farm Postings



Source: DOH, CWB 2015

Residents and commercial tour operators approach this scenic hideaway by boat to play, fish and gather *limu* (edible seaweed) in the nearshore waters; foot traffic is not allowed above the high water mark. It is unclear how the family will sustain the land in the near term under a growing tax burden, and details remain unsettled as to how the State will protect Kipu Kai's resources in the long term (NPS 2008).

The 1,476 acre Kipu Ranch, north of MVSW, was purchased by William Hyde Rice in 1881 and has remained in the Rice family, operated first as sugar plantation and then as cattle ranch. The Kipu property ascends from Huleia to the Haupu ridge above Kipu Kai and Mahaulepu, and is zoned for agriculture except on upper portions of the ridge, which is designated as conservation. Uses of the land today include not only cattle ranching, but also ecotourism. Tour operators offer kayak and hiking trips that begin at Huleia and then venture inland to Kipu's pastures and forested slopes. The ranch is home to a variety of non-native wildlife

introduced by the Rice family. An ATV operation on site provides guided adventures throughout the Kipu property.

Lands to the west and south of MVSW are, for the most part, owned by Mahaulepu Farm, except for the southwest corner of the MW that is a privately owned mix of golf course and resort lodgings. The rest of the MW is a mix of farms, cattle ranches, a solar farm, a beach rental, and the old Koloa Sugar Mill.

3.1.2. Land Use Commission, Important Agricultural Lands

On February 23, 2011, Mahaulepu Farm LLC petitioned the Land Use Commission (LUC) to designate 1,533 acres at Mahaulepu as Important Agricultural Lands (IAL) (see section 5.3.). On May 19, 2011, the LUC approved the petition and designated all 1,533 acres as Important Agricultural Lands (IAL). Mahaulepu Farm LLC is the third entity in the State to seek voluntary IAL designation and receive approval (LUC Feb 2011, May 2011). Mahaulepu Farm LLC waived the 85/15 reclassification Incentive that would have allowed 15 percent of land for other use, such as rural or urban development. HDF is part of the 1,533 acres designated as IAL. For more information on IAL see:
http://hipaonline.com/images/uploads/Important_Ag_Lands_Overview_July_2010.pdf

In November 2012, Mahaulepu Farm LLC and its affiliate, Haupu Land Company, petitioned the LUC to designate an additional 11,026 acres of their land as IAL; approximately 760 acres of which surround the Waita Reservoir, which lies within the MW. The petition was approved by the LUC in February 2013 (http://luc.hawaii.gov/wp-content/uploads/2012/09/DR12-48-GROVE-FARM-COMPANY-INC-FOF-COL-DO.pdf). Again, Mahaulepu Farm LLC declined the 15% Reclassification Incentive and kept the entire 11,026 acres in IAL.

3.1.3. Past Land Use

In 1875, Koloa Plantation began growing 875 acres of sugar cane in Mahaulepu Valley. In 1897, Koloa Plantation dug wells to better provide water for their sugar cane, as rainfall was insufficient for growing sugar cane.

In 1948, Grove Farm Company, Inc. purchased Koloa Plantation. After nearly a century of independent sugar production, Grove Farm ceased sugar cultivation in 1974 and leased its Koloa lands and Koloa Mill, to McBryde Sugar Company. From 1974 until 1996, McBryde Sugar Company continued sugar production and in September 1996, McBryde Sugar Company harvested their last crop and the Koloa Mill closed. The mill area is currently used by several small businesses.

On September 21, 1998 the Mahaulepu quarrying operation of Grove Farm Rock Company was transferred to Jas. W. Glover, Ltd. The Land Use Commission acknowledged this transfer in a letter to Grove Farm Rock Company dated October 20, 1998. The quarry was located near the Makauwehi Cave/sinkhole and began operations sometime in the mid-1950s.
See: http://luc.hawaii.gov/wp-content/uploads/2014/03/SP92-382-Annual-Report-2011.pdf

According to Grove Farm lease records, a portion of MW was leased to William Ludington for cattle ranching. In 2002, CJM Country Stables and David and Moana Palama began their cattle operation. Sometime after that, cattle operations stopped in the plains and valley of MW but continued on the slopes and high meadows of the Haupu mountain range. The cattle are rotated in and out depending on the amount of forage available.

In 2003, Aqua Engineers, Inc. leased 45 acres from Grove Farm. Aqua Engineers, Inc. provides water and wastewater services on Kauai and were applying sludge from various sewage treatment plants to grow forage crop to be harvested for animal feed. Sludge from the Lihue-Puhi, Princeville, Poipu Water, and Popiu Kai treatment plants were applied to the Mahaulepu lands. In January 2011, the land within the MVSW was sold to Mahaulepu Farm LLC, and in December of 2013, sludge delivery from the Lihue-Puhi, Princeville, and Poipu Water WWTP was stopped. In September 2014, Poipu Kai Resort WWTP stopped its sludge delivery. Today, sludge is no longer applied to the area.

In early 2015, a free ranging chicken and duck operation makai of Haraguchi's taro farm moved out of Mahaulepu taking along a donkey and several dogs.

3.1.4. Current Land Use

Gillin's House, a three bedroom, two bath vacation rental is located about 200 yards east of where Waiopili Ditch enters the ocean. The rental accommodates a maximum of six and has its own septic system as well as its own private water system.

To protect the unique and valuable resource of the Makauwahi Cave/Sinkhole and to make the resource available for research, Mahaulepu Farm LLC leased 17 acres of land surrounding the site to the nonprofit Makauwahi Cave Reserve. In 1992, research began at the site and in 1996 they received their first federal funding. The cave site is probably the most important pre-Hawaiian archaeological site in the entire Pacific region. The reserve also includes a taro patch with sheep and a fenced native plant restoration site with roughly 25 land tortoises.
See: http://www.cavereserve.org/resources.php

Although CJM Country Stables no longer have cattle leases at Mahaulepu, they still operate a rodeo facility and horseback riding services located east of the Poipu Kai Golf Course. The trail ride crosses Waiopili Ditch near its estuary, heads inland past the Makauwahi Cave Reserve, along the Haula Dunes and back along the shoreline. See: http://www.youtube.com/watch?v=SwJMcTLpmdo

On March 19, 1993, the Land Use Commission approved a Special Permit to establish a limestone and basalt quarrying operation northeast of the old Mahaulepu Quarry. The quarry continues to operate today. See: http://luc.hawaii.gov/wp-content/uploads/2014/03/SP92-382_Grove-Farm-Rock-_Co_DO_3-19-93.pdf

In 2007, W. T. Haraguchi signed a 20 year lease to grow taro in Mahaulepu Valley, which continues today. Sheep were added to the taro farm to control the guinea grass and weeds. In March 2010, the DOH issued a Solid Waste Management Permit to Dennis Esaki for a green waste facility northwest of the former Aqua Engineers sludge/forage project. The facility may only accept and process up to 3,000 tons per year of clean, source-separated green waste. A banana farm is located to the west of the Haraguchi taro patch on the slopes of Ka Lae o Kahonu Ridge. Pioneer Parent Seed and Pioneer Research & Development began growing seed corn in 1996 at Mahaulepu. Their lease runs through 2019 and the tenants have plans to expand the leased area up to 805 acres to grow future bio-energy crops and to expand their corn field.

In 2014, Hawaii Dairy Farms began installation of an overhead irrigation system, drilled water quality monitoring wells, and began planting kikuyu grass on their leased land. No grading or grubbing of the land has taken place, no buildings are being constructed, and no dairy cattle have been brought to MVSW. The only disturbance to the ground has been for the drilling of water quality monitoring wells, the installation of the overhead irrigation system, and field plowing to grow Kikuyu grass.

3.2. Natural Setting

MVSW lies in the leeward portion of the Haupu Mountain Range and receives from 44.13 to 49.95 inches of rainfall per year (Giambelluca 2013). Average temperatures range from 72-86 ^{o}F in the hottest months and 64-80 ^{o}F in the cooler months of January and February (WRRC 2007). Wetter and cooler conditions prevail north of the Haupu ridge, where moisture-laden northeast trade winds are slowed by the nearly 3000 foot Mount Haupu before sweeping over and around to Mahaulepu. The upper half of the watershed receives 400-450 cal/sq.cm/day of solar

radiation, while the lower half receives 450-500 cal/sq/cm/day. As a comparison, Hanalei, on the northern side of the island receives 350- 400 cal/sq.cm/day. See: http://files.hawaii.gov/dbedt/op/gis/maps/solrad_kauai.pdf.

Along the coast the trade winds run roughly parallel to the shore, shaping the dunes from Kipu Kai to Makawehi Bluff (NPS 2008).

3.3. Existing Hydrological Resources

Sugar production in the Koloa area began in 1837. In 1869, in response to a major drought, Koloa Plantation dug what was to become the Wilcox Ditch. In 1875, Koloa Plantations began growing roughly 875 acres of sugar cane in Mahaulepu Valley. The ditch was extended in 1885 and irrigated an additional 200 acres. In 1893, the ditch was again extended to irrigate another 400 acres. The ditch eventually reached approximately five miles long with a capacity of eight million gallons per day (mgd) and an average daily flow of about four mgd. In 1897, Koloa Plantation dug wells to better provide water for their sugar crop.

Constrained by a lack of surface and ground water sources, Koloa Plantation concentrated on developing water storage. Between 1903 and 1906, the Waita Reservoir was constructed and is the largest reservoir in the State. The water source for Waita was initially supplied by Wilcox Ditch. The initial storage capacity was 1.47 billion gallons of water and in 1908, the reservoir dam and spillway were raised increasing the capacity to 2.1 billion gallons. However, it became evident that the Wilcox Ditch was inadequate to keep Waita supplied.

In 1914, an agreement was reached between Koloa Sugar Company, Lihue Plantation, and George Wilcox (Grove Farm) whereby Lihue Plantation would build the Waiahi-Kuia aqueduct also known as Koloa Ditch. In 1915, the ditch was completed, and at approximately five miles long, used a combination of tunnels, flumes, and ditches to carry approximately 65 mgd of water from the Waiahi and Kuia areas to the Wilcox Ditch, and then to the Waita Reservoir.

In 1926, Lihue Plantation enlarged the capacity of the Koloa Ditch to 90 mgd to better capture floodwaters. In 1931, the Waita Reservoir dam and spillway were raised an additional three feet and increased the capacity to 2.3 billion gallons.

Currently the Waita Reservoir is the main water source for the Important Agricultural Lands (IAL) of Mahaulepu. The 415 acre reservoir with its 2.3 billion gallon capacity supplies the Mahaulepu Farm-owned Puuhi and Mahaulepu Reservoirs within the IAL. The combined capacity of the Puuhi and Mahaulepu Reservoirs is about 2.5 million gallons. The gravity flow

system from Waita is capable of supplying 7.9 mgd to the IAL. (LUC 2011). The Waita Reservoir is currently fed by Kuia Stream through the Kuia-Waita Tunnel and Waihohonu Stream (LUC 2013).

MVSW is laced with irrigation ditches, wells, and a few ground water springs that in the past supplied water to the sugar cane fields. A majority of the irrigation ditches still flow today, especially during the wet season where intermittent flow from the Haupu Mountain range supplement the irrigation ditches. However, the main source of water for MVSW remains to be the Waita Reservoir. The irrigation ditches converge on Warner Dam shown in Figure 7, named after Ernie Warner, Cultivation Superintendent of Grove Farm. The purpose of the dam was to provide water to agricultural lands to the southwest and southeast of the dam. After sugar cane cultivation ended, the dam's gates were left in the open position allowing water to flow downstream where it ultimately enters the ocean. (Killerman per com 2015).

Figure 7. Warner Dam (Site #11c, just over weir)



Source: DOH, CWB 2015

The former Kapunakea Pond and the Waiopili Ditch are shown to be northwest and north respectively of the Makauwahi Sinkhole (NPS 2008). However, a historic map and an old photo of Kapunakea Pond and Waiopili Spring taken between 1890-1920 (Attachment 7) shows that

Kapunakea Pond went right up to and possibly past the north entrance to the Makauwahi Cave (Burney 2010).

Burney believes that pond water flowed in and out of the north cave entrance due to the presence of mullet bones found in the cave. The present ground level fronting the cave is about three feet higher than in the past, based on his excavation work (Burney per com 2015).

Elbert Gillin, a Grove Farm engineer, lived for decades with his wife, Adena in the one house along the Mahaulepu coast (currently a beach rental). In addition to his monumental work creating some of Kauai's water tunnels through the mountains, Mr. Gillin also drained the large brackish Kapunakea pond which stood outside the Makauwahi Cave and extended up into the area that was quarried for limestone. He cut a ditch to the ocean in the early 1950s. The pond was largely drained off and the Waiopili Spring near the adjacent limestone quarry then fed into a small dredged channel. Just upstream from the cave, this channel joined a larger ditch that straightened a former stream channel draining the cane fields in the central part of the Mahaulepu Valley. Today, these freshwater sources pass by the entrance to the north cave (entrance to sink hole) through a narrow man-made ditch, then on out to the ocean west of the Gillin House (Burney 2010) (Figures 8 and 9). This man-made ditch was known by various names: Waiopili Stream, Kapunakea Pond, and Mill Ditch (Burney, Kikuchi 2006).

Figure 8. Waiopili Ditch (heavy canopy at cave entrance)



Source: DOH, CWB 2014

The 1983 edition of the Koloa, Hawaii, U.S. Geological Survey Map clearly shows Waita Reservoir Ditch servicing Puuhi and Mahaulepu Reservoirs, going past Ka Lae o Kahonu Ridge to the head of Mahaulepu Valley and flowing south along the ridge from Mount Haupu to the present Mahaulepu Quarry site. The map also shows the Mill Ditch, Waiopili Heiau, Spring, Quarry, and remnants of Kapunakea Pond. It does not show the Makauwahi Cave/sinkhole, however, other earlier and later maps do.

Figure 9. North Cave Entrance (note cave entrance is gated)



Source: DOH, CWB 2015

In his book "The Story of Koloa", Donald Donohugh calls the irrigation channel draining Mahaulepu Valley, the Mahaulepu Drain and his 1935 Koloa Plantation Map shows the Mahaulepu Drain and a spring pump at the western end of Kapunakea Pond. This spring is probably Waiopili Spring and what we now call Waiopili Ditch is a man-made drainage ditch flowing through the MVSW and eventually to the ocean. Figure 10 shows the path of the Waiopili Ditch (Stream) through the MVSW.

Figure 10. Current Map Showing the Waiopili Ditch



The 1912 U.S. Geological Survey map (Figure 11) shows an irrigation grid in Mahaulepu Valley, the alignment of Mahaulepu Drain through Mahaulepu Valley, Kapunakea Pond and to the ocean. Kapunakea Pond is clearly shown in the 1912 map but Kapunakea Pond no longer exists today. Gillin's House is located approximately where the estuary was located on the 1912 map.

Figure 11. 1912 U.S. Geological Survey Map



The location of the once present Kapunakea Pond is shown on the lower left

4.0. Potential Contaminant Sources

There are no sewer lines, septic systems, cesspools, or injection wells within the MVSW. Potential sources of contamination within the MVSW include: feral animals, beef cattle on the Haupu slope and ridges, day visitors to Mahaulepu Beach (no public restrooms), and unauthorized activities.

In the parent MW, there are several on site disposal systems (OSDS) scattered in the watershed, a private Waste Water Treatment Plant (WWTP), and drainage and wastewater injections wells located in the southeast extremity. A vacation rental east of Waiopili Ditch has its own OSDS. A green waste facility owned by Dennis Esaki is located northwest of the Aqua Engineers fields where, at one time, WWTP sludge was applied to grow forage for cattle. That practice has ended in September 2014.

Combined, there are approximately 2,200 OSDS in the MW and the adjacent PKW, most of which are cesspools, and 120 recorded injection wells for wastewater, urban storm water drainage, and industrial waste (Figure 12). The Koloa karst topography and lava tube system that straddles both the PKW and the WW may provide subterranean transport of injection well and cesspool effluent from the PKW to the Makauwahi Cave/sinkhole lava tube system in the MW.

Hawaii Dairy Farms LLC has installed an overhead irrigation system, drilled water quality monitoring wells, planted Kikuyu grass for pasture, and is preparing a Voluntary EIS. There are no dairy cattle in MVSW at the present time.

4.1. Wastewater

All wastewater treatment facilities and OSDS in the PKW and MW are privately owned and all are discharged into the ground by way of injection wells, leech fields, and/or cesspools. There is no known surface water discharge. Most injection wells are for sewage wastewater, followed by storm water drainage wells, and two dry cleaning/laundry industrial wells.

4.2. Wastewater Discharges and Collection Systems

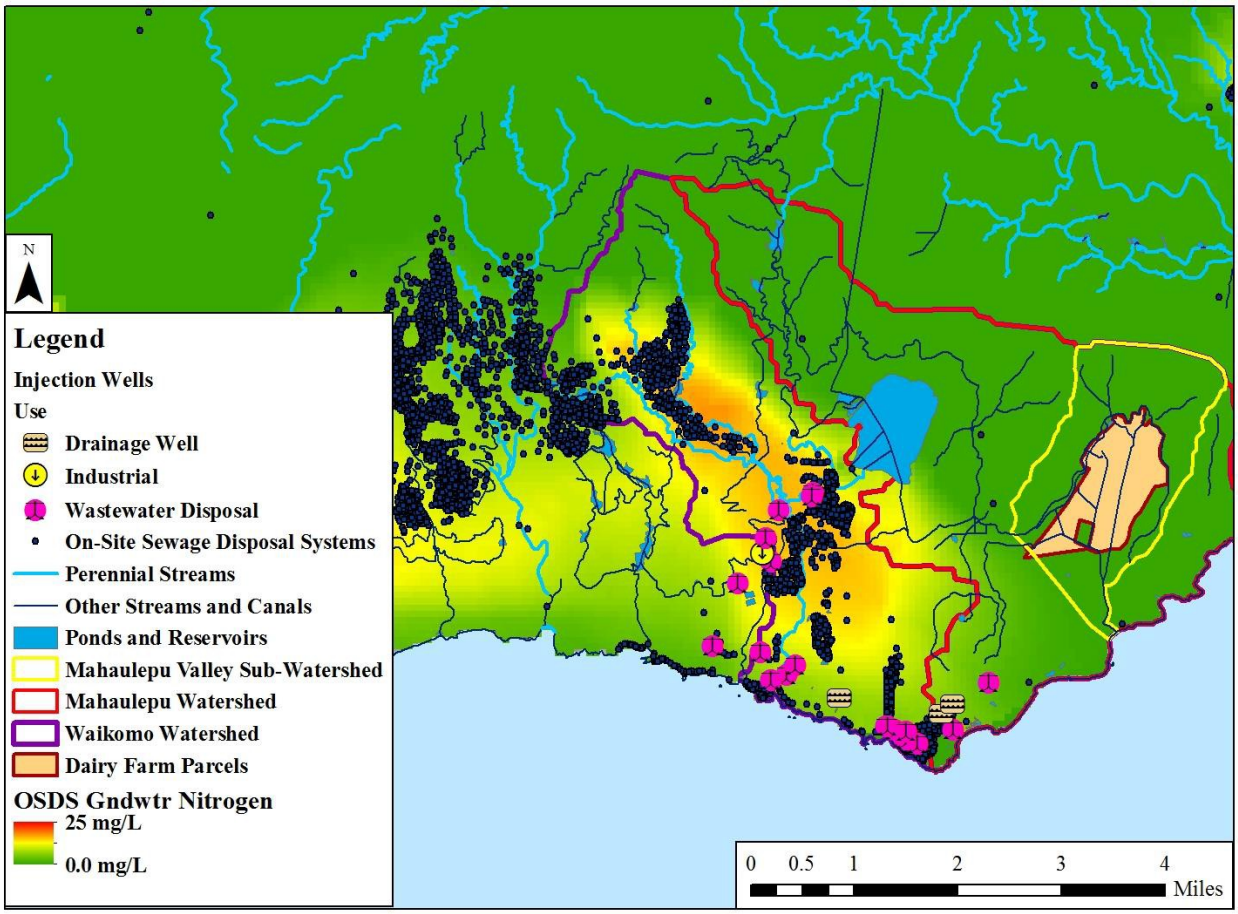
The locations of all wastewater, drainage, and industrial injection wells in the PKW and MW are shown in Figures 12 and 13. In Total, there are 116 injection wells in the PKW: 47 are drainage wells, 2 industrial, and 67 wastewater. There are only two drainage and two wastewater wells in the MW, both of which are in the southwestern end of the MW. These two drainage wells

discharge a total of about 1.41 mgd into the ground, more if there is rain. There are no known wastewater discharge in the MVSW. Attachment 8 lists the injection wells and OSDS in the PKW and the MW along with the Underground Injection Control (UIC) permit number, facility type, flow, facility name, and the TMK number.

