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DEPUTY DIRECTOR

October 25, 2021

IN REPLY REFER TO:

WEC.PE 21-039

Ms. Mary Alice Evans, Director
Environmental Review Program
Office of Planning and Sustainable Development
Department of Business, Economic Development and Tourism
235 South Beretania Street, Suite 702
Honolulu, Hawaii 96813

Dear Ms. Evans:

SUBJECT: Draft Environmental Assessment and Anticipated Finding of No Significant Impact
Waianae Wastewater Treatment Plant Outfall Improvements and Rehabilitation
Waianae District, Island of Oahu, Hawaii

With this letter, the City and County of Honolulu Department of Environmental Services, Division of Wastewater Engineering and Construction hereby transmits the Draft Environmental Assessment and Anticipated Finding of No Significant Impact (DEA-AFONSI) for the proposed Waianae Wastewater Treatment Plant Outfall Improvements and Rehabilitation project on the Island of Oahu for publication in the next available edition of *The Environmental Notice*.

In addition to this letter, the Environmental Review Program's online Publication Form has been completed and submitted with one electronic copy of the DEA-AFONSI as an Adobe Acrobat PDF file.

Should you have any questions, please contact Cindy Masuoka, Project Manager of the Division of Wastewater Engineering and Construction at (808) 768-8761 or via email at cmasuoka@honolulu.gov.

Sincerely,

Wesley T. Yokoyama, P.E.
Director

From: webmaster@hawaii.gov
To: DBEDT OPSD Environmental Review Program
Subject: New online submission for The Environmental Notice
Date: Friday, October 29, 2021 3:54:23 PM

Action Name

Waianae Wastewater Treatment Plan Outfall Improvements and Rehabilitation

Type of Document/Determination

Draft environmental assessment and anticipated finding of no significant impact (DEA-AFNSI)

HRS §343-5(a) Trigger(s)

- (1) Propose the use of state or county lands or the use of state or county funds
- (2) Propose any use within any land classified as a conservation district
- (3) Propose any use within a shoreline area

Judicial district

Waiʻanae, Oʻahu

Tax Map Key(s) (TMK(s))

(1) 8-6-001:007 (por.)

Action type

Agency

Other required permits and approvals

Numerous

Proposing/determining agency

City & County of Honolulu Department of Environmental Services, Wastewater Engineering and Construction Division

Agency contact name

Cindy Masuoka

Agency contact email (for info about the action)

cmasuoka@honolulu.gov

Agency contact phone

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Agency address

1000 Uluohia Street, Suite 308
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United States
Map It

Was this submittal prepared by a consultant?

Yes

Consultant

SSFM International, Inc.

Consultant contact name

Jennifer Scheffel

Consultant contact email

jscheffel@ssfm.com

Consultant contact phone

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Consultant address

99 Aupuni Street, Suite 202
Hilo, Hawaii 96720
United States
Map It

Action summary

The City & County of Honolulu (CCH) Department of Environmental Services (ENV), Wastewater Engineering and Construction Division, proposes to install a concrete encasement structure over the existing Waianae Wastewater Treatment Plant (WWTP) outfall and cap three manholes on the existing outfall pipe in response to a 2018 inspection report that identified advancing shoreline erosion as a threat to the stability of the outfall and actively corroding cast iron manhole covers at an elevated risk of failure.

Reasons supporting determination

The Proposed Action would have no significant impact on environmental resources, as discussed in Section 5.1 of the Draft EA. All impacts would be short-term and temporary during the construction period. BMPs and other measures would be implemented to minimize impacts. Upon completion of construction, there would be beneficial impacts to the environment. The repairs to the land-based segment of the outfall and the underwater manholes would mitigate the risk of failure of the outfall that could result in a release of effluent in the nearshore waters and at the manhole locations that could impact water resources, biological resources, and cultural practices.

Attached documents (signed agency letter & EA/EIS)

- WEC.PE-21-039.pdf
- 211029-Waianae_DraftEA_forPublication.pdf

Action location map

- Waianae-WWTP-Outfall-shapefiles.zip

Authorized individual

Jennifer Scheffel

Authorization

- The above named authorized individual hereby certifies that he/she has the authority to make this submission.