4.3. Septic Tank Systems and Cesspools

The PKW and MW has approximately 2,200 OSDS: 296 are Class I, 111 are Class II, 239 are Class III, and 1592 are Class IV. Most are within the PKW. Class I OSDS are those systems receiving soil treatment. This includes disposal types listed as bed, trench, and infiltration chambers. Class II are septic systems discharging into a seepage pit. Class III are aerobic treatment units discharging to a seepage pit, and class IV are cesspools. Discharge from OSDS is estimated at 1.6 mgd (Whittier, El-Kadi 2014).

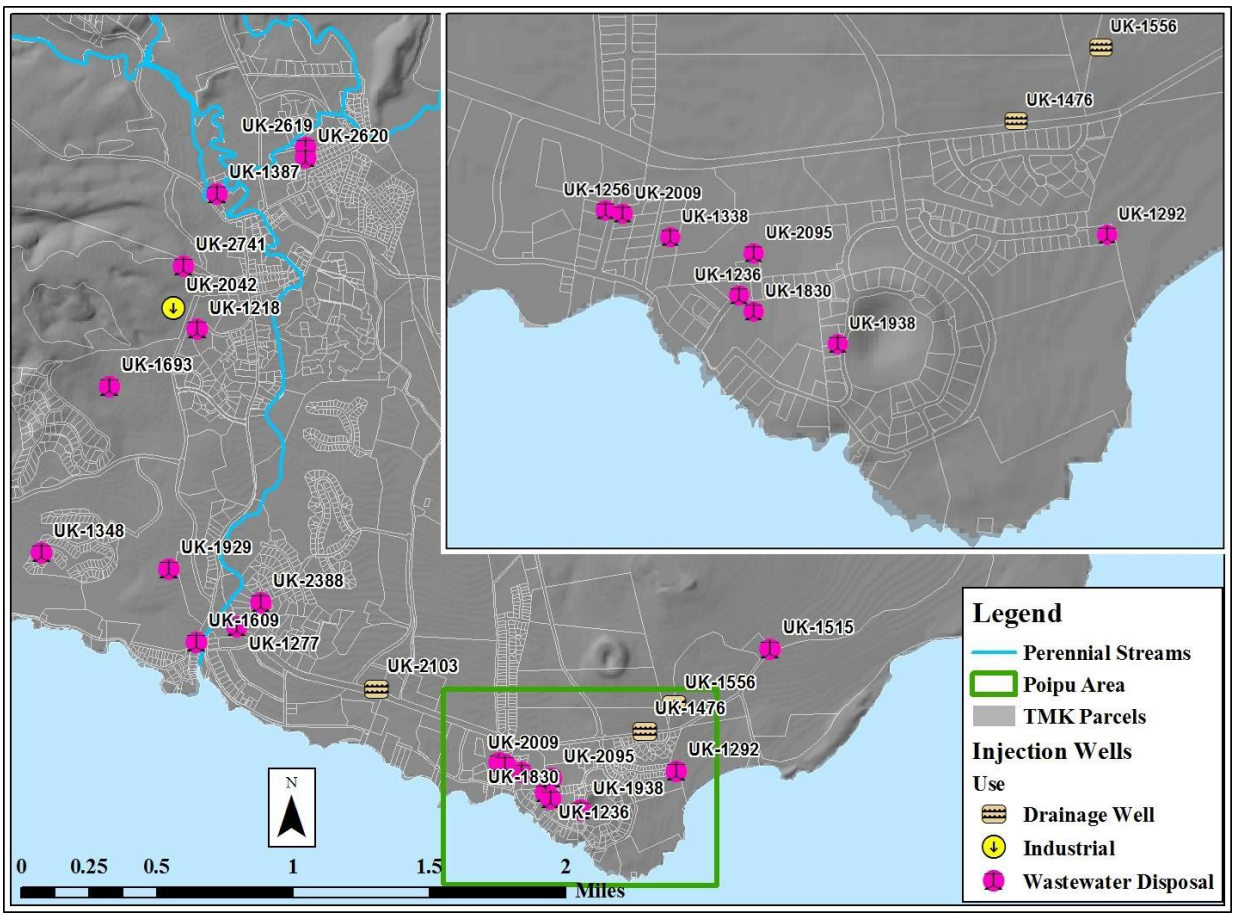
Figure 12. Injection Wells, OSDS in Poipu/Koloa (Waikomo) and Mahaulepu Watersheds



Source DOH, SDWB

Figure 12 also shows a map of the MW and PKW showing the modeled nitrate concentration in the groundwater from OSDS leachate. The pattern of the nitrate plume implies a southeast groundwater flow direction from the PKW to the MW.

Figure 13. Facility Permits



Source DOH, SDWB

4.4. Reclaimed Water

The DOH Waste Water Branch administers HAR 11-62, Wastewater Systems and Guidelines for the Treatment and Use of Recycled Water. There are three classifications of recycled water: R-1, R-2, and R-3. These classifications are based on the degree of treatment, which in turn governs applicable use. Definitions for each classification of recycled water are provided below.

R-1 Water means recycled water that is at all times oxidized, then filtered, and then exposed, after the filtration process, to a disinfection process that, when combined with the filtration process, has been demonstrated to inactivate and/or remove 99.999 percent of the plaque-forming units of F-specific bacteriophage MS2, or polio virus in the wastewater. A virus that is

at least resistant to disinfection as polio virus may be used for purposes of demonstration; and a disinfection process that limits the concentration of fecal coliform bacteria to the following criteria:

- The median density measured in the disinfected effluent does not exceed 2.2 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been compiled;
- The density does not exceed 23 per 100 milliliters in more than one sample in any 30-day period; and
- No sample shall exceed 200 per 100 milliliters.

R-2 Water means recycled water that has been oxidized, and disinfected to meet the following criteria:

- The median density measured in the disinfected effluent does not exceed 23 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed;
- The density does not exceed 200 per 100 milliliters in more than one sample in any 30-day period.

R-3 Water means oxidized wastewater and does not include any disinfection requirements.

In the PKW, Kiahuna Golf Course receives R-1 water from the Poipu Wastewater Reclamation Facility (WWRF) for irrigation and to supply its plastic/rubber lined water feature. In the MW, Poipu Bay Golf Course receives R-2 water from the Grand Hyatt Kauai Resort for irrigating the golf course and to supply a polypropylene lined water feature. What cannot be accommodated for these purposes is sent to an injection well.
See: http://health.hawaii.gov/wastewater/files/2014/08/11-62_draft.pdf

No reclaimed water is used in the MVSW.

4.5. Urban Runoff and Industrial Area Runoff

Both urban and industrial activities may be regulated under the NPDES Permit program and the UIC permit program. If there is a discharge of pollutants into state waters, then an NPDES permit is required. All storm water drainage wells are required to have a UIC permit. Attachment 8 shows 21 active urban runoff drainage wells and two industrial wells and figure 13 shows their locations. Key contaminants of concern in urban runoff discharges are pathogens, heavy metals (cadmium, lead, copper, and zinc), hydrocarbons, unknown chemicals,

animal fecal matter, and suspended solids. There may also be additional contaminants of concern specific to different industrial areas depending on the type of industrial activity.

4.6. Agricultural Crop Land Use

Wet land taro is currently being cultivated at the Haraguchi Farm in MVSW. Banana is grown west of the Haraguchi Farm on Ka Lae o Kahonu Ridge. Pioneer Parent Seed and Pioneer Research & Development grows seed corn in the MW. A taro patch demonstration project is located at the Makauwahi Cave Reserve site.

4.7. Grazing Animals

The ridges of the Haupu mountain range that form the Mahaulepu Valley are used for beef cattle grazing and the cattle are routinely rotated in and out of the area depending on the amount of available forage. A herd of feral sheep reportedly roam the eastern ridges of the Haupu Mountain Range. About 85 sheep are used by the Haraguchi taro farm for weed control and about 5 sheep do the same at the Makauwahi Cave Reserve field. In the Native Plant Restoration Area about 25 tortoises keep the grasses down. The tortoises apparently do not eat endemic plants.

4.8. Concentrated Animal Feeding Operation (CAFO)

No CAFO exists at the present time in MVSW. A pasture based dairy is being proposed for MVSW. HDF is currently working on a voluntary EIS. There are three wells near the proposed site of dairy shown in Figure 14. The closest well to the dairy is a standby well. The other two wells are being actively used for drinking water.

4.9. Source Water Assessment Program (SWAP)

The Source Water Assessment Program (SWAP) managed by the Safe Drinking Water Branch evaluates the vulnerability of public drinking water sources to contamination. For wells this is done using groundwater time of travel delineations. The methods used and the results are detailed in Whittier et al. (2004 and 2006). The SWAP delineates two groundwater time of travel setbacks. The first is a two year groundwater time of travel setback to evaluate contamination risk from chemical and biological sources (Zone B). The second is a 10 year groundwater time of travel setback to evaluate the contamination risk from chemical sources only (Zone C). Figure 14 shows a map of south Kauai showing the location of the proposed dairy in relation to the Koloa public drinking water wells and their SWAP zones. The Koloa Wells are located just to the west of the proposed dairy. A portion of the Zone C SWAP delineation for these wells intersects the western edge of the proposed dairy. This means that the potential

exists for the wells to capture some fraction of any contaminants that may leach from the dairy operations.

Due to the complexity of this discipline and the evolving knowledge of groundwater flow paths, groundwater modeling has some degree of uncertainty and should be regularly reevaluated. The Kauai SWAP model has been updated and the details documented by Whittier and El-Kadi (2014). The results of this model revision are shown in Figure 14 as the black path lines emanating from the Koloa Wells. As with the original SWAP Zone C delineations, these path lines define the area in which the groundwater time of travel to the Koloa Wells is 10 years or less. A polygon enveloping the revised 10 year time of travel delineation would be narrower but much longer than the original Zone C delineation. In relation to the proposed dairy, the revised path lines just barely intersect the western edge of the dairy's footprint. Both sets of model results agree on the possibility that leachate from the proposed dairy may be captured by the Koloa Wells. The two sets of model delineations also agree that majority of the water captured by these wells comes from the west and not from the direction of the proposed dairy location.

The final risk factor that is evaluated by the map shown in Figure 14 is the potential for the soil to allow leaching of contaminants to the groundwater. The map shows the results of the soil's role in evaluating the potential for contamination from on-site sewage disposal systems to leach to groundwater. Many of the same factors used by this on-site sewage disposal system risk study also apply to leaching of surface-applied farm waste. The methodology is detailed in Whittier and El-Kadi (2014). Factors considered in evaluating the soil's leaching potential include:

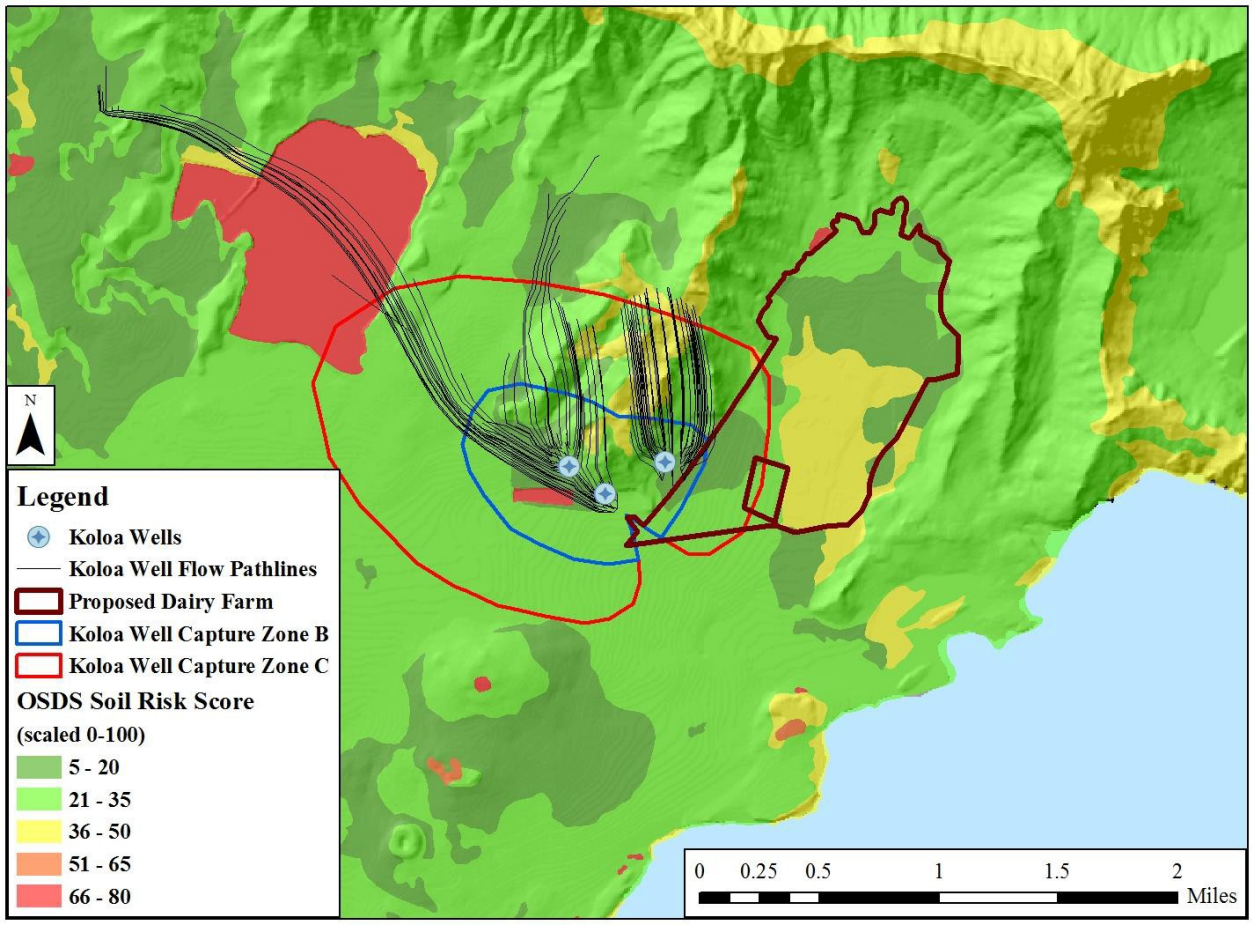
- Soil permeability,
- Soil thickness,
- Depth to the water table,
- Flooding and ponding potential, and
- Seepage out of the bottom soil layer.

The leaching potential for the soils at the proposed dairy location ranges from low (dark green) to moderate (yellow).

The groundwater velocity in southern Kauai was estimated to be about 10 ft/day by doing a particle track simulation using the OSDS model for Kauai (Whittier and El-Kadi, 2014). This groundwater velocity may be of some significance in the transport of pollutants through subterranean channels to not only drinking water sources, but also to groundwater which may eventually appear on the surface (as in the cave/lava tube system) or coastal regions such as

Mahaulepu Beach where the Waiopili Ditch enters the ocean. The detection of pollutants in such waters may be attributable to sources that are not in the immediately obvious due to the distance from which they originate.

Figure 14. Koloa Wells, Capture Zone, and Site of Proposed Hawaii Dairy Farm LLC



Source: DOH, SDWB 2015

4.10. Pesticides and Herbicide Use

Pesticide applications to State waters are regulated in the Water Quality Standards (WQS) in Hawaii Administrative Rules (HAR), Chapter 11-54. The term "pesticide" applies to insecticides, herbicides, fungicides, rodenticides, and various other substances used to control pests. Please click on the following link for HAR, Chapter 11-54.
http://health.hawaii.gov/cwb/files/2013/04/Clean_Water_Branch_HAR_11-54_20141115.pdf

HAR, Section 11-54-4 states that “pesticide applications may be made to State waters if the pesticide applications are:

A. Registered by the U.S. Environmental Protection Agency and licensed by the State Department of Agriculture or other state agency regulating pesticides;
B. Used for the purpose of controlling mosquito and other flying insect pests; controlling weed and algae pests; controlling animal pests; controlling forest canopy pests; or protecting public health or the environment in a declared pest emergency situation or as determined by the director;
C. Applied in a manner consistent with the labeling of the pesticide under FIFRA;
D. Applied under permits issued pursuant to HRS chapter 3420, if the director requires such permits under chapter 3420, HRS;
E. Applied in a manner so applicable narrative and numeric state water quality criteria as required in chapter 11-54 are met."

Hawaii WQS does not provide exemptions for experimental or research activities.

The only pesticides/herbicides used in the MVSW is at Haraguchi's Taro farm. In the MW, no pesticides are used by the Makauwahi Cave Reserve. Pesticides/herbicides are used by Pioneer Parent Seed and Pioneer Research & Development, Poipu Bay Golf Course, and portions of the Poipu Resort areas. Much higher usage occurs in the adjacent highly urbanized PKW and its resort areas.

4.11. Wildlife

Feral pigs may be found roaming the MW and surrounding areas. Mahaulepu Farm LLC has a feral pig control program where volunteers take an average of 30-35 pigs per month. USDA National Wildlife Disease Surveillance & Emergency Response Program harvested 31 problem feral pigs in 2014 and so far seven were harvested in 2015 in the Koloa-Mahaulepu area (Goldstein USDA 2015). Feral chickens are numerous throughout Kauai and Mahaulepu is no exception.

Nene Geese were released in the adjacent Kipu Kai watershed and frequents Mahaulepu Valley, as do Koloa Ducks, Hawaiian Coots, and Hawaiian Stilts.

4.12. Solid and Hazardous Waste Disposal Facilities

In 2003, Aqua Engineers, Inc., who provides water and wastewater services on Kauai, leased 45 acres of land from Grove Farm onto which they applied sludge from the sewage treatment operations to grow forage crop as animal feed. Sludge from the treatment plants in Lihue-Puhi, Princeville, Poipu Water, and Poipu Kai WWTP were applied to the southern portion of the MW, west of the Makauwahi Cave/Sinkhole. This operation stopped in September 2014.

Dennis Esaki operates a green waste facility (Solid Waste Management Permit #CO-0030-13, issued March 16, 2010) in the MW. This facility is limited to 3,000 tons per year of clean, source-separated green waste as defined in HAR §11-58.1-03. No clear and grub material as defined in HAR §11-58.1-03 may be accepted at this facility. No other municipal solid waste may be accepted at this facility. This facility (TMK 2-9-001:001), is located northwest of the Aqua Engineers facility.

4.13. Logging

There is no logging activity in the MW, PW, or in the Kipu Kai Watershed.

4.14. Recreational Use

CJM Country Stables conducts horseback riding along the southeast coastal portion of Mahaulepu watershed under a lease agreement with Mahaulepu Farm LLC. Mahaulepu Farm allows day-use of the same area for fishing, hiking, and sunbathing. With special permission, overnight fishing/camping is allowed. All unpermitted vehicles are towed away at 6 pm.

At the Waita Reservoir, a zip line and fishing for peacock bass, tilapia, and small mouth bass is available. Waita is the largest man-made reservoir in the State. Water from the Waita Reservoir flows through the Waiopili Ditch to ocean.

4.15. Unauthorized Activity

Poaching seems to be a problem in this watershed. On December 11, 2014, CWB staff discovered offal in the area between sampling sites 10 and 11 (Figure 18). Offal was most likely from a feral pig. On February 10, 2014 while conducting sampling at Site 10 (Figure 18) a de-boned pig skeleton and hide was discovered in irrigation ditch. The remains were about a week old.

Mahaulepu Farm LLC policy for their animal control volunteers is to remove carcass to a more proper setting for processing and disposal of the offal, skeleton, and hide. USDA animal control agents completely remove the carcass. No other hunting is permitted in the area which leads to the speculation that poaching is occurring.

Makauwahi Cave has been secured by the Makauwahi Cave Reserve to protect the endangered species within. In the past, the cave was subject to break-ins; however, after the construction of a stronger gate by Mahaulepu Farm and the posting of signs by the Makauwahi Cave Reserve, incidents of break-ins have diminished.

4.16. Traffic Accidents/Spills

Data on traffic accidents were not available.

DOH Waste Water Branch documents show that a 500 gallons waste water spill occurred at the Poipu Kai Manualoa Lift Station on December 16, 2008.

4.17. Groundwater Influencing Surface Water Quality

On Kauai, 84 percent of the TMKs that have OSDS are located within a perennial watershed. Nearly the entire area of Kauai's perennial watersheds are classified as high-level groundwater. This makes discharge of groundwater to the surface water probable throughout the majority of perennial watershed area. Kauai also has the highest simulated OSDS derived groundwater nitrogen (ODGWN) concentration. The combination of the high ODGWN concentration and predominance of high-level aquifers in the perennial watersheds greatly increase the probability that OSDS effluent may impact the stream water quality on Kauai.

The high ODGWN concentration in Kauai's groundwater also elevates the probability of risk to drinking water sources and to the coastal ecosystems. On Kauai nearly half of the drinking water Capture Zone Delineation (CZD) have simulated ODGWN. This indicates that OSDS contaminated groundwater may be captured by drinking water wells. The elevated nitrogen in the groundwater also increases the coastal zone risk severity score, which indicates a greater potential for coastal environmental degradation by OSDS compared to that of the other islands (Maui, Molokai, and Hawaii) evaluated. The combined potential adverse impact of OSDS on streams, drinking water, and the coastal waters resulted in an OSDS risk severity score, higher than that of the islands of Molokai, Maui, and Hawaii (Whittier, El-Kadi 2014).

There are no OSDS and no perennial streams on the proposed HDF site within the MVSW, but there is at least one spring that feeds one of the former sugar cane irrigation ditches. The closest OSDS is at the Gillin's House located just east of the MVSW.

4.18. Geologic Hazards

Kauai is the oldest and westernmost of the main Hawaiian Islands. At five million years of age, Kauai's volcanic slopes are deeply carved by streams, and its forests host Hawaii's richest array of flora and fauna. Because of Kauai's relative age and distance from the volcanic hot spot under the Big Island, it escapes the seismic activity and lava hazards that affect the younger islands in the chain. However, tsunamis and hurricanes do pose threats. In 1992, Hurricane Iniki

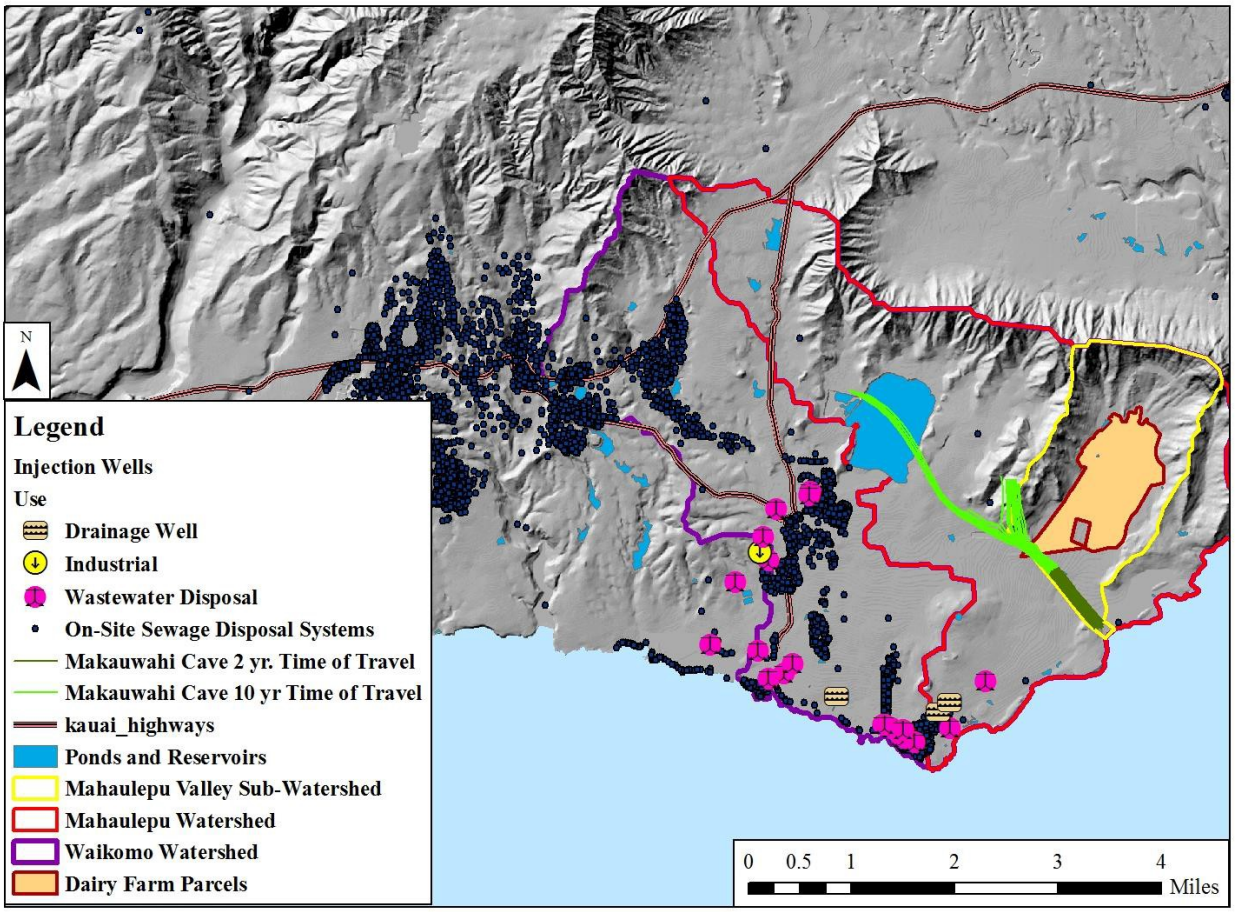
devastated the island, wreaking havoc on residents' lives, the local economy, and the fragile native ecosystems.

The pseudo-karst topography and associated Koloa lava tube system of the PKW seem to be connected to the Makauwahi Cave/Sinkhole system. Two endangered species, the Kauai Cave Wolf spider (*Adelocosa anops*) and its prey, the Kauai Cave amphipod (*Spelaeorchestia koloana*) are found in both systems (see: http://legacy.earlham.edu/%7Ereyeras/noeyedbigeyed.htm). Both species have lost their eyes to evolution and have adapted to life in complete darkness. They are believed to be unable to survive outside the lava tube cave system which is estimated at 4-6 square miles. This cave system is the only known habitat for these species. Because this cave system extends from the PKW to parts of the MW, it may serve as a possible transmission route for contaminants from the injection wells and OSDS in the PKW to the MW and the Waiopili Ditch. This potential transmission route (hydrological connection) is supported by groundwater nitrite modeling of OSDS leachate in the PKW and MW, which implies a groundwater flow towards the southeast, from the PKW to the MW (Figure 12).

The transmission of sewage effluent from injection wells into coastal waters has been observed in other areas of the state. University of Hawaii tracer studies at the Lahaina WWRF on the island of Maui established a hydrological connection between the injection well and the nearby coastal area. Since late 2011, CWB has been monitoring the underwater seeps on a monthly, and more recently, a bimonthly schedule. See: http://health.hawaii.gov/sdwb/files/2014/09/SessionB-02.Lahaina-Groundwater-Tracer-Study_8-13-14.pdf

The average groundwater velocity in the PKW is 10 feet per day, and in the MVSW is five feet per day. The time of travel (TOT) for possible groundwater contaminants in the MVSW is half that of the PKW. Assuming there is groundwater contamination in the PKW, the TOT from north of Koloa town to Makauwahi Cave would be approximately 10 years. As a comparison, time of travel from the center of MVSW to Makauwahi Cave is about two years. Figure 15 shows the two year and ten year time of travel flow paths to the Makauwahi Cave. This groundwater time of travel assessment does not account for fast travel paths associated with karst type geology and lava tubes.

Figure 15. Groundwater Flow Paths to the Makauwahi Cave, Southern Kauai



Source: DOH, SDWB

This map of southern Kauai shows the flow paths to the Makauwahi Cave (located near the end of the dark green line). Groundwater from the up-gradient end of the light green flow paths will take about 10 years to reach the cave. Groundwater from the up-gradient end of the dark green flow paths will take about two years to reach the cave.

4.19. Fires

On March 31, 2015 a 100 acre brush fire took place west of CJM Stables. The cause has not yet been determined. In this fire, County of Kauai firefighters and their helicopter responded, as well as Mahaulepu Farm lessees in the area who provided a water tanker truck, manpower, and a front loader. An additional helicopter was hired by the County Fire Department to combat the blaze. See 5.2.10.

4.20. Significance of Potential Contamination Sources

The Haraguchi taro farm in MVSW poses no significant risks. The proposed HDF dairy in MVSW could possibly be a significant source of contamination if another hurricane should hit Kauai.

HDF is currently working on an Environmental Impact Statement addressing the various issues. However, while there is opposition to the proposed dairy in MVSW and the possible risk of contaminating the groundwater, there seems to be no concern about what is currently happening in adjacent PKW and the lower MW. In the PKW, at least 3.01 mgd of wastewater from Waste Water Treatment Plants, industrial source, OSDS, and storm water runoff flow into the ground by way of injection wells and a variety of seepage pits/cesspools.

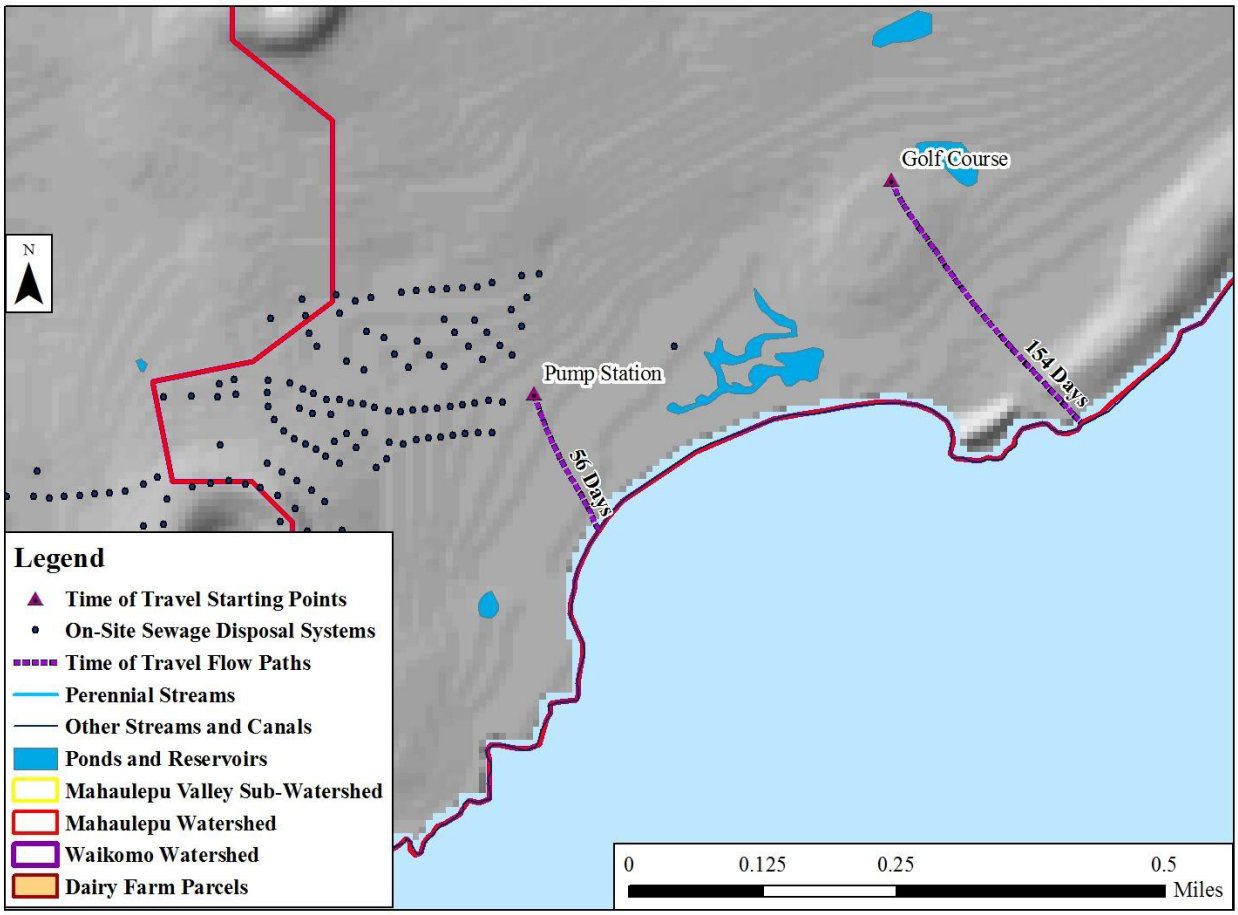
The Kauai cesspool study, *Human Health and Environmental Risk Ranking of On-Site Sewage Disposal Systems for the Hawaiian Island of Kauai, Molokai, Maui and Hawaii* (Robert B. Whittier, Aly I, El-Kadi, September 2014) shows that most of the PKW has a hydraulic conductivity of about 300 feet per day and a hydraulic gradient of about 0.0015 feet per feet. See Attachment 9 for more information. Assuming an aquifer porosity of 0.05, the groundwater velocity is approximately 10 feet per day. The site of the proposed HDF in the MVSW has a hydraulic conductivity of about 33 feet per day and a hydraulic gradient of about 0.0018 (Whittier, El-Kadi 2014). Thus the groundwater velocity in the MVSW (beneath the site of the HDF) is about 1.2 feet per day about one-tenth that at the PKW.

The Lahaina Groundwater Tracer Study (Glenn et al., 2013) demonstrated a hydrologic connection between the injection wells and the nearby coastline. In the Lahaina study, the groundwater velocity was measured at about 6.2 feet per day. With a groundwater velocity about 1.5 times faster than Lahaina, and the short distance to the ocean, it seems reasonable that a discharge into coastal waters takes place within the MVSW. The actual travel time for injected wastewater would be shorter than predicted by the 10 feet per day groundwater velocity since the model did account for the increased groundwater velocity near an injection well. Thus for some injection wells the TOT can be as short as a few weeks, much shorter than the 1.3 years measured between the injection wells at the Lahaina WWRF and the coast. The shorter TOT underground greatly reduces the attenuation period for bacteria, viruses, and nutrients levels. At the MVSW (beneath the HDF) the model computed the travel time to be on the order of several years. So, any ground water contamination in MVSW will undergo an attenuation period 10 to 20 times that of the PKW.

The large number of injections wells and OSDS in the PKW may be threatening the two endangered species living in the Koloa and the Makauwahi lava tube system. Obvious concern is the two industrial injection wells from the commercial dry cleaning operation in Koloa. Particle track models tend to indicate that the groundwater flows to the cave and passes north of the injection wells and most of the OSDS (Figure 15). However, the model does not take into account the lava tubes beneath the area.

The proximity of the Poipu Resort area injection wells along the coastline creates additional concern for the DOH. The relatively high groundwater velocity and proximity of injections wells along coastline suggest rapid discharge of waste water into coastal waters classed by the HAR 11-54 as AA. High aquifer levels, moderate aquifer permeability, and OSDS also suggests surface waters in the PKW and MW may be impacted. Figure 16 shows modeling of TOT from two injection well sites. The TOT modeling from the pump station is 56 days + 20 days and the TOT from Golf Course is 154 +60 days. The modeling does not take into account injection well flow rate and other factors that may shorten the TOT considerably.

Figure 16. Time of Travel from Two Injection Well Sites



Source: DOH, SDWB 2015

4.21. Anticipated Growth and Projected Changes in Contaminant Sources

As in the case with any new project, the establishment of the proposed HDF dairy may become a possible source of contaminants in MVSW. Great thought must be exercised in the design and layout of the dairy and the establishment of best management practices to prevent discharges and contamination. The Voluntary EIS being developed should address these concerns.

As more agriculture comes to MW, there could be the potential for contamination from herbicides, fertilizer, pesticides, and animal wastes. Great care must be taken to address and control these issues.

An IAL designation in the MW significantly lessens the potential for population growth and minimizes development in the area. Mahaulepu Farm LLC has demonstrated its intent in keep one-third of their lands for agricultural purposes and supports the island's sustainability. See: http://thegardenisland.com/business/local/luc-converts-one-third-of-grove-farm-lands-into-ial/article_38eb2916-7417-11e2-b78e-0019bb2963f4.html

Any growth in the PKW under the current conditions will only add to the present levels of groundwater contamination. The sources will probably remain the same; however, the volume of discharge will most likely increase. Contamination of streams and groundwater is of great concern on Kauai due to its high aquifers (Figure 16). Compared to Hawaii, Maui, and Molokai, Kauai has the highest OSDS severity risk that threatens drinking water wells and coastal environments (Whittier, El-Kadi 2014).

5.0. Watershed Control and Management Practices MVSW

This chapter discusses existing and recommended watershed management practices used by the agencies controlling the watershed to protect surface water quality.

5.1. Management Practices in the Mahaulepu Valley Sub-Watershed

MVSW is privately owned by Mahaulepu Farm LLC and is not subject to the management practices of any water agency. Due to ongoing and pending litigation, this sanitary survey will not provide comments on management objectives, management structure, and roles and responsibilities of the offices or work groups associated with watershed management.

There is no watershed plan for MVSW. The land is designated as an Important Agricultural Land (IAL) and access is controlled by locked gates on most areas of the watershed. An IAL designation makes it difficult to change the land usage from agriculture to any other purpose, strictly limiting the amount of development that can occur on the land. The public is allowed day use of the beach areas but all vehicles must leave at 6 pm or vehicle will be towed. There are no septic systems, cesspools, and urban runoff in the MVSW.