Waianae District,
Island of Oahu, Hawaii

November 2021

Draft Environmental Assessment
Waianae Wastewater Treatment Plant Outfall Improvements and Rehabilitation

Prepared for:
City & County of Honolulu Department of Environmental Services
Wastewater Engineering and Construction Division

Prepared by:
SSFM International

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Draft Environmental Assessment

Waianae Wastewater Treatment Plant Outfall Improvements and Rehabilitation

Waianae District, Island of Oahu, Hawaii

Prepared for:

City & County of Honolulu Department of Environmental Services
Division of Wastewater Engineering and Construction

Prepared by:

SSFM International, Inc.

November 2021

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Project Summary

Project Name	Waianae Wastewater Treatment Plant Outfall Improvements and Rehabilitation
Location	Lualualei Beach Park, Island of Oahu, Hawaii
District	Waianae
Project Site Tax Map Key	(1) 8-6-001:007 (por.)
Landowners	State of Hawaii
Project Site Existing Uses	Recreation
State Land Use District	Urban
City & County of Honolulu Zoning	P-2, General Preservation

Proposed Action

The City & County of Honolulu (CCH) Department of Environmental Services (ENV), Wastewater Engineering and Construction Division, proposes to install a concrete encasement structure over the existing Waianae Wastewater Treatment Plant (WWTP) outfall and cap three manholes on the existing outfall pipe in response to a 2018 inspection report that identified advancing shoreline erosion as a threat to the stability of the outfall and actively corroding cast iron manhole covers at an elevated risk of failure.

The proposed project includes the following actions:

1. Installation of a concrete encasement structure over the land-based portion of the existing outfall at the shoreline. The structure would be designed to not have blunt faces on the offshore side of the structure to minimize potential for cracking or failure. This could include arcing or rounding the face, and chamfering or rounding hard edges where possible.
2. Cap three of the cast iron manhole cover plates on the original 36-inch pipeline. To protect the caps from peak lift forces from wave action, the caps would be designed to not rely exclusively on mass for stability and would incorporate some form of mechanical connection to the cap of the existing manhole riser structure or other suitable alternative.

Anticipated Impacts

As discussed in **Chapter 3.0**, the Proposed Action would have no significant impact on environmental resources. All impacts would be short-term and temporary during the construction period. BMPs and other measures would be implemented to minimize impacts. Upon completion of construction, there would be beneficial impacts to the

	environment. The repairs to the land-based segment of the outfall and the underwater manholes would mitigate the risk of failure of the outfall that could result in a release of effluent in the nearshore waters and at the manhole locations that could impact water resources, biological resources, and cultural practices.
Proposing Agency	City & County of Honolulu Department of Environmental Services, Wastewater Engineering and Construction Division
Anticipated Determination	Finding of No Significant Impact (FONSI)
Project Site Permits/ Approvals Required	Hawaii Revised Statutes Chapter 343, Environmental Assessment Hawaii Revised Statutes Chapter 6E, Historic Preservation Section 10, Rivers and Harbors Act Section 404, Clean Water Act Section 401, Water Quality Certification Conservation District Use Permit Shoreline Certification Shoreline Setback Variance Special Management Area Permit Coastal Zone Management Consistency Determination National Pollutant Discharge Elimination System, Dewatering Permit Community Noise Permit/Variance Conditional Use Permit – Minor Land Disposition
EA Preparer	SSFM International 99 Aupuni Street, Suite 202 Hilo, Hawaii 96720 Contact: Jennifer Scheffel (808) 356-1273
Consultations	
<u>*Federal*</u>	U.S. Army Corps of Engineers U.S. Fish and Wildlife Service National Marine Fisheries Service
<u>*State of Hawaii*</u>	Department of Business, Economic Development & Tourism Office of Hawaiian Affairs Department of Hawaiian Home Lands Department of Health, Clean Water Branch Department of Health, Clean Air Branch Department of Health, Indoor and Radiological Health Branch Department of Land and Natural Resources, Land Division Department of Land and Natural Resources, Historic Preservation Division Department of Transportation, Highways Division

City & County of Honolulu	Department of Parks and Recreation Department of Planning and Permitting Department of Transportation Services Honolulu Fire Department Honolulu Police Department
Elected Officials	Mayor Rick Blangiardi Councilmember Andria Tupola, Honolulu City Council District 1 Chair Sharlotte Poe, Waianae Coast Neighborhood Board No. 24

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Table of Contents

List of Figures

List of Tables

Appendices

Acronyms

$\mu g/m^3$	micrograms per cubic meter
%	percent
AAQS	Ambient Air Quality Standards
ALRFI	Archaeological Literature Review and Field Inspection
BFEs	base flood elevations
BMP	Best Management Practices
CCH	City & County of Honolulu
CHHA	Coastal High Hazard Areas
CIA	Cultural Impact Assessment
cm	centimeter
CRM	concrete rubble masonry
CWB	Clean Water Branch
CZM	Coastal Zone Management
CZMA	Coastal Zone Management Act of 1972
DAR	Division of Aquatic Resources
DBEDT	Department of Business, Economic Development & Tourism
DLNR	Department of Land and Natural Resources
DPP	Department of Planning and Permitting
DOH	Department of Health
EMS	Emergency Medical Services
ENV	Department of Environmental Services
FONSI	Finding of No Significant Impact
ft^2	square feet
GHG	greenhouse gases
HAR	Hawaii Administrative Rules
HDOT	Hawaii Department of Transportation
HFD	Honolulu Fire Department
HRS	Hawaii Revised Statutes
m/s	meters per second
MGD	million gallons per day
NAAQS	National Ambient Air Quality Standards
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NWI	National Wetland Inventory
ROH	Revised Ordinances of Honolulu
ROV	remote-operated vehicle
SEI	Sea Engineering, Inc.
SHPD	State Historic Preservation Division
SLR-XA	sea level rise exposure area
SWCA	SWCA Environmental Consultants, Inc.
USACE	U.S. Army Corps of Engineers
WWTP	Wastewater Treatment Plant

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1.0 Project Description

1.1 Introduction

The City and County of Honolulu (CCH) Department of Environmental Services (ENV), Wastewater Engineering and Construction Division, proposes to install a concrete encasement structure over the existing Waianae Wastewater Treatment Plant (WWTP) outfall to protect the pipe from progressive shoreline erosion from wave action compounded with ongoing sea level rise. In addition, three manholes along the pipe would be capped.

This project is subject to the state environmental review process prescribed under Chapter 343 (Environmental Impact Statements), Hawaii Revised Statutes (HRS), as amended, also known as the Hawaii Environmental Policy Act, and Title 11, Chapter 200.1 (Environmental Impact Statement Rules), Hawaii Administrative Rules (HAR). Under these regulations, nine specific types of actions are identified that “trigger” environmental review. This project triggers the state environmental review process under these regulations because it proposes the use of state or county lands and the use of state or county funds (HRS Section 343-5(1)).

1.2 Project Background

The Waianae WWTP serves as the primary sewage reception, treatment, and disposal facility for a large part of West Oahu. The facility utilizes a reinforced concrete pipe ocean outfall structure for conveying treated effluent from the treatment plant to offshore waters for disposal. The Waianae WWTP’s ocean outfall was initially constructed in 1965 with a 3,133-foot-long entrenched reinforced concrete pipe with a diameter of 36 inches and terminated with a 230-foot-long southward angled diffuser. Between 1982 and 1986 an extension was added to the original outfall to extend the outfall to 6,180-feet-long to meet state water quality standards. The extension section is 42-inches in diameter, is 3,051 feet long, and extends to an approximate depth of 105 feet.

The original outfall pipe was constructed with four pressure manholes (Manhole 1 through 4), with Manhole 1 located onshore. Manholes 2, 3, and 4 are located at station (STA) 10+47, 20+23, and 26+15, respectively. The extension of the outfall pipe connects to the original outfall pipe at a special wye structure and was constructed with four additional pressure manholes (Manholes A, B, C, and D). Pressure manholes A, B, C, and D are located at STA 0+00, 01+68, 11+48, 21+30, and 30+77 respectively where STA 0+00 for the added pressure MHs starts at the special wye structure.

The entire pipeline, including the original pipe, new extension, and new diffuser leg, were installed on a crushed gavel bed within a trench excavated from the reef. Once installed in the trench the reinforced concrete pipe joints were typically capped with a tremie concrete jacket. In some limited locations along the original outfall where the trench wall height was insufficient, the pipe was backfilled with small stone and then ballasted with larger armor stone.