Roads are maintained as needed. All roads in the watershed are unpaved, and speed limits are enforced in the watershed. There was no evidence to indicate that erosion is an ongoing problem in the watershed. Mahaulepu Quarry on the eastern boundary of the watershed has an NPDES permit (HI0021491) for wastewater and storm water associated with the quarry operations. HDF has prepared a water quality monitoring plan that outlines the monitoring of their well and surface water and the nearby beach at the end of the Waiopili Ditch. Response plans are being drawn up as part of the voluntary EIS.

For over a hundred years, sugar cane was grown in the MVSW, so there has been very little riparian management going on in the watershed. Majority of the wetlands in the watershed have been drained during the early sugar growing era. The remaining wetlands in the watershed are associated with the Haraguchi taro farm and the Makauwahi Cave Reserve taro field. After sugar cane production ended in the MVSW, beef cattle was used to control vegetation. Today, sheep are used.

Mahaulepu Farm LLC oversees management control and inspections and surveillance of the watershed through its lease holders and staff. Lessees are required to prepare a Soil Conservation plan (see section 5.2.9.). Surveillance, management, and tours of the Makauwahi Cave/Sinkhole are handled by the Makauwahi Cave Reserve. USDA animal control staff assist Mahaulepu Farm LLC in the removal of feral pigs where traditional hunting methods cannot be

conducted. Access into MVSW is controlled by locked gates. Public access is allowed only at the extreme end of the watershed by a dirt road parallel to the Poipu Bay Golf Course. This road provides day time access to the Makauwahi Cave Reserve, Gillin's House, Mahaulepu Beach, Kawailoa and Haula Bays. All vehicles are required to vacate the public visitor sites by 6 pm or the vehicles will be towed.

5.1.1. Lease Agreements

Through lease agreements, beef cattle are grazed on the slopes and high meadows of the watershed on a rotational basis by David and Moana Palama, long time beef cattle ranchers.

In 2007, W. T. Haraguchi signed a 20 year lease to grow taro in Mahaulepu Valley. This continues today and the farm uses sheep to control the grass and weeds around the farm.

Pioneer Parent Seed and Pioneer Research & Development began growing seed corn in 1996 at Mahaulepu. Their lease runs through 2019 and the tenants have plans to expand the leased areas up to 805 acres for future bio-energy crops and corn expansion.

Details of Hawaii Dairy Farms LLC lease agreement is not included in the sanitary survey due to on-going litigation.

The Makauwahi Cave Reserve also uses sheep in their taro field and land tortoises in the native plant restoration area to control grass and weeds.

Feral pigs are controlled using permitted volunteer hunters and assistance from the USDA animal control staff.

There are no recreational activities in MVSW. CJM Country Stables trail rides crosses the extreme lower portion of MVSW but does not ride in the MVSW.

5.2. Other Agencies with Watershed Control Authority

In addition to the specific watershed management measures described in section 5.1, local, state, and federal agencies may also have watershed control authority through policies, programs, or regulations. Lease agreements with other agencies may include specific watershed or water quality protection requirements. In many cases, these policies and programs regulate the types of land uses, density of development, or discharge of contaminants within the watershed, and consequently are key elements in assessing the potential for future water quality preservation or degradation.

This section of the survey:

- Identifies other agencies and landowners that have control authority within the watershed;
- Summarizes relevant policies, programs, regulations, ordinances and agreements that govern land uses, development density, recreation density, or water quality;
- Identifies specific contaminant discharge requirements that have been imposed in the watershed; and
- Provide an analysis for the potential water quality impacts for all relevant policies, programs, etc. For example, a strict county general plan zoning stipulation which prohibits extensive industrial development within a watershed represents a method of potentially preserving water quality and should be identified in the sanitary survey document.

Some of the other agencies' and/or landowners' policies, programs, and regulations that commonly impact watersheds or water quality within the watershed are identified below.

5.2.1. County General Plan Policies

Mahaulepu Farm LLC owns almost all of the land in the MW. The Koloa-Poipu-Kalaheo District Land Use Map (Attachment 4) shows that most of the land in the MW is zoned for agriculture except for the extreme south portion which is zoned resort and open. The Kauai General Plan can be viewed at:
http://www.kauai.gov/Government/Departments/PlanningDepartment/LongRangeDivision/TheKauaiGeneralPlan/tabid/130/Default.aspx

5.2.2. Federal Agency Plans and Policies

No federal agency is involved in the MW.

5.2.3. Wastewater Discharge Requirements

Wastewater discharge is regulated by the Waste Water Branch (WWB) and the Safe Drinking Water Branch (SDWB) of the DOH. Injection wells are primarily used to dispose of rainfall runoff, sewage, and industrial wastewaters directly into the ground. Except for sewage injection wells receiving less than 1,000 gallons per day, all injection wells are required to obtain a UIC permit. The UIC permit is issued by the SDWB UIC program under the authority of Hawaii Administrative Rules (HAR), Title 11, Chapter 23 which was promulgated on July 6, 1984. The primary purpose of the UIC permit and the permitting process is to protect the underground sources of drinking water (USDW). USDWs are identified by a delineation known as the UIC line.

The construction of new sewage or industrial injection wells are prohibited in the areas inland or mauka of the UIC line. See: http://health.hawaii.gov/sdwb/files/2013/09/11-23.pdf
Since the early 1990's, no new cesspools have been allowed on what are considered critical wastewater disposal areas; areas with high water tables, impermeable soil or rock formation, steep terrain, in a flood zone, in or near protected coastal, inland surface, or ground waters, or in areas with a high rate of cesspool failures. Kauai is considered one of those critical wastewater disposal areas in the state and the installation of new cesspools have been prohibited since this regulation was promulgated. Effective March 2016, no new cesspools will be allowed in the remaining areas not covered by the 1990 regulation, thereby banning all new cesspools in the state. Individual Wastewater Systems (IWS) are allowed if the facility is a single family residence with 5 bedrooms or less and discharge less than 1000 gallons per day or a non-residential facility with less than 1000 gallons per day. IWS are administered by the Waste Water Branch under HAR Chapter 11-62 Waste Water Systems, see:
http://health.hawaii.gov/wastewater/files/2014/08/11-62_draft.pdf

5.2.4. Storm Water and NPDES Regulations

Storm water discharges are regulated by the National Pollutant Discharge Elimination System (NPDES). The DOH, Clean Water Branch (CWB) administers and issues permits under the NPDES in the State of Hawaii. NPDES permits are required for all point source discharges to State waters and three situations involving storm water:

1. Storm water associated with construction activities that disturb one (1) acre or more;
2. Storm water associated with industrial activities; and
3. Storm water from Municipal Separate Storm Sewer Systems.

A point source is any discernible, confined, and discrete conveyance from which pollutants are or may be discharged. Anyone proposing a point source discharge must obtain an NPDES permit prior to the start of operations, except for Concentrated Animal Feeding Operations (CAFOs). On July 19, 2012, the EPA issued a final rule to revise its CAFO permit regulation to remove the requirement that CAFOs that "propose to discharge" must seek NPDES permit coverage. This rule revision was in response to a 2011 U.S. Court of Appeals for the Fifth Circuit decision in National Pork Producers Council v. EPA, which vacated portions of the Agency's 2008 CAFO rule. Due to the court's decision, a CAFO is not required to obtain an NPDES permit for operational effluent discharges unless there will be an actual discharge to state waters. Simply put, if there is no discharge to state waters, then an NPDES permit is not needed.

The only active NPDES permit within the MW has been issued to Mahaulepu Quarry, Jas. W. Glover Ltd., HI0021491. This permit is for the discharge of wastewater from existing operations and storm water associated with industrial activity.

5.2.5. Mines/Mining Reclamation

On March 19, 1993, the Land Use Commission approved a Special Permit to establish a Limestone and Basalt quarrying operation north east of the old Mahaulepu Quarry. Jas. W. Glover, Ltd continues to operate this quarry. See: http://luc.hawaii.gov/wp-content/uploads/2014/03/SP92-382_Grove-Farm-Rock-Co_DO_3-19-93.pdf

Mahaulepu Quarry has an NPDES permit (HI0021491) that expires on 6/19/2016 for waste water from existing (quarry) operation and storm water associated with industrial activity.

5.2.6. Open Space Policies

The Koloa-Poipu-Kalaheo Planning District Land Use Map shows open space designation surrounding the MVSW on three sides (Attachment 4). Portions of agriculture zoned lands of MW and Open space policies are often established by local or regional land use agencies as a means of encouraging the preservation of open space where development is limited or prohibited. These policies are often reflected in general plans or zoning ordinances. In some cases, open space policies are applied to watershed lands to either protect water quality directly or to protect sensitive environmental resources.

The Open Lands policy, is found in the Kauai General Plan, Chapter 5, Preserving Kauai's Rural Character. Section 5.3.1 states:

(a) The intent of the Open designation is to preserve, maintain or improve the natural characteristics of non-urban land and water areas that:
- *(1)* are of significant value to the public as scenic or recreation resources;
- *(2)* perform essential physical and ecologic functions important to the welfare of surrounding lands, waters, and biological resources;
- *(3)* have the potential to create or exacerbate soil erosion or flooding on adjacent lands;
- *(4) are potentially susceptible to natural hazards such as flood, hurricane, tsunami, coastal erosion, landslide or subsistence; or*
- *(5) form a cultural, historic or archaeological resource of significant public value.*

(b) Lands designated Open shall include: important landforms such as mountains, coastal bluffs, cinder cones, and stream valleys; native plant and wildlife habitat; areas of predominantly steep slopes (20 percent or greater); beaches and coastal areas susceptible

to coastal erosion or hurricane, tsunami, or storm-wave inundation; wetlands and flood plains; important scenic resources; and known natural, historic and archaeological resources. Open shall also include parks, golf courses, and other areas committed to outdoor recreation.

(c) Lands designated Open shall remain predominantly free of development involving buildings, paving and other construction. With the exception of kuleanas and other small lots of record, any construction that is permitted shall be clearly incidental to the use of open character of the surrounding lands.

The open space designation is the reason that the public access road (Weliweli Road) to Makauwahi Cave Reserve, Gillin's House, Mahaulepu Beach, Kawailoa and Hauula Bay has remained unpaved. Weliweli Road is adjacent to the Poipu Bay Golf Course. The Poipu Bay Golf Course is located on open space lands and was given a Special Use Permit on agriculture zoned lands by the Land Use Commission.

5.2.7. Erosion Control/Soil Management Policies

In Hawaii, agricultural activities with a Soil Conservation Plan approved by the Soil and Water Conservation District (SWCD), is exempt from County grading ordinances. Conservation plans are developed by agricultural producers, in conjunction with the SWCDs, to manage the natural resources on their farms or ranches. Each farm and ranch has its own unique resource concerns, and without proper management, human activity can negatively impact soil, water, air, plants and animals. A plan combines the producer's business and personal goals with the science-based knowledge of the conservation planner to protect natural resources. With assistance from SWCD Conservation Planners, producers select the best combination of conservation practices to meet their resource needs and management goals.

Benefits of a Conservation Plan include:

- Receiving technical assistance at no cost;
- Optimize the use of natural resources on the property and decrease soil erosion;
- Improve water use efficiency and minimize the environmental impact of farming;
- Become familiar with government regulations and receive guidance on how to prevent violations;
- Comply with lease requirements for other agencies;
- Qualify for County Grading, Grubbing & Stockpiling permit exemptions

Agricultural lease agreements often require conservation plans. Mahaulepu Farm LLC requires their agriculture lessees (HDF, Pioneer, and Haraguchi) to have a Soil Conservation Plan.

5.2.8. Fire Management

Historically, the Division of Forestry and Wildlife (DOFAW) of the Department of Land and Natural Resources (DLNR) relied on a system of district fire wardens to help suppress fires in rural settings. Because of their location and distribution throughout the islands, many sugar plantations and ranchers served as an effective network of partners who could respond with their manpower and equipment to extinguish wildland fires in a timely fashion. Decline in sugar plantations saw the demise of this special partnership within the past decades. In recent years, local fire departments improved their capabilities by increasing the number of stations and fire fighters principally in response to the growth of the islands' population and the resultant urban sprawl. The improved fire protection served to provide extended coverage to rural and wildland areas as well. However, there was a need to clarify these relationships because DOFAW, which has no full-time firefighters, was often requested to respond to fire situations outside its legal jurisdiction. The consequence was the rapid depletion of its own fire suppression funding and subsequent inability to address fire threats on land under its own jurisdiction. To still meet its legal fire protection mandate for state-owned lands and honor its partnership with other fire services, DOFAW negotiated with its local fire departments and established a cooperative mechanism for prevention, pre-suppression and suppression measures by way of the current Memorandum of Agreements. Fire Maps (http://dlnr.hawaii.gov/forestry/fire/response-maps/) were also drawn to delineate agency fire responsibilities.

In the early 1980s, a map of each county was delineated to depict areas where DOFAW has primary fire responsibility (color-coded green in the Fire Maps reference above), areas where it could respond mutually with other firefighting agencies (color-coded pink of the Fire Maps), and areas totally out of its jurisdiction (color- coded white of the Fire Maps). DOFAW would automatically respond to fires in the green area. The pink areas generally are those areas which are adjacent to the green areas. If fires occurred in these areas, DOFAW would respond mutually if the request came directly from the county fire department.

The following illustrates what happened in a recent brush fire at Koloa on March 31, 2015.

KOLOA, KAUAI (HawaiiNewsNow) -

> Firefighters on Kauai contained a roughly 100-acre brush fire that broke out in Koloa Tuesday afternoon. No injuries were reported and no structures were damaged.
>
> Dispatch was notified of a brush fire that broke out at around 4 p.m. in a vacant lot at the end of Poipu Road, west of CJM stables. Firefighters from the Koloa, Kalaheo, and Hanapepe stations responded to the scene along with Rescue 3 aboard Air 1. Within the

hour, several private companies and community members had stepped in to provide water tenders and a loader to assist in the effort.

The Fire Department also hired an additional helicopter to assist in making water drops before nightfall forced both helicopters to retreat shortly after 7 p.m.
The fire was contained at around 8:30 p.m. and fully extinguished by 9:20 p.m. Koloa firefighters were back on scene Wednesday morning to monitor hot spots.
The cause of the fire has not yet been determined. Anyone with information on the incident is urged to call police at 241-1711.

Fire management within the MW and PKW is under the jurisdiction of Kauai County Fire Department with voluntary assistance from the private sector and community members.

5.3. Agency-Organization Coordination Measures

This section specifies control measures currently being used by agencies and non-government organizations to protect watershed lands which are outside of their ownership and jurisdiction.

In 1961, Hawaii became the first state to institute statewide land use planning. The State Land Use Law (Chapter 205, HRS) establishes four land use districts: urban, rural, agriculture, and conservation, as well as permitted uses within each district. Conservation is the most restrictive. A Conservation District is comprised primarily of lands in existing forest and water reserve zones and include areas necessary for protecting watersheds and water sources, scenic and historic areas, parks, wilderness, open space, recreational areas, habitats' of endemic plants, fish and wildlife, and all submerged lands seaward of the shoreline. A Conservation District also includes land that are subject to flooding and soil erosion. Conservation districts are administered by the State Board of Land and Natural Resources and uses are governed by rules promulgated by the State Department of Land and Natural Resources.

Agricultural districts include land with significant potential for the cultivation of crops, aquaculture, livestock, timber, wind energy facilities. Agricultural districts also may be used to support agriculture-support activities (i.e., mills, employee quarters, etc.) as well as golf courses and golf course related activities, depending on the productivity category (http://luc.hawaii.gov/about/state-land-use-districts/). Agricultural districts may also include agricultural parks and open area recreational facilities

Within the Agricultural Districts, the LUC can designate agricultural lands as Important Agricultural Lands (IAL). In 2008, the Hawaii Legislature passed SB 2646 which provided

incentives and protections to establish and sustain viable agricultural operations on important agricultural lands, and provides for the designation of important Agricultural lands on public lands. The intent of an IAL designation is to conserve and protect agricultural lands that are capable of sustaining high agricultural yields; contribute to Hawaii's economic base through the production of agricultural commodities for local consumption or export; and promote the expansion of the agricultural industry in the future. Once so designated, IALs cannot be reclassified or rezoned by the state or counties without legislative approval. Landowners may voluntarily seek IAL designation by petitioning the LUC. Counties may also seek IAL designation by mapping designated lands under their jurisdiction and submitting the maps to the LUC for review and approval. An IAL designation provides various incentives to the land owner including tax credits, guaranty on loans, expedited processing of permits, and land by allowing up to 15% of the land to be reclassified to urban, rural, or conservation. In considering an IAL petition, the LUC evaluates whether the land has sufficient quantities of water for its intended use and that the land contributes to a critical land mass important to agricultural operating productivity.

There are eight criteria which are to be considered although lands need not meet every standard and criteria listed. The standards and criteria are as follows:

1) Land currently used for agricultural production;
2) Land with soil qualities and growing conditions that support agricultural production of food, fiber, or fuel and energy producing crops;
3) Land identified under agricultural productivity rating systems, such as the agricultural lands of importance to the State of Hawaii (ALISH) system adopted by the board of agriculture on January 28, 1977;
4) Land types associated with traditional native Hawaiian agricultural uses, such as taro cultivation, or unique agricultural crops and uses, such as coffee, vineyards, and aquaculture, and energy production;
5) Land with sufficient quantities of water to support viable agricultural production;
6) Land whose designation as important agricultural lands is consistent with general, development, and community plans of the county;
7) Land that contributes to maintaining a critical land mass important to agricultural operating productivity; and
8) Land with or near support infrastructure conducive to agricultural productivity, such as transportation to markets, water or power.

The Urban District generally includes lands characterized by "city-like" concentrations of people, structures and services. This District also includes vacant areas for future development. Jurisdiction of this district lies primarily with the respective counties. Generally, lot sizes and

uses permitted in the district area are established by the respective county through ordinances or rules.

Rural Districts are composed primarily of small farms intermixed with low-density residential lots with a minimum size of one-half acre. Jurisdiction over Rural Districts is shared by the Commission and county governments. Permitted uses include those relating or compatible to agricultural use and low-density residential lots. Variances can be obtained through the special use permitting process.

All amendments to boundaries within conservation districts, land greater than 15 acres, or IAL must be approved by the State Land Use Commission. Amendments to boundaries on land less than 15 acres, rural, urban and agriculture districts (except IAL) are under the authority of each county. Counties are authorized to govern zoning within their jurisdiction for rural, urban, and agricultural districts.

The Kauai County Planning Department protects watershed lands by designating land use on urban, rural, and agricultural districts on Kauai. Most of the lands in the MW is designated for agricultural use. Lands along the Mahaulepu coastline and Haupu Mountain Range are designated as open. As discussed in 5.2.6, lands designated open are intended to remain predominantly free of development involving buildings, paving and other construction.

In the MW, land along the Mahaulepu coast and Haupu Mountain Range, which borders the MVSW on three sides, are designated as a Conservation District. Land within the MVSW is designated as an Agricultural District. An IAL designation has been approved for 1,533 acres in the MW, encompassing all of the land within the MVSW, including all of the land on which the proposed HDF will be situated.

6.0 Water Quality

This chapter contains a discussion of relevant water quality regulations and monitoring conducted at Mahaulepu Valley Watershed. Data on fecal indicator bacteria concentrations collected in the watershed are compared to existing state water quality standards.

6.1. Water Quality Indicators

Fecal contamination of recreational waters has long been associated with an increased risk of gastrointestinal illness associated with human pathogens derived from sewage. The main source of exposure to these pathogens in recreational waters is through direct contact with sewage-impacted water while swimming, most commonly through accidental ingestion of the contaminated water. EPA published recommended criteria to protect swimmers from gastrointestinal illness in waters that are specifically designated for use in primary contact recreation, i.e., waters in which full body contact, total immersion or ingestion of the water is likely to occur. To identify sewage-impacted water (and therefore the presence of pathogens), bacterial indicators have traditionally been used as surrogates for actual pathogenic organisms.

In 1968, the U.S. Public Health Service published recommendations for using fecal coliforms as fecal indicator bacteria to detect the presence of sewage in waterbodies. These recommendations were carried over to the 1972 Federal Water Pollution Control Act, also known as the Clean Water Act (CWA). In the late 1970s and early 1980s, EPA conducted a series of epidemiological studies in marine and fresh water beaches that evaluated the use of several organisms which could be used as possible indicators of fecal contamination in recreational waters. The study showed that enterococci were good predictors of gastrointestinal illnesses in marine and fresh waters due to their positive correlation with reported illness rates. In 1986, EPA published its *Ambient Water Quality Criteria for Bacteria.* In this criteria document, EPA replaced its previous recommendation of fecal coliforms in favor of enterococci as fecal indicators in marine and fresh recreational waters and *Escherichia coli* (*E. coli)* for fresh recreational waters.

Amendments to the CWA by the BEACH Act of 2000 required the EPA to conduct studies associated with pathogens and human health and publish risk-based criteria recommendations for pathogen indicators based on those studies. In 2012, the EPA released its recreational water quality criteria recommendations for protecting human health in all coastal and non-coastal waters that are designated for primary contact recreational use. These criteria rely on the latest research and include information that show a risk-based correlation between illness and the concentration of fecal indicators in primary contact recreational waters. This science-based criteria provide information to help states protect public health by addressing a broader range

of illness symptoms; better accounting for pollution after heavy rainfall; providing more protective recommendations for coastal waters; encouraging early alerts to beachgoers; and promoting rapid testing of water samples. The 2012 criteria do not impose any new requirements; instead, they provide additional tools that states can choose to use in setting their own water quality standards. The indicators recommended in 1986 (*E. coli* and enterococci) were retained since the epidemiological studies demonstrated adequate protection of public health; however, the numerical concentration thresholds were updated.

6.1.1. Recreational Use Regulations

The Clean Water Act directs States, Territories, and authorized Tribes, with the oversight of EPA, to adopt water quality standards to protect the public health and welfare. EPA's recommended recreational water quality criteria (RWQC) are applicable to all waters in the United States including marine, estuarine, and inland waters and are designated to protect users engaged in primary contact recreation. Primary contact recreation typically include activities where there is a high degree of bodily contact with the water and immersion and ingestion are likely. Such activities include swimming, bathing, surfing, water skiing, tubing, skin diving, or similar water-contact activities.

Hawaii DOH is charged with creating and enforcing all water quality standards within the State. The Hawaii Water Quality Standards are established in the Hawaii Administrative Rules Title 11, Chapter 54 (HAR 11-54), which must be reviewed and approved by EPA before each revision may be implemented, is consistent with EPA's current RWQC. The most current revision of HAR 11-54 is provided at: http://health.hawaii.gov/cwb/files/2013/04/Clean_Water_Branch_HAR_11-54_20141115.pdf.

Public health agencies have long used fecal indicator bacteria to identify the potential for illness resulting from recreational activities in surface waters contaminated by fecal pollution. Hawaii's use of fecal coliforms dates back to 1968; however, there was no established connection between indicator levels and public health risk. In 1986, EPA published their recommended criteria for marine and fresh recreational waters based on an epidemiological study showing the correlation between observed illness levels in swimmers and the corresponding levels of enterococci and *E. coli* for fresh waters and enterococci for marine waters. In this study, illness rates were different in fresh and marine waters and different criteria values were provided based on the intensity of use of the water body. In 1988, in response to the new recommended criteria, Hawaii began using enterococci as a fecal indicator in marine recreational waters while maintaining fecal coliforms as the fecal indicators in inland waters. In 2004, Hawaii ended the

use of fecal coliforms as a fecal indicator in inland waters and enterococci became the sole indicator in all recreational waters in the state.

EPA's 2012 RWQC included data from updated and more comprehensive epidemiological studies and provided better information for the updated criteria, which is designed to be more protective than the previous 1986 criteria in that it now provides similar protection for users of fresh and marine waters. EPA continues to recommend the use of enterococci and *E. coli* as indicators of fecal contamination for fresh water and enterococci for marine water. In addition to the revised criteria, EPA provides tools that states may use for site specific evaluation and management of waters, including the use of sanitary surveys, which involve the collection of information about a water body and its surrounding watershed for the purpose of cataloging physical conditions that may influence water quality in the area.

In 2014, HAR 11-54 was amended to incorporate the recommendations from the 2012 EPA RWQC (http://water.epa.gov/scitech/swguidance/standards/criteria/health/recreation/). The current recreational water quality criteria are listed in HAR 11-54-8. Previous versions of Hawaii's water quality standards specified a set of criteria for inland waters and another for marine waters; however, the 2014 revision now specifies the magnitude, duration and frequency of the exceedance of enterococci in all recreational waters (both inland and marine) based on risk management decisions allowable by the 2012 RWQC. Hawaii's recreational water quality standards now specify a geometric mean of 35 colony forming units (CFU) or most probable number (MPN)—depending on the method used—of enterococci per 100 mL over any 30-day interval with a statistical threshold value of 130 CFU or MPN of enterococci per 100 mL. The statistical threshold value may not be exceeded by more than ten percent of the samples taken within the same 30-day interval in which the geometric mean is calculated.

6.1.1.1. Problems associated with the current indicator

Enterococci are common, commensal members of gut (intestinal) communities in mammals and birds, yet they are also opportunistic pathogens that cause millions of human and animal infections annually. Because they are shed in human and animal feces, are readily culturable, and may be used to predict human health risks due to exposure to recreational waters impacted by sewage, they are used as surrogates for waterborne pathogens and as fecal indicator bacteria in research and in water quality testing throughout the world. However, research spanning more than three decades has shown that these indicator bacteria are widely distributed in a variety of environmental habitats, even when there is little or no input from human and/or animal fecal sources (Byappanahalli, M 2012). These extra-enteric habitats

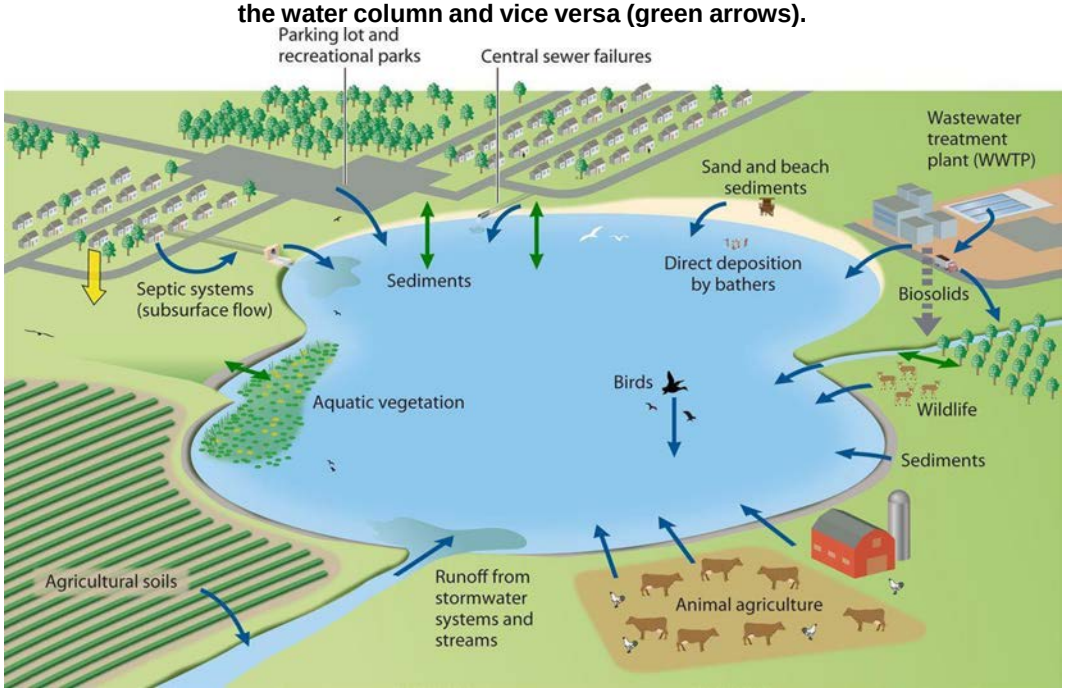
include soil and sediments, beach sand, aquatic and terrestrial vegetation, and ambient waters, including rivers, streams, and creeks.

Figure 17 illustrates the possible sources of enterococci in a waterbody, which include human sources such as sewage discharge through failures in sewage systems, improperly functioning septic systems, biosolids, stormwater runoff, and fecal shedding by recreational water users; agricultural sources through the direct deposition from farm animals or indirectly from the application of manure to the soil; and wildlife through direct deposition or runoff (birds, deer, feral animals). Some studies have shown the existence of populations of endogenous enterococci in soil, sediment and aquatic vegetation that are not of fecal origin (Byappanahalli, 2012). Sources such as soil and beach sand may retain and harbor enterococci long after the initial contamination, especially in environments in which the normal environmental stressors of these organisms are diminished.

A literature search and physical surveys of the Mahaulepu Watershed, particularly area around Waiopili Ditch conducted by the CWB revealed no evidence to demonstrate that the following were significant contributors to elevated fecal indicator levels: biosolids, wastewater treatment plants, central sewage systems, septic systems, or stormwater systems. Waiopili Ditch does, however, have agricultural soils, animal agriculture (domestic sheep), wildlife and birds. The stream also contains sediments which may harbor these organisms. The human factors that are commonly attributed to elevated levels of enterococci could not be identified.

Figure 17. Sources of Enterococci

Sources of enterococci in water bodies (blue arrows) as well as sinks where enterococci are immobilized (yellow arrow) and areas of flux, in which enterococci can transition from a reservoir to the water column and vice versa (green arrows).



Muruleedhara N. Byappanahalli et al. Microbiol. Mol. Biol. Rev. 2012;76:685-706

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In 2009, EPA conducted an epidemiological study at a beach in Boquerón, Puerto Rico. Although the study did not refine EPA's understanding of health risk associated with elevated fecal indicator bacteria levels enough to justify changing the current fecal indicator for tropical waters, a literature search by EPA in the report *Review of Fecal Indicator Organism Behavior in Ambient Waters and Alternative Indicators for Tropical Regions* (U.S. EPA, 2009c) indicates that fecal coliforms, enterococci, and *E. coli* are endemic to tropical, subtropical, and temperate regions. Other studies conducted in the tropics and subtropics show proliferation of *E. coli*, enterococci, and/or fecal coliforms in the environment that is supported by runoff due to heavy rainfall and changing environmental conditions in tidally-influenced sediments (Boehm, 2007; Byappanahalli, 2012; U.S. EPA, 2009c).

Hardina and Fujioka (1991) conducted a study to determine the source of fecal indicator bacteria in Hawaii's pristine streams. They concluded that soil was the primary source of fecal indicator bacteria in the environment in Hawaii and that soil-bound fecal indicator bacteria were transported by precipitation events into the pristine streams and rivers. These results

were based on the fact that the fecal indicator bacteria, *E. coli* and enterococci, were found in all soil samples and high concentrations of these same bacteria were found in stream water. The concentrations of fecal indicators increased as the stream flowed from the mountain to the ocean in the same manner as does the land mass area, which also had greater concentrations of fecal indicators as the land mass increased. The warmer temperature and higher nutrient concentrations of the soils served to create a microenvironment which favored the persistence and regrowth of fecal indicator bacteria (EPA 2010).

Enterococci has also been found in insects taken from nonurban, wild and cultivated fields and woods and is an important component in their intestinal flora (Martin 1972). Even termites have been shown to have enterococci in their gut (Robinson, 2010).

Enterococci flourishes in the nutrient rich and relatively protected confines of the mammalian intestinal tract; however, when they are released into the environment, they are subject to a range of environmental stressors which leads to a decline in their populations over time. Environmental stressors include sunlight (which is a major stressor in Hawaii), salinity levels, the lack of nutrients, and predation by other microorganisms. Fujioka et al. (1981) observed the effects of sunlight and salinity on fecal coliforms and fecal streptococci (i.e., enterococci) in coastal waters of Oahu. The study found that sunlight dramatically inactivated fecal indicator bacteria. Bacteria survived for days in the absence of sunlight, but in the presence of sunlight, 90% of bacteria were inactivated within 30 to 180 minutes, depending on the type of bacteria. In areas in which sunlight is limited or diminished, such as canopied areas or areas with high turbidity, enterococci have been shown to survive for extended periods. The mounting evidence for widespread extra-enteric sources and reservoirs of enterococci demonstrates the versatility of the genus Enterococcus (Byappanahalli, 2012). Basing decisions only on the detection enterococci can be misleading because the enterococci that are detected may not be due to human fecal contamination.

The EPA 2012 RWQC provides additional information to help states develop alternative water quality criteria that are scientifically defensible and protective of the primary contact recreational use. Predictive modeling, sanitary surveys, site specific water quality criteria, and quantitative microbial risk assessment (QMRA) are additional tools that can be developed and implemented. The 2012 RWQC also provided the states with the opportunity to develop alternative indicators and information on how to develop those criteria.

6.1.1.2. Secondary Tracer Organism

Overall, EPA believes that the state of the science is not developed sufficiently to distinguish environmental sources from other sources of fecal indicator bacteria on a national basis. In some circumstances, the presence of fecal indicator bacteria in water is not necessarily an indication of recent fecal contamination or potential health risk (EPA RWQC 2012). The presence of elevated levels of fecal indicators that cannot be attributable to human fecal contamination continue to confound DOH, especially during rain events in which sewer manhole overflows, sewage pump station failures, sewer line breaks have not occurred. It is speculated that soil or plant-bound indicator bacteria along the stream banks are suspended in the runoff during rain events leading to elevated concentrations of the indicators in the stream. Once these indicators have been suspended in the water, the lack of environmental stressors likely contribute to their continued detection during routine water quality monitoring despite the absence of an identifiable source of human fecal contamination.

In 1994, DOH and Dr. Roger Fujioka of the University of Hawaii, Water Resources Research Center recommended the use of a secondary tracer organism, *Clostridium perfringens* (CP) to assist in making decisions on recreational water quality. Unlike enterococci, CP is not known to replicate in the environment and is shed in fecal matter by a lesser number of animals and birds. See Attachment 10.

Although not approved by EPA as an alternative indicator, EPA has allowed DOH to use CP as a secondary tracer organism to help determine whether elevated levels of enterococci may be due to human fecal contamination; however, regulatory action cannot be taken based solely on CP concentration, rather the concentrations of both organisms must be taken into consideration. With over 20 years of data, DOH has determined that samples showing elevated levels of enterococci with low levels of CP tends to have a low association with reported or observed sewage related incidents (i.e., spills) and therefore a lower probability of human fecal contamination is associated with that sample. Likewise, if CP levels are elevated and enterococci levels are within acceptable levels, there is a low probability of human fecal contamination associated with that sample. If both enterococci and CP levels are elevated, then there is a reasonable probability of human fecal contamination and further investigation and resampling is warranted at the site.

CP is also not a perfect indicator. Although studies have shown that CP are not found in significant concentration in the fecal matter of as many animals as enterococci, some animals do harbor CP in high concentrations (Attachment 10). CP does not replicate in the presence of oxygen (i.e., is anaerobic); however, the spores that they produce provides them with a higher

tolerance to normal environmental stressors, as a result, they have been shown to remain dormant in the environment long after their initial introduction. These dormant spores are readily detectable during laboratory analyses, therefore, there is no way of knowing when the initial contamination occurred. It should be noted that CP, like enterococci, is a normal inhabitant of the human intestinal tract and is present in concentrations similar to those of enterococci.

6.1.2. Constituents of Concern

The detection of elevated levels of enterococci have prompted concerns that the Waiopili Ditch area was being subject to human fecal contamination. The enterococci detected in the MVSW is not believed to be of human origin as there is no supporting physical evidence to identify a constant source. There were no sewer lines, septic systems, WWTP, sludge disposal sites or evidence of illegal sewage discharge in the vicinity of the sampling points. There are, however, reports of people recreating in the Waita Reservoir. There is also a possibility that day visitors and unauthorized users of the area may be relieving themselves in or near the water; however, this could not be confirmed.

Within the MW, Gillin's vacation rental and the CJM Stables both have septic systems; however, both are down gradient from the sampling stations and are not believed to be significant contributors of fecal indicator bacteria in the samples collected in this survey. The sludge-forage project by Aqua Engineers ended in September 2014, and sludge is no longer being applied to the field. DOH could not verify any illegal dumping in the MW.

6.1.2.1. Animal Fecal Matter

There is concern that animal waste in Waiopili Ditch may pose a public health issue. Literature search and physical surveys of the watershed area revealed that feral pigs, sheep, chickens, Nene Geese, Hawaiian Coot, and Hawaiian Stilts are known to frequent the area; however, population densities could not be ascertained. Although no direct evidence was found, it is highly likely that rats and feral cats may also be found near the Waiopili Ditch. Beef cattle are also rotated along the slopes of the nearby mountain range.

Animals are a known source of enterococci and CP. Fujioka's 1994 study (Attachment 10) shows the concentration of indicator bacteria in the fecal matter of several animal species, including several of the animal species found in the MW. Chickens were found to have the highest concentration of enterococci per gram of fecal matter followed by pigs and rats. Ducks, pigs, cats and sheep were found to have the highest concentration of CP per gram of fecal matter. All of these animals are known or suspected of frequenting the area. Of all the animals tested in

the study, cattle was found to have relatively low concentrations of enterococci in their fecal material.

Fecal contamination of fresh water bodies from animal sources has long been a concern; however, risks due to exposure to recreational water bodies impacted by sources other than humans are not well understood. Even in human impacted waters, the primary etiologic agents (i.e., specific pathogens) as well as the relationship between exposure and infection and infection and illness are not well understood. EPA has known that risks to swimmers in fresh water bodies contaminated by fecal material differ depending on the source of the excreta (human or animal) because the pathogens in animal manure differ in type, occurrence, and abundance from those in human sewage (WHO, 2004b). Furthermore, the routes by which zoonoses (diseases transmittable to humans from animals) reach swimmers can differ from the manner in which human enteric pathogens do (e.g., intermittent rainfall transport as compared to wastewater treatment effluent with relatively constant flow). Under the Beach Act of 2000, EPA committed to conduct studies which more closely associated pathogens with human health. Epidemiological studies alone cannot provide sufficient sensitivity to measure all risks directly, given the many possible permutations and combinations of the various sources of contamination, the etiologic agents involved, and the various environmental characteristics.

The 2012 RWQC utilizes quantitative microbial risk assessments (QMRA) to estimate illness rates at fresh water beaches impacted by agricultural animal sources (cattle, swine, and chickens) of fecal contamination. Risk assessments provide a way to predict relative risks for various scenarios to evaluate various management actions in response to contamination in which a direct human source cannot be identified.