Sea Engineering, Inc. conducted an inspection of the outfall in 2018. The inspection included the following tasks:

- High resolution multibeam bathymetric survey of the pipeline and surrounding seafloor
- External visual inspection of the entire outfall including diffuser port

- Visual inspection of Cathodic protection
- Corrosion assessment
- Stability analysis modeling

The findings of the 2018 inspection were as follows:

- Advancing shoreline erosion is threatening pipeline stability at its shoreline landing where emergency repairs were completed in 2017 to shore up an undermined section of pipe near the waterline.
- Actively corroding cast iron manhole covers on the original 36-inch pipeline are at an elevated risk of failure due to loss of effective metal thickness of the cover from long-term galvanic corrosion.

The *Waianae Wastewater Treatment Plant (WWTP) Outfall Improvements and Rehabilitation: Comprehensive Summary of Condition Assessment Activities, Final Report* is provided in **Appendix A**.

1.3 Project Location and Site Characteristics

1.3.1 Project Location

The Waianae WWTP is located approximately 1.5 miles south of Waianae Small Boat Harbor on the western shoreline of the island of Oahu, as shown in **Figure 1**. The WWTP utilizes an ocean outfall structure for conveying treated effluent from the facility to offshore waters for disposal where it is released at a water depth of 105 feet by an array of diffusers for dilution and dispersal in the water column by natural oceanographic processes. The ocean outfall makes landfall at the northern end of Mailiili Beach Park, directly across Farrington Highway from the Waianae WWTP.

1.3.2 Site Characteristics

Shoreline

The shoreline is characterized by a mix of monolithic and broken limestone formations, beach rock, coral rubble, and some limited sand pockets. The waterline follows an irregular and variegated rocky step, both up and down the shoreline, which drops sharply several feet into the water. Since the construction of the outfall in 1965, it is estimated that the shoreline south of the pipe has retreated (i.e., eroded) approximately 25 to 30 feet.