QMRA is a formal process, analogous to chemical risk assessments, of estimating human health risks due to exposure to microbial pathogens. It provides a scientifically accepted framework that has been used by various government agencies to evaluate drinking water, food products, biosolids, and recycled water. Because it is a numerical simulation (i.e., a model), the process cannot be completely objective, especially in the selection of the parameters to be studied and the assumptions that need to be made. One of the most important limitations is that of differential susceptibility of the population for which very little quantitative information is available.

In developing their 2012 RWQC, EPA posed two primary questions in their QMRA:

- What is the risk of illness associated with recreation in freshwater bodies impacted by agricultural animal (cattle, swine, and chicken) sources of fecal contamination during or immediately after a rain event?
- How do those risks compare to risks associated with freshwater bodies impacted by human sources of fecal contamination (sewage effluent)?

EPA used two complementary approaches in their QMRA; a traditional forward QMRA, which addresses the first question posed above, and a relative QMRA, which addresses the second question. The traditional forward QMRA method evaluated the risk associated with recreation (swimming) in water impacted by agricultural sources of fecal contamination. The study was based on land-applied fecal material that enter water through runoff following a rain event. The relative QMRA compared the risk associated with fecal contamination from agricultural animal sources to those associated with human-impacted water (i.e., agricultural sources versus sewage effluent). This method assumes that each source contributes a level of fecal indicators that is equivalent to 33 cfu/100 mL.

The predicted dominant risk agent (i.e., the specific pathogens) differ in each of the animal scenarios. The results of the forward study are summarized as follows:

- The risk of illness in cattle-impacted waters is effectively equivalent to illness associated with the current RWQC
- The risk of illness in pig-impacted water is approximately four times lower than the risk associated with the current RWQC
- The risk of illness in chicken-impacted water is approximately 300-times lower than the risk associated with the current RWQC

The results of the relative QMRA show that at the current RWQC, the predicted mean risk of illness due to exposure to:

- Cattle-impacted waters is approximately 25- to 150-times lower than the risk of illness associated with human sources of contamination
- Pig-impacted waters is approximately 30-times lower than the risk of illness associated with human sources of contamination
- Chicken-impacted waters is approximately 20- to 5000-times lower than the risk of illness associated with human sources of contamination

QMRA has been recommended as an important component of a “holistic” approach to recreational water quality assessment which includes extensive knowledge of the watershed(s), including potential pathogen sources and transport pathways. An important caveat in all risk

assessment models that use fecal indicator bacteria as surrogates is that the ratio of indicator bacteria to pathogens is highly variable in contaminating fecal material and in water samples (Ashbolt, N.J. etal 2010). QMRA is a viable complement to epidemiological studies for which epidemiological studies are not available or are impractical.

6.2. Existing Water Quality

The CWB currently does not perform routine water quality monitoring of the Waiopili Ditch or the various intermittent streams in the MVSW. The CWB historically conducted limited water quality monitoring of Mahaulepu Beach where water from the Waiopili Ditch enters the ocean; however, the lack of manpower and resources forced the CWB to focus its routine water monitoring activities on the more frequently used public beaches. Areas with low user densities and those areas that are privately owned or are subject to restricted access are given a lower priority. Waiopili Ditch is situated on private property and access to Mahaulepu Beach is limited.

Other sources of data from Mahaulepu Beach have been submitted to DOH for regulatory consideration; however, the validity of those data could not be ascertained since a valid quality assurance project plan (QAPP) was not submitted to DOH for approval prior to the data collection activities. Quality assurance measures and quality control activities were not properly documented. As a result, the data could not be considered for regulatory purposes.

Before water quality data may be accepted by DOH for possible regulatory action, the data submitter is required to provide a Quality Assurance Project Plan (QAPP) for review and approval by CWB. The QAPP must provide detailed information on the data generation process, including the procedures that the submitter will use to collect and analyze the samples. The QAPP must encompass project planning and logistics, sample collection, laboratory analyses, quality assurance and quality control (for both field and laboratory activities), data reduction, data verification, and data validation. The submitter is required to demonstrate that the data they produce are scientifically valid, and are of known and defensible quality. The data submitter must also demonstrate proficiency in the method(s) that they use for analyses. Only after the data submitter has demonstrated the ability to meet these criteria to the satisfaction of CWB will the data be considered for regulatory purposes. Using data of unknown quality for regulatory purposes could potentially lead to erroneous decisions and subject CWB to unnecessary liability, and therefore, should never be used.

6.2.1. Monitoring Program DOH Data

In response to a complaint, the CWB conducted water quality testing and found elevated levels of enterococci and CP in Waiopili Ditch; however, no obvious human sources could be readily identified during the initial sampling event. To further investigate the possible source of these elevated levels of fecal indicator bacteria in the MVSW, CWB conducted a site assessment, which included a physical survey of the area; researched the current and historic land use in the watershed; and collected five additional sets of water samples for traditional enterococci and CP testing over a period of four months. Samples were collected from the 12 sites along the ditch system in the sub-watershed shown in Figure 18. The physical boundaries of the study area is the Mahaulepu Watershed and the area of interest is the Mahaulepu Valley Sub-Watershed, outlined in yellow in Figure 1. The results are shown in Table 1. The water samples collected in this study represent the Mahaulepu Valley Sub-Watershed and may include potential impact from adjacent watersheds.

It was speculated that lava tubes under the Aqua Engineers Sludge-Forage project (Figure 18) may have transported the fecal indicators to the Waiopili Ditch. Water from the Waiopili Ditch flows south, eventually reaching the Makauwahi Cave/lave tubes before flowing into the ocean. The Makauwahi Cave/lave tube was found to contain the same two endangered species as the Koloa lava tube system in the adjacent PKW. The presence of these endangered species, both of which are not known to exist outside of this series of lava tubes, indicate a high probability of a subterranean connection between the two systems. It seems reasonable to assume that if there was any percolation of bacteria from the human sludge into the lava tubes, the fecal indicators would have shown up in Makauwahi Cave/lava tube system. Likewise, if there were any contamination from the adjacent PKW entering the lave tube system, it would likely appear in the Makauwahi Cave/lave tube system.

Sediment in and near streams in tropical environments have been shown to contain fecal indicator bacteria in the absence of a known or identifiable human source, as discussed in Section 6.1.1.1. Sediment from the Waiopili Ditch was collected and tested for the presence of enterococci and CP. The results are presented on Table 2.

6.2.1.1. Microbial Source Tracking

In addition to the use of routine tests for enterococci and CP, select samples were collected to undergo microbial source tracking, a technique used to identify the origin of fecal contamination based on molecular analysis of genetic material (DNA or RNA) on fecal bacteria. The microbial source tracking used in this study examines whole water extracts for human- and ruminant-specific genetic markers on fecal bacteria and do not rely on the culturing or

identification of any microorganisms. Instead, this method is based on the detection of specific genetic markers (gene targets) unique to the host species from where the organism originated. In this study, specific host-associated (human and ruminant) gene sequences on the Bacteriodales order of bacteria (which include anaerobic, gram negative, non-spore forming rod shaped bacteria) are targeted. This group of bacteria is extremely common in the fecal matter of humans and warm blooded animals (even more so than enterococci), has been extensively studied, contain several known genetic markers for human and several common animals, and, unlike enterococci, is not known to proliferate in the environment. The use of markers for both humans and other warm blooded animals (in this case ruminants) is useful in differentiating point sources of human of sewage from non-point sources (runoff containing animal fecal matter). Microbial source tracking is one of the tools identified in the EPA 2012 RWQC that may be used to help verify the results of a sanitary survey by confirming the presumed sources of fecal contamination in a watershed. If human-specific markers are not detected, then there is a high probability that the FIB recovered using the routine culture based methods did not originate from a point source discharge of sewage, whereas if ruminant-specific markers are detected, then there is a high likelihood that the FIB originated from a non-point source. Quantitative Polymerase Chain Reaction (qPCR) is a molecular technique used to rapidly detect and quantify the relative abundance of specific DNA sequences and is an essential component in microbial source tracking method used in this study. QPCR is intended for the detection of specific microorganisms and is also currently being developed for the rapid detection of enterococci for beach notification.

Samples were collected for microbial source tracking from sites 9, 10, and 11, and two samples were collected from site 12. Additional samples were collected from the beach fronting Gillin's house, the Makauwahi Cave/lava tube system, and from the Waikomo Stream in the adjacent Poipu/Koloa watershed. The samples were analyzed for two human-specific markers (HF183 and BacHum) and two ruminant-specific markers (Rum2Bac and BacR) to determine whether the sources of the enterococci were of human or animal origin. The results are shown in Attachment 11.

Figure 18. DOH Sampling Sites in Mahaulepu



Source: DOH 2015

6.2.2. Evaluation of Monitoring Data

Samples for enterococci and CP could not be collected from all sites during all sampling events due to the lack of water at some of the sampling sites.

Two intermittent streams flow off the mountain range and onto the valley floor at sites 1 and 2 and enter into an irrigation ditch system (Waiopili Ditch). Intermittent streams are defined in HAR 11-54 as *fresh waters flowing in defined natural channels only during part of the year or season and include many tributaries of perennial streams*. Intermittent streams typically flow after heavy or steady rain or may be attached to natural basins or man-made reservoirs. When these reservoirs exceed their maximum capacity, water spills over and flows to lower ground via these temporary streams. Most of the time, these streams are dry.

The source at site 3 is a well located just to the east of that site which flows toward sites 5 and 8. Site 6, also an intermittent stream, is normally dry and only flows during or after heavy rain events. Samples could not be collected from site 6 during any of the sampling events. Water from the Waita Reservoir, located in an adjacent sub-watershed west of MVSW, flows through

site 7 and mixes with site 8 and flows to site 9. Water from the Waita Reservoir also flows through site 3 and to Mahaulepu Reservoir near site 1. Flows from sites 1, 2, 4, and 5A converge at Site 10 and mixes with flows from sites 3, 5, 6 (when it flows), 7, 8, and 9. The combined flow from the upper watershed flows to Warner Dam and then to sites 11 and 12 before entering the ocean at Mahaulepu Beach.

Just upstream from site 11 is a weir like structure fronting (makai of) Warner Dam. The weir acts as the point of transition where Waiopili Ditch becomes heavily canopied from the weir, through sites 11 to 12, and to Mahaulepu Beach. The twelve monitoring stations were established from the head of Mahaulepu Valley, down through Warner Dam, to the Bridge to Makauwahi Cave.

Tabulated numerical results are shown on Tables 1 and 2. Graphical representation of the enterococci and CP geometric mean results are shown on Figure 19. Site 6 did not have any flow during the five sampling trips, therefore no samples were collected. Site 1 could only be sampled on the first sampling event. Sites 2 and 3 flowed on the first two sampling events but not on the 3rd, 4th or 5th. Site 3 only flowed on the first three sampling events. The geometric mean of all samples that were collected for enterococci exceeded the recreational water quality standard of 35 mpn/100 mL and all but 3 samples exceeded the statistical threshold value of 130 mpn/100 mL. Three of the five samples collected from sites 11 and 12 exceeded the method detection limit (2005 mpn/100 mL) therefore the geometric mean from those samples were calculated using the maximum detection limit.

The results show a clear trend of an increasing enterococci concentration towards the stream mouth. The dense vegetation extending along sampling sites 11 and 12 near the estuary forms a canopy over the stream segment, blocking out a large portion of sunlight to the area. There is also a high degree of turbidity in the area as may be seen Figures 20, 21, and 22. This area is believed to serve as a protective barrier to the natural inactivation of the indicator bacteria by sunlight, thereby leading to their elevated concentration.

The geometric mean of the secondary tracer, *Clostridium perfringens*, did not show a similar increase in density towards the estuary. Overall, the concentrations of the secondary tracer were relatively low at all sampling sites. The evaluation of more than 20 years of collective CP data by CWB indicates that the concentrations obtained cannot be directly attributable to active human sewage contamination. It is expected that human sewage contamination would yield much higher and more consistent levels of CP from each of the sampling sites.

Table 1. Enterococci Levels in Mahaulepu Valley Sub-Watershed

Enterococci MPN/100ml						
Site Number	11/6/2014	11/24/2014	12/15/2014	2/10/2015	3/3/2015	**Geo Mean**
1	697	ns	ns	ns	ns	697.00
2	429	207	ns	ns	ns	298.00
3	164	111	429	ns	ns	198.40
4	344	42	ns	ns	ns	120.20
5	453	207	831	164	75	249.07
5a	429	782	593	697	624	612.95
6	ns	ns	ns	ns	ns	
7	406	178	831	406	1091	484.15
8	178	478	137	624	591	336.25
9	560	306	945	504	1652	669.82
10	560	1013	478	406	591	578.99
11	2005*	2005*	2005*	782	885	1410.26
12	2005*	2005*	2005*	1445	1847	1847.29

ns = no sample; sample could not be collected due to the lack of water at the monitoring station
* = exceeded the detection limit (2005)

Source: DOH, CWB, March 2015

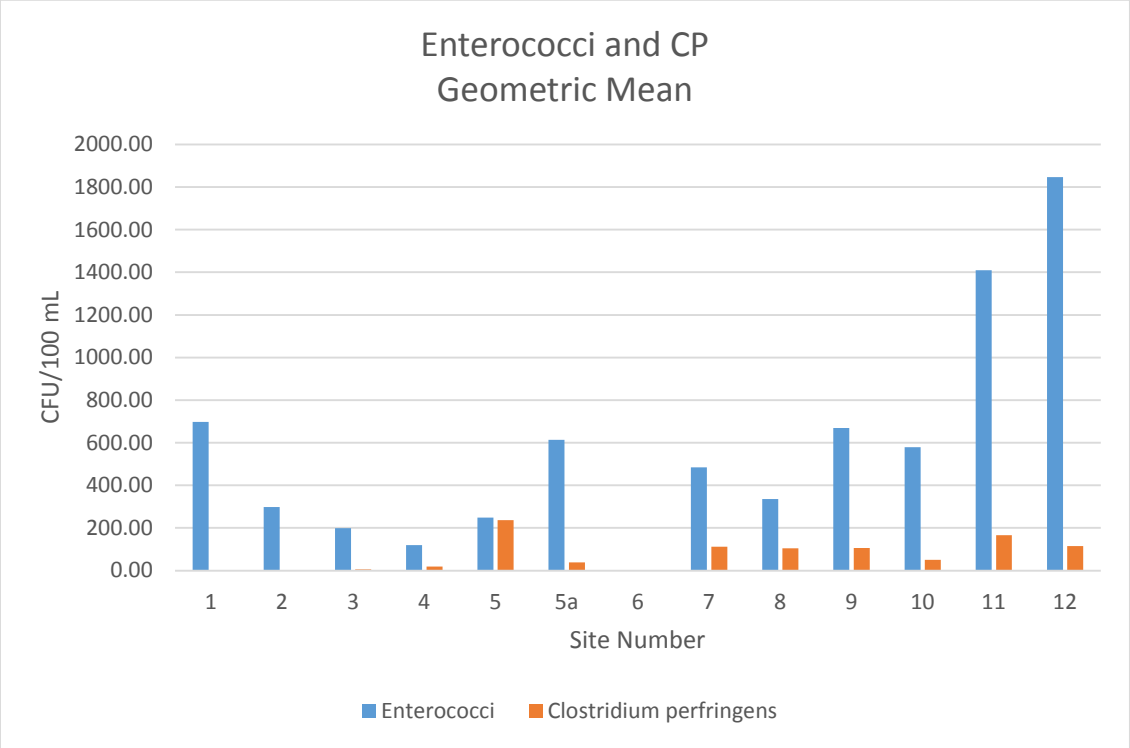
Table 2. Clostridium perfringens Levels in Mahaulepu Valley Sub-Watershed

***Clostridium perfringens* CFU/100ml**						
Site Number	11/6/2014	11/24/2014	12/15/2014	2/10/2015	3/3/2015	**Geo Mean**
1	2	ns	ns	ns	ns	2.00
2	1	1	ns	ns	ns	1.00
3	58	2	1	ns	ns	4.88
4	6	60	ns	ns	ns	18.97
5	600	240	380	90	150	236.43
5a	32	40	36	42	46	38.90
6	ns	ns	ns	ns	ns	
7	24	310	55	108	400	112.07
8	900	48	230	44	28	104.13
9	90	190	100	36	210	105.27
10	30	46	66	62	54	49.76
11	80	340	210	195	115	166.53
12	74	175	130	105	110	114.22

ns = no sample; sample could not be collected due to the lack of water at the monitoring station

Source: DOH, CWB, March 2015

Figure 19. Enterococci and Clostridum perfringens Geometric Mean



Source: DOH, CWB, March 2015

Bacteriological testing of water from Makauwahi Cave to determine the potential impact due to the sludge forage project show enterococci levels of 87 mpn/100ml and CP levels of 1 cfu/100ml. These levels are significantly lower than those found in sewage sludge and significantly lower than those found in the other sampling sites and indicate that the activities due to the former sludge forage project does not appear to significantly contribute to the elevated levels of indicator bacteria in the Waiopili Ditch.

Sediment from the Waiopili Ditch was tested for the presence of enterococci and CP. High levels of enterococci and CP were found in the sediment as shown on Table 2. It should be noted that the results of the sediment samples cannot be directly compared to those from the water samples; the Hawaii recreational water quality criteria for enterococci as specified in HAR 11-54-8, only apply to enterococci concentration in water. It can, however, be inferred that high concentrations of the indicator in the sediment may lead to elevated concentrations in the water column if the sediment is disturbed (by turbulence due to storm water flow or due to human or animal activity) which may re-suspend the organisms in the water column. It has been shown that traditional fecal indicator bacteria can survive in the environment; however, it

is not possible at this time to determine when the indicators were initially introduced in this environment.

Table 3. Waiopili Ditch Sediment Sampling Results

	Sample Date: 2/10/15		Sample Date: 3/3/15	
Sample Location	*C. perfringens* (cfu/gram)*	Enterococci (mpn/gram)*	*C. perfringens* (cfu/gram)*	Enterococci (mpn/gram)*
Site #10	2,200	1,218	1,600	1,779
Site #11	1,300	721	920	686
Site #11b	3,200	4,435	2,600	654
Site #11c	670	37	300	40
Site #12	3,700	1,127	3,400	3,757

** = Dry weight*

Source: DOH, CWB 2015

Note that Site 11c shows a lower recovery for both enterococci and CP than the rest of the sites on both sampling days. Site 11c is just upstream of the weir in the photo below and is exposed to sunlight/UV, which is believed to have contributed to the lower recovery.

Figure 20. Site 11c



Source: DOH, CWB, November 2014

Figure 21. Site 11b



Source: DOH, CWB, March 2015

Figure 22. Waiopili Ditch Mouth and Beach



Source: DOH, CWB 2014 (Note trail used by CJM Stables for horse tail rides)

6.2.2. Monitoring Data, Molecular Source Tracking

A total of 8 samples were collected from sites 9, 10, 11, Gillin's beach, Makauwahi Cave, and two samples from site 12. A sample was also collected from the Waikomo Stream in the adjacent Poipu/Koloa watershed. The samples were prepared by DOH Kauai lab for molecular source tracking (MST) analysis. The prepared samples were sent to Dr. Alexandria Boehm, Stanford University for MST analysis.

The MST analysis (Attachment 11) shows that enterococci were detected in all of the samples with the lowest concentration measured in the Makauwahi Cave and the highest at Gillin's beach.

Both human markers were positively detected, but were below the limit of quantitation (BLOQ) in sites 10 and 11 as well as at Gillin's beach. One human marker (HF183) was detected and quantifiable in the first sample collected from site 12, but BLOQ for the second human marker (BacHum). HF183 was detected (BLOQ) from the second sample collected from site 12

(collected 10 months later), but the BacHum was not detected. Human markers were not detected from the Waikomo Stream sample.

Site 9 contained both ruminant markers at concentrations approximately 200 to 500 copies / filter. The ruminant marker Rum2Bac was detected in site 11 and both samples from site 12. The marker was not detected in site 10, Makauwahi Cave, or from Waikomo Stream. The ruminant marker BacR was detected in sites 10, 11, Gillin's Beach, the Makauwahi Cave, and the second sample from site 12. BacR was not detected in the second sample of site 12, and from Waikomo Stream.

6.2.2.1. Discussion of MST Findings

These results suggest that both ruminants and humans likely contribute to contamination in the area in which the samples were taken. The levels of the human markers were low (BLOQ) most of the time. Generally, much higher levels of these markers –certainly in quantifiable amounts— are expected in areas that are significantly impacted by animal or fecal contamination. In all of these sites, enterococci was detected using both molecular (qPCR) as well as the traditional method employed by DOH (Enterolert).

It is difficult to draw a definitive conclusion from this dataset. The results of this MST study indicate that there is at least a potential for human and ruminant fecal impact in sites 10, 11, 12 and Gillin's beach, and a less likely potential of human fecal impact in site 9 and the Makauwahi cave. The results indicate the least potential of human or ruminant fecal impact to the Waikomo Stream.

Since this is a fairly new and emerging technique, there is still debate on how to best interpret these results; however, at least one study has indicated that the recovery of low levels of human markers (BLOQ) may be useful in source identification. Dr. Boehm suggests that validation studies be performed in the watershed to ensure that cross reactions of the markers do not occur with non-targeted host feces (i.e., to ensure that feces from animals other than humans and ruminants do not cross react with the genetic markers). Although the markers used in this study was extensively studied in California and other locations and show little or no cross reactivity with other host feces, they have not been as well studied in Hawaii. More samples will need to be collected and analyzed to develop a more robust dataset from which a more definitive conclusion may be drawn; however, this technique is rather costly and the development of such a database will likely take place slowly over time.

MST markers are being implemented around the world to better understand sources of fecal pollution, yet interpreting MST marker concentrations remain challenging. Overall, qPCR results for enterococci have generally correlated well with illness rates at sites impacted by point sources; however, the correlation is not as well established for nonpoint sources and evidence of health effects has been thus far conflicting.

6.3. Additional WQ Monitoring in Progress

Two studies are currently underway that may help to determine the source of the elevated enterococci levels within the Mahaulepu watershed. The results of these highly specialized studies were not available in time for this report.

6.3.1. USGS

The U.S. Geological survey (USGS), Pacific Islands Water Science Center has successfully developed for the DOH a multi-tracer approach to detecting nutrient and wastewater compounds in streams and coastal waters. The proof of concept for this approach was first developed at Kualoa, Oahu, tested at Honokohau, Kona, and then refined at Kihei and Lahaina on Maui. These projects were an extension/implantation phase of the multi-tracer approach developed by the USGS for DOH.

For data consistency, analytical services for pharmaceuticals and wastewater indicator compounds will be provided by the USGS National Water Quality Laboratory and the USGS Reston Stable Isotope Laboratory. Seven environmental samples and one blank were collected and are being tested for the presence of pharmaceuticals compounds, wastewater indicator compounds, nutrients, stable isotopes of hydrogen and oxygen in water, and stable isotopes of nitrogen and oxygen in nitrate. Sampling was completed on October 28, 2015 at the targeted sites in the MVSW and the PKW. The samples are currently being analyzed at their respective labs. The results are expected later in 2016.

The proposed dairy has a draft monitoring program that may be revised in their Voluntary EIS. In the public interest, DOH will continue to monitor Waiopili Ditch and the adjacent water bodies. DOH has met with major Poipu Resort injection well owners to discuss access through their properties to coastal sites. All Poipu beach sites will need to be monitored to determine what impacts the injection wells and OSDS have on Poipu recreational waters.

6.3.2. UC Berkeley PhyloChip

DOH is actively pursuing the application of the Lawrence Berkeley National Laboratory's PhyloChip as a microbial source tracking diagnostic tool in MW and the PKW with the assistance

of EPA Region IX. The PhyloChip assay is a test that detects variable gene sequences in bacterial species using a hybridization approach and is able to provide in-depth classification of a wide variety of microorganisms. Whereas conventional methods for microbial source tracking typically use single, or a few molecular markers to identify or exclude sources, this high density microarray based assay can contain over one million discrete probes per chip, each capable of detecting a specific gene sequence and is able to potentially detect and differentiate all microbial species of interest within a sample. This assay has been used to measure the total diversity of fecal microbial communities and has been shown to distinguish fecal bacteria from human sources from those of various animals. The inventors of the PhyloChip, Dr. Gary Anderson and Dr. Eric Dubinsky, EPA Region IX staff, and CWB have reached an agreement on a project plan. The plan and contract is currently being reviewed by DOH and will end on February 28, 2017.

7.0. Conclusions

This sanitary survey has confirmed the presence of elevated levels of enterococci and *Clostridium perfringens* in the Waiopili Ditch in the Mahaulepu Valley sub-watershed. Physical site surveillance and literature review on the current and historic land use of the area has failed to identify a defined source of human sewage contamination in the area that would justify the elevated levels of enterococci.

There has been concern regarding the reliability of the use of enterococci as an indicator of sewage contamination. Sources have reported the presence of naturally occurring fecal indicator bacteria in tropical environments in the absence of sewage contamination. Known non-human sources include animal, plants, soil and decaying organic matter. It is speculated that these factors all contribute to the elevated recovery of enterococci in the area and that animals may play a major role. Studies have shown that animals may serve as a source of enterococci in water; however, EPA has found that, in general, the median risk of illness from recreational exposure to water impacted by animals is significantly lower than the risk due to water impacted by sewage. To definitively determine whether the animals in this specific area pose a significant risk of illness to humans, a site-specific risk assessment must be performed; however, such a process is cost-prohibitive and resource intensive and is unrealistic for this location at this time given that the area is not a heavily used recreational area and is subject to restricted access.

Fecal indicator bacteria introduced into the environment, regardless of the initial source, may survive in the environment long after the initial contamination event. The survival of these indicators in the environment has been shown to be dependent on environmental stressors, including the amount of ultraviolet (UV) radiation from the sun, the salinity of the water, availability of nutrients, and the presence predatory microorganisms that feed on the indicator bacteria. UV radiation has been identified as a major environmental stressor which leads to the most significant reduction in the recovery of the indicators. Several factors affect the degree to which the indicators are exposed to UV radiation (and thereby impacting their survival in the environment), including the presence of a layer of vegetative canopy over the waterbody and the turbidity of the water, both of which physically inhibit the amount of UV reaching the organisms. Sediment in the water also serve to protect the indicators from exposure to UV radiation as well as provide protection from predatory microorganisms. These factors are believed to be contributing to the elevated levels of fecal indicator bacteria encountered in the survey area, especially at sites 11 and 12.

Hawaii's water quality standards at HAR 11-54-8e, specifies that raw or inadequately treated sewage or other pollutants of public health significance, as determined by the director of health, shall not be present in natural public swimming, bathing or wading areas and that warning signs shall be posted at locations where human sewage has been identified as temporarily contributing to the enterococci count. In this sanitary survey, no direct sources of human sewage could be identified within the sub-watershed that would lead to the elevated levels of fecal indicators within the Waiopili Ditch. Historic documents show that the entire MVSW was once used for the production of sugar cane and remnants of the irrigation ditches used at the time still exist throughout the sub-watershed (see section 3.1.2). Former stream channels were dredged, straightened, and channelized forming what is now Waiopili Ditch. It is clear from historical documentation that irrigation was the primary purpose of this ditch system. The ditch still serves this purpose today, albeit on a much smaller scale, serving the taro farms and the propagation of forage crop for grazing animals; however, with the decline and final abandonment of the sugar plantation, the amount of water drawn for irrigation purposes has dwindled but water still flows through the ditch system and into the ocean. It is clear from historical documents that this ditch system was never meant to serve as a recreational water body. There was no evidence identified in this survey to indicate that the water at the sampling sites or along the Waiopili Ditch system are currently used for public swimming, bathing or wading. The lower reaches of the ditch is man-made for the purpose of draining the once present Kapunakea pond. The low flow conditions of the Waiopili Ditch as well as its shallow depth makes it impracticable for recreational uses. Furthermore, the area identified in the sub-watershed is privately owned and is subject to restricted access. For these reasons, the DOH does not believe that the posting of warning signs at any of the locations in the Mahaulepu Valley sub-watershed or along the Waiopili Ditch in accordance with HAR 11-54-8 is warranted.

Figure 23. Landscape View of Waiopili Ditch Mouth



Source: DOH, CWB 2015

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9.0. Attachments

Attachment 1: Species of the Genus Enterococci in Their Known Habitats

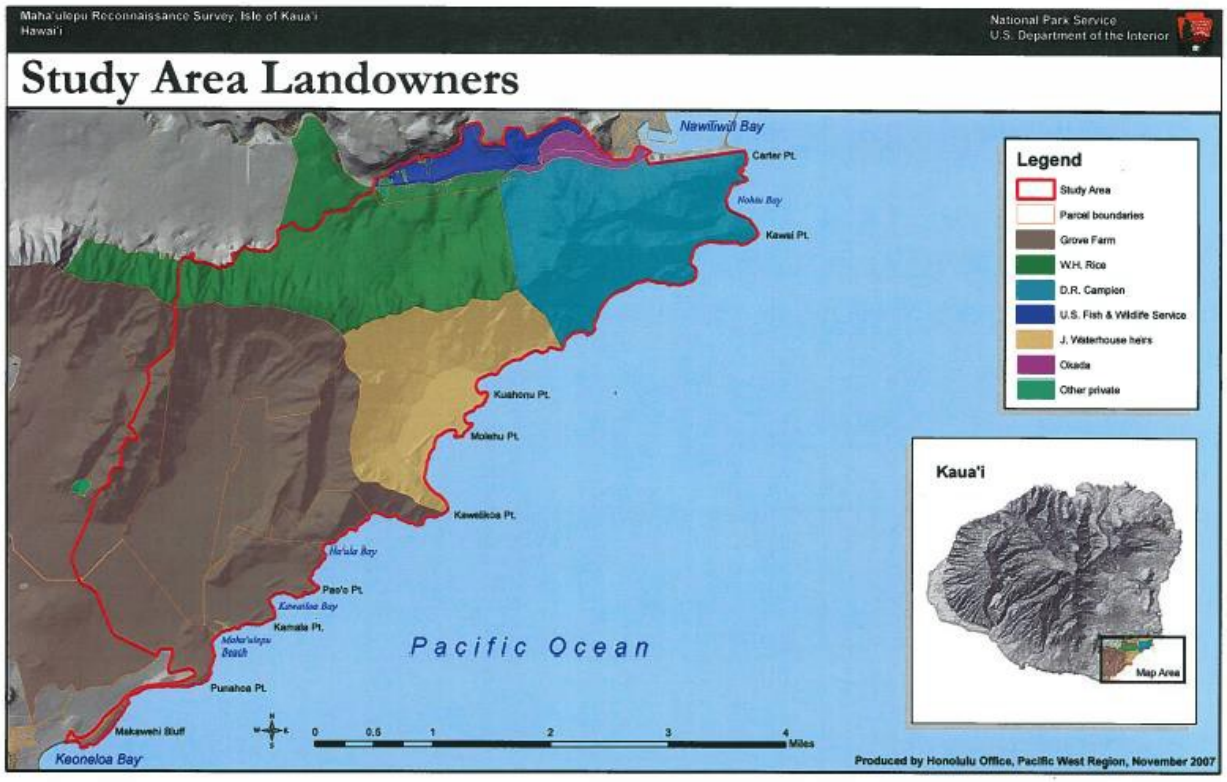
Group	Species	Known habitats	Human pathogen	Reference(s)
E. faecalis	*E. faecalis*	Human, animal (multiple), plant, insect	Yes	70, 203, 235, 283
	E. haemoperoxidus	Surface water		320
	E. moraviensis	Surface water		320
	E. silesiacus	Drinking water		323
	E. termitis	Animal (termite)		323
	E. caccae	Human		54
E. faecium	*E. faecium*	Human, animal (multiple), plant, insect	Yes	70, 192, 203, 235, 283
	E. durans	Human, animal (multiple),	Yes	67, 70, 203
	E. hirae	Animal (multiple), plant		101, 203, 235
	E. mundtii	Soil, plant	Yes	66
	E. villorum	Animal (hog)		339
	E. canis	Animal (dog)		82
	E. ratti	Animal (rat)		324
	E. asini	Animal (donkey)		86
	E. phoeniculicola	Animal (bird)		202
	E. canintestini	Animal (dog)		243
	E. thailandicus	Human, animal (cattle)		55, 295, 316
E. avium	*E. avium*	Human, animal (multiple)	Yes	67, 121, 203, 257
	E. pseudoavium	Human		65
	E. malodoratus	Animal (cattle)		67
	E. raffinosus	Human	Yes	65, 241
	E. gilvus	Human		330
	E. pallens	Human		330
	E. hermanniensis	Animal (dog)		195
	E. devriesei	Animal (cattle)		322
	E. viikkiensis	Animal (broiler plant)		269
E. gallinarum	*E. gallinarum*	Human, animal (multiple),	Yes	67, 70, 203
	E. casseliflavus	Plant, soil, human, animal	Yes	67, 203, 239, 241
E. cecorum	*E. cecorum*	Animal (chickens)		88, 360
	E. columbae	Animal (pigeon)		87
Ungrouped	*E. saccharolyticus*	Animal (cattle)		203, 270
	E. aquimarinus	Seawater		321
	E. sulfureus	Plant		218
	E. dispar	Human		68
	E. italicus	Animal (cattle)		107
	E. camelliae	Plant		316

From: Enterococci in the Environment. Microbiology and Molecular Biology Reviews, December 2012, Volume 76, Number 4.
See: http://mmbr.asm.org/content/76/4/685.full.pdf

Attachment 2: Enterococci in Extra-Enteric Habitats

Habitat for Enterococci	Occurrence (reference(s))	Persistence/Survival (reference(s))	Growth (reference(s))	Population Genetics (reference(s))
Soil	Recovered in tropical and temperate soils (36, 40, 85, 110, 145, 237)	Persist longer than E. coli; survive longer than other FIB (37, 305)	May grow in soil under certain conditions (40, 85)	Different Enterococcus spp. have been recovered in tropical soils (40); metabolically diverse strains of Enterococcus spp. are found in soil (40, 111)
Sediment	Enterococci are found in both freshwater and marine water sediments (102, 116, 207, 252, 258)	Survive longer in sediments than in water (10, 282); found mostly in surficial layers, with no seasonal trends in distribution (258); hydrometeorological events influence the bacterial flux between sediments and water (116, 134, 282); differential survival	May grow in sediments under certain conditions (85, 102, 116)	
Beach Sand	Found in both freshwater and marine beaches (44, 120, 142, 264, 278, 363, 366); bacterial distribution is patchy over space and time (44, 142	Persists longer in moist beach sand and in nearshore and backshore areas (44)	*In situ* growth has been suggested for persistent populations of enterococci in sand (148, 205, 367)	Numerous Enterococcus spp., including E. faecalis, E. faecium, E. casseliflavus, E. mundtii, and E. hirae, have been recovered from beach

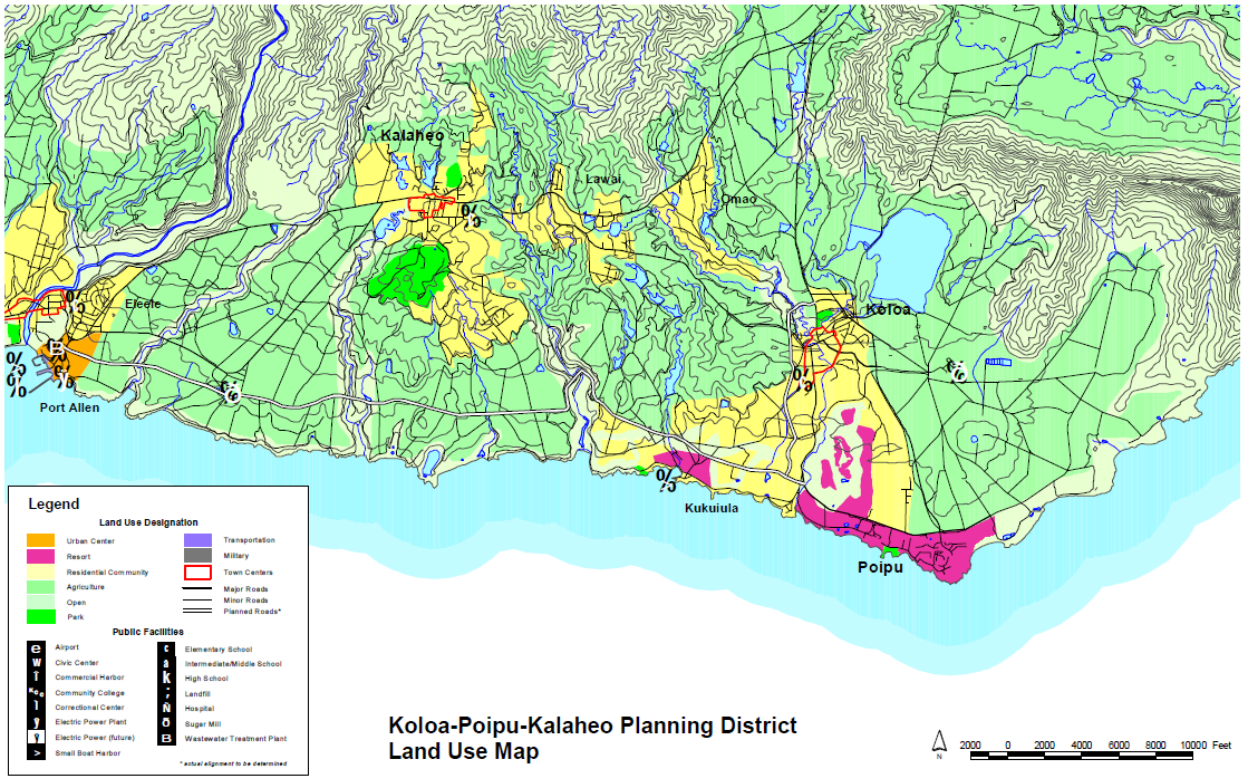
Attachment 3: Study Area Land Owners



Source: U.S. Department of Interior National Park Service, Honolulu Office, Pacific West Region, November 2007



Attachment 4: Koloa-Poipu-Kalaheo Planning District Land Use Map



Legend

Land Use Designation

- Urban Center
- Resort
- Residential Community
- Agriculture
- Open
- Park
- Transportation
- Military
- Town Centers
- Major Roads
- Minor Roads
- Planned Roads*

Public Facilities

- Airport
- Civic Center
- Commercial Harbor
- Community College
- Correctional Center
- Electric Power Plant
- Electric Power (future)
- Small Boat Harbor
- Elementary School
- Intermediate/Middle School
- High School
- Landfill
- Hospital
- Sugar Mill
- Wastewater Treatment Plant

** actual alignment to be determined*

Attachment 5: Mahaulepu Map



Attachment 6: Aerial Photos of Study Area



Source: County of Kauai Planning Department 2015



Source: County of Kauai Planning Department 2015



Source: County of Kauai Planning Department 2015

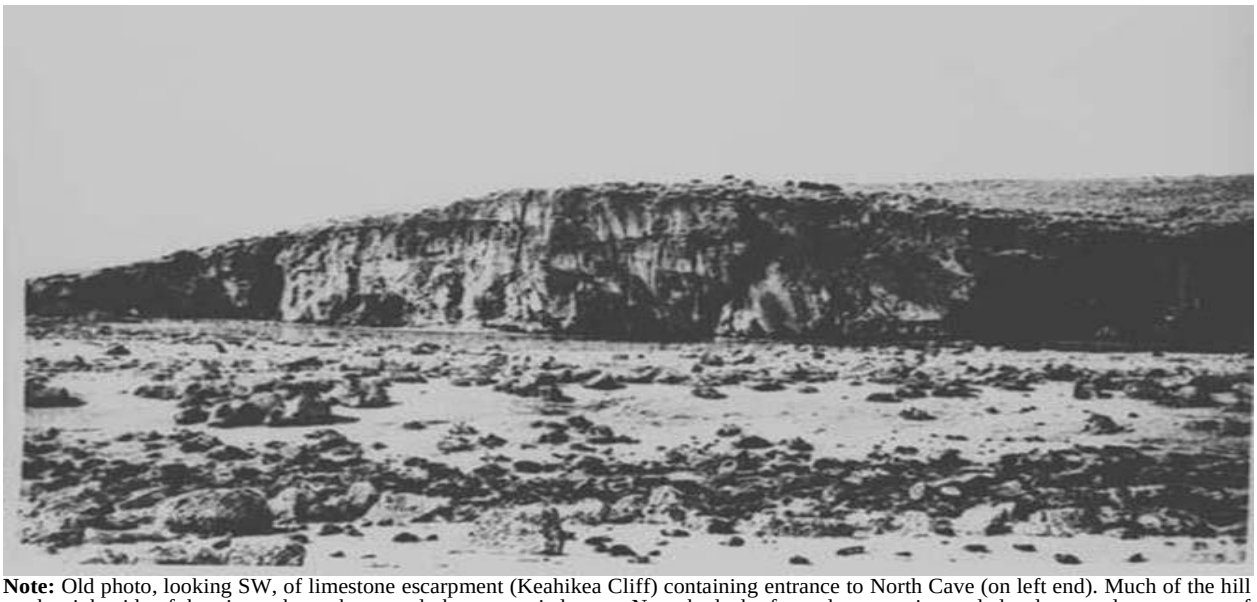


Source: County of Kauai Planning Department 2015

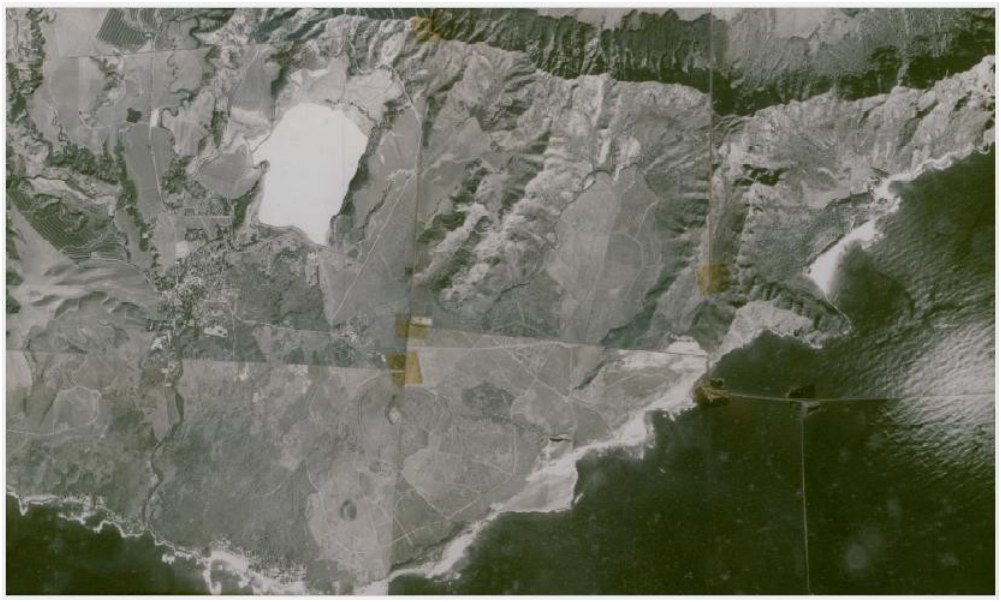
Attachment 7: Historical Kapunakea Pond and Waiopili Spring



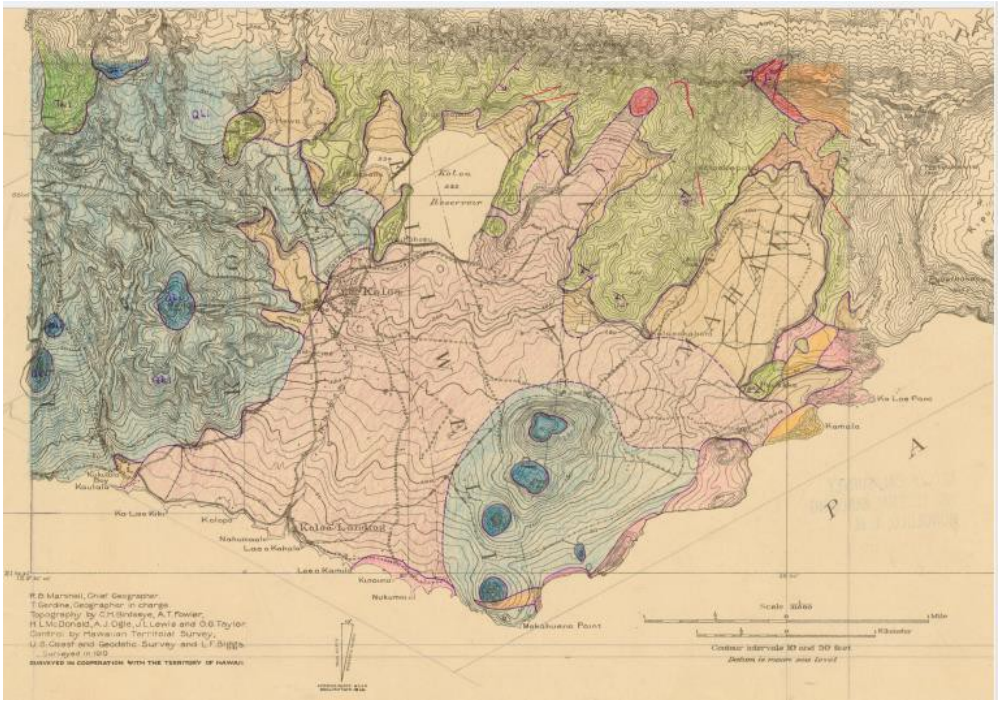
Note: This excerpt from an 1886 map shows the Makauwahi Cave area, including the large brackish pond (Kapunakea) that formerly existed on the site, as well as the sinkhole itself (indicated by arrow added by the author). Insert not to scale. (Courtesy of Grove Farm Museum)



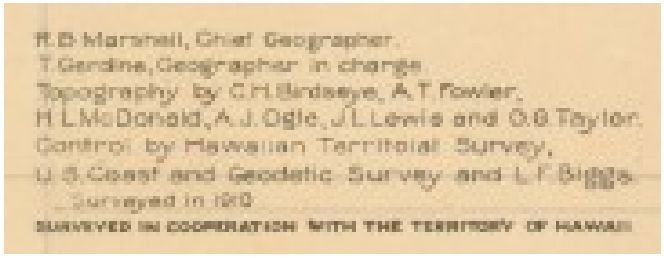
Note: Old photo, looking SW, of limestone escarpment (Keahikea Cliff) containing entrance to North Cave (on left end). Much of the hill on the right side of the picture has subsequently been quarried away. Note the lack of woody vegetation and closely grazed appearance of the landscape. Kapunakea Pond is the strip of water extending across the middle ground of the photo, up against the escarpment. Picture was probably taken between1890–1920. (Courtesy of Bernice P. Bishop Museum).



Note: 1910 Aerial Photograph of Mahaulepu, Kauai (Source: unknown)



NOTE:



R.B Marshall, Chief Geographer
T.Gerdine, Geographer in charge
Topography by C.H.Birdseye, A.T.Fowler,
H.L.McDonald, A.J.Ogle, J.L.Lewis and O.G.Taylor
Control by Hawaiian Territorial Survey,
U.S.Coast and Geodetic Survey and L.F.Biggs
Surveyed in 1910
SURVEYED IN COOPERATION WITH THE TERRITORY OF HAWAII

Attachment 8: List of Injections Wells Poipu-Koloa (Waikomo) and Mahaulepu Watersheds

PERMIT #	# OF WELL	FACILITY TYPE	FLOW gpd	FACILITY NAME	TMK #
UK-1218	1	WWD	7,000	Koloa Garden Apts SEW	4:2-6-04:033
UK-1236	1	WWD	6,000	Poipu Palms Condo	4:2-8-20:041
UK-1256	3	WWD	27,200	Nihi Kai Villas SEW	4:2-8-19:012
UK-1277	2	WWD	20,000	Whaler's Cove Condo	4:2-6-07:013
UK-1292	4	WWD	240,000	Poipu Kai STP	4:2-8-28:013
UK-1338	3	WWD	10,000	Poipu Shores Condo STP	4:2-8-19:004
UK-1387	4	WWD	0_1	Old Koloa Town STP	4:2-8-07:003
UK-1476	4	Drainage Well	*	Hyatt Regency Kauai	4:2-9-01:002
UK-1515	1	WWD	50,000***	Hyatt Regency Kauai WWTP	4:2-9-01:002
UK-1556	17	Drainage Well	*	Hyatt Regency Kauai DW	4:2-9-01:002
UK-1609	2	WWD	4,800	Alihi Lani Apts SEW	4:2-8-15:009
UK-1830	2	WWD	3,000	Poipu Makai STP	4:2-8-20:004
UK-1929	3	WWD	16,000	Waikomo Stream Villas	4:2-8-15:07&079
UK-1938	2	WWD	32,000	Makahuena Resort	4:2-8-20:003
UK-2009	1	WWD	3,000	Hale Kahanalu WWTP	4:2-8-18:027
UK-2042	2	Industrial	50,000	Up-to Date Cleaners Kauai	4:2-6-08:03
UK-2095	2	WWD	9,000	Sunset Kahili Condominium	4:2-8-19:03
UK-2103	28**	Drainage	*	Marriott Waiohai Beach Club	4:2-8-17:7,8,12&20
UK-2619	16	WWD	18,000	Hale Ohana I Apts	4:2-8-03:038
UK-2741	5	WWD	16,283	Koloa Elementary School	4:2-8-10:011
UK2620	10	WWD	9,000	Hale Ohana II Apts	4:2-8-0.3:036
UK-1348	6	WWD	92,000	Lawai Beach Resort	4:2-6-05:004
UK-2388	1	WWD	800,000	Poipu WRF	4:2-8-14:027

Source: SDWB UIC Program, July 2015 WWD = Waste Water Disposal

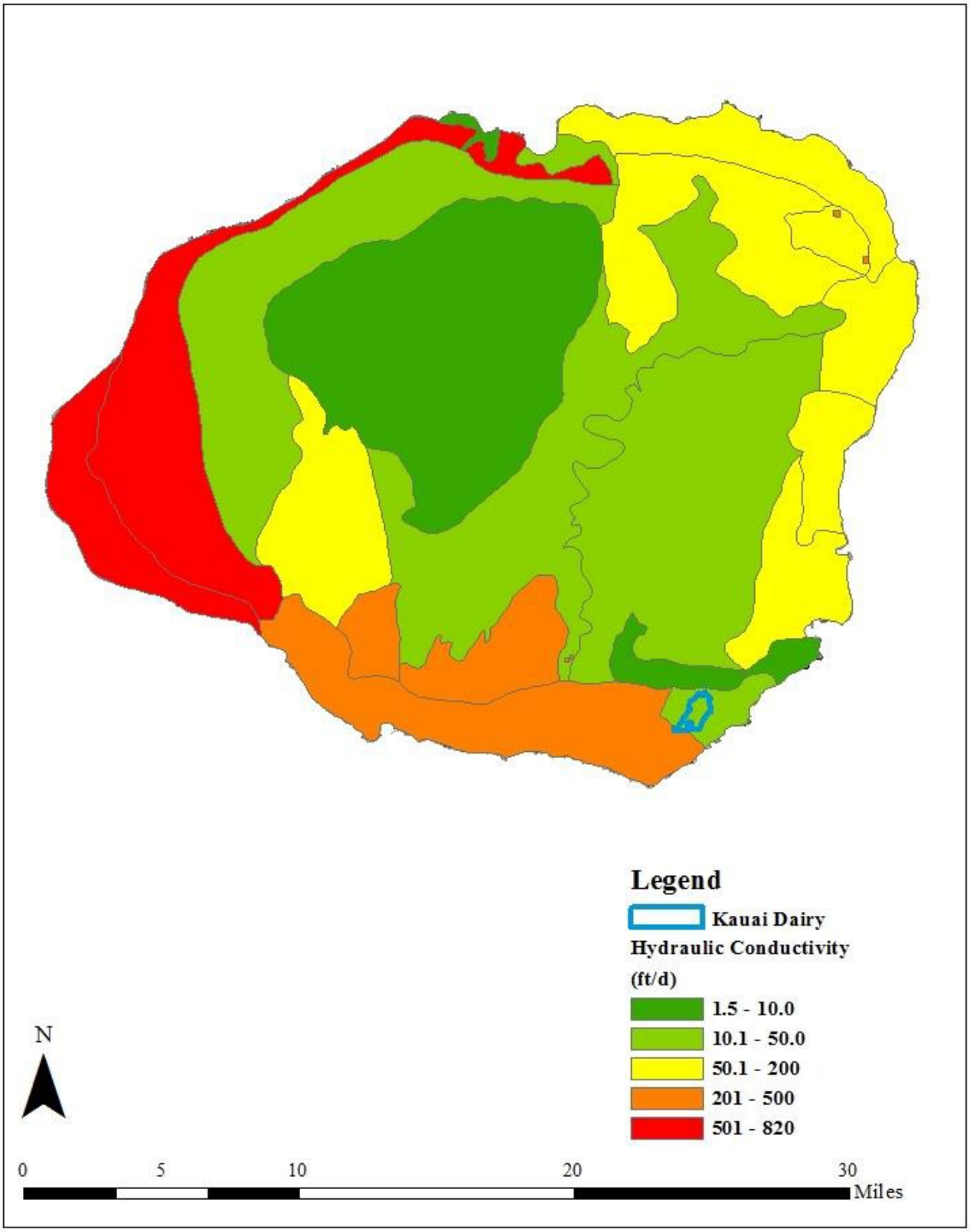
1 Abandoned but not closed

* Variable and Intermittent discharge

** Damage due to hurricane and may not be operating but permit is still open

*** Standby well to accommodate effluent not used for irrigation or water feature at Poipu Kai Golf Course

Attachment 9: Kauai Hydraulic Conductivity Map



Source: Whittier, El-Kadi 2014

Attachment 10: Concentration of Indicator Bacteria in Animal Feces

Concentrations of Indicator Bacteria in Animal Feces*
(ranked by Enterococci)

SAMPLE	BACTERIA (CFU/gram)			
	Fecal Coliform	*Escherichia coli*	Enterococci	*C. perfringens*
Chicken	1.62×10^8	1.62×10^8	3.81×10^7	<67
Pig	5.73×10^7	5.80×10^7	9.33×10^6	1.73×10^5
Rat	1.08×10^7	1.03×10^7	6.33×10^6	<67
Quail	5.40×10^7	3.40×10^7	5.80×10^6	<67
Pigeon	1.87×10^7	1.71×10^7	5.00×10^6	<67
Rabbit	1.55×10^7	1.57×10^7	3.23×10^6	<67
Mice	2.03×10^6	3.83×10^6	1.99×10^6	<67
Sheep	3.47×10^5	2.80×10^5	1.67×10^6	4.07×10^4
Duck	7.60×10^5	1.60×10^6	1.40×10^6	2.90×10^5
Cat	1.32×10^6	1.46×10^6	3.57×10^5	5.50×10^4
Monkey	1.45×10^7	2.35×10^7	1.35×10^5	<67
Dog	6.47×10^4	7.13×10^4	5.33×10^4	1.47×10^4
Cow	1.87×10^6	1.87×10^6	4.27×10^4	2.67×10^2
Guinea Pig	8.00×10^3	1.17×10^3	1.57×10^3	<67

*Fujioka, R.S., and Byappanahalli, M.N. 1996. Assessing the Applicability of USEPA Recreational Water Quality Standards to Hawaii and Other Tropical Islands. Water Resources Research Center, University of Hawaii, WRRC Project Completion Report: WRRC 96-01.

Attachment 11. Microbial Source Tracking Data

Sample ID	Location	Time Sampled	Entero1A (CE/Filter)	Entero1A SD (CE/Filter)	HF183 (Copy/Filter)	HF183 SD (Copy/Filter)	BacHum (Copy/Filter)	BacHum SD (Copy/Filter)	Rum2Bac (Copy/Filter)	Rum2Bac SD (Copy/Filter)	BacR (Copy/Filter)	BacR SD (Copy/Filter)
7/23/14---1 CO	Waiopili Ditch	8:32	73393	9380	241	106	BLOQ	NA	BLOQ	NA	ND	NA
7/23/14---2 CO	Gillin's Beach	8:50	182001	21275	BLOQ	NA	BLOQ	NA	ND	NA	BLOQ	NA
7/23/14 Blank CO	Filtration Blank	NA	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
EB	Extraction Blank	NA	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
SP5 5/26/15 Cave	Cave	8:13	673	261	ND	NA	ND	NA	ND	NA	BLOQ	NA
5/26/15 Blank	Filtration Blank	NA	BLOQ	NA	ND	NA	ND	NA	ND	NA	BLOQ	NA
5/26/15 SP1	Mahaulepu 9	7:11	2000	600	ND	NA	ND	NA	644	193	1740	453
5/26/15 SP3	Mahaulepu 11	7:46	22234	3445	BLOQ	NA	BLOQ	NA	BLOQ	NA	BLOQ	NA
5/26/15 SP2	Mahaulepu 10	7:31	913	297	BLOQ	NA	BLOQ	NA	ND	NA	BLOQ	NA
5/18/15 Blank	Filtration Blank	NA	BLOQ	NA	ND	NA	ND	NA	ND	NA	ND	NA
5/26/15 SP4	Mahaulepu 12	8:00	36443	1306	BLOQ	NA	ND	NA	BLOQ	NA	BLOQ	NA
5/26/15SP6 Waikomo	Waikomo Stream	8:50	5990	1182	ND	NA	ND	NA	ND	NA	ND	NA
EB	Extraction Blank	NA	BLOQ	NA	ND	NA	ND	NA	ND	NA	ND	NA

* Entero1A = enterococcus spp., HF183 = human specific Bacteroidales marker, BacHum = human specific Bacteroidales marker, Rum2Bac = ruminant specific marker, BacR = ruminant specific marker

* ND = non detect, NA = not applicable, BLOQ = below limit of quantification

LOQ: Entero1A = 75 CE/Filter; HF183,BacHum, Pig2Bac, Rum2Bac & BacR = 447 copies/Filter