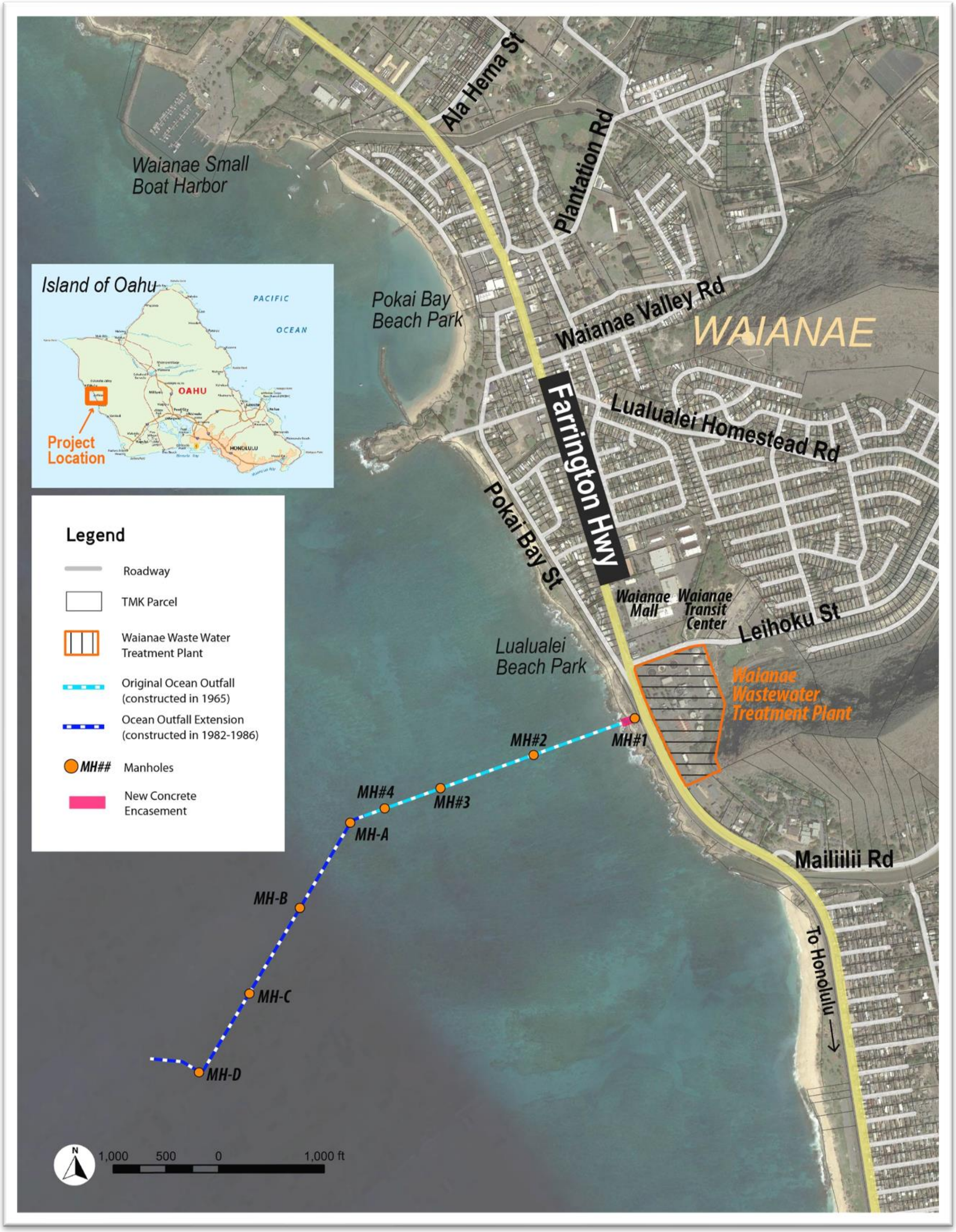
Waves

Ocean waves can generally be categorized into three groups (excluding tsunami):

- **Long period swell:** Characterized with periods[1] between 12 and 20+ seconds, generated by distant North or South Pacific storm systems.
- **Short period wind waves:** Characterized with periods between 6 and 12 seconds, generated by regional winds.
- **Unpredictable and episodic wave events:** Characterized with periods between 12 and 17 seconds, associated with intense local storms.

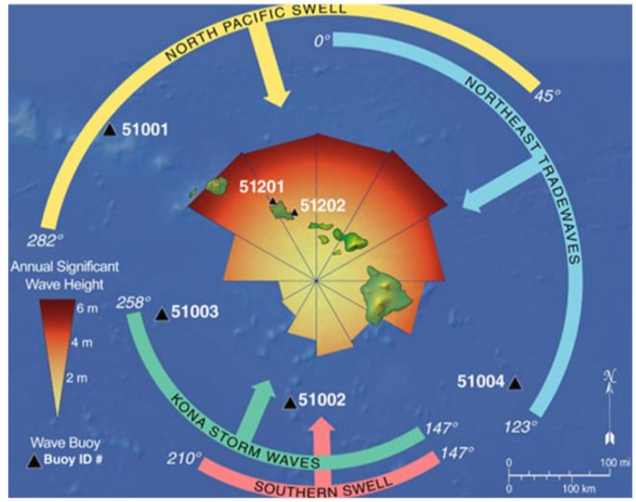
[1] Wave period is the distance between two successive wave crests passing through a stationary position, measured in time (seconds).

Figure 1. Project Location



The Hawaiian Islands receive waves from six sources:

- Northeast tradewind waves
- Southeast tradewind waves
- South swells from the southern hemisphere
- North swells from the Aleutians or other parts of the North Pacific
- Kona storm wind waves
- Hurricane waves



Wave Sources

Waves approaching a straight coastline at an angle can generate a steady longshore current, which is largely responsible for the erosion and longshore transport of sediment. The impact of this current and sediment load directly affects any structures, including portions of the existing outfall, which may interrupt the flow.

At the Waianae WWTP outfall location, the longshore current generally originates from the north in the winter months due to the arrival of waves generated by persistent north and northwest winds from large North Pacific storm systems. The longshore current direction reverses in the summer months due to exposure to southern hemisphere swell. Other components of the nearshore current include tidal currents with semi-diurnal reversing of the onshore/offshore and upcoast/downcoast flow, regional oceanic circulation patterns, and currents produced by local winds such as sea breeze or thunderstorms and squalls. The combination of these wave and current-related forces make the nearshore a very dynamic environment in terms or sediment transport and generating forces that act on coastal structures.

Breakers in the Vicinity of the Project Site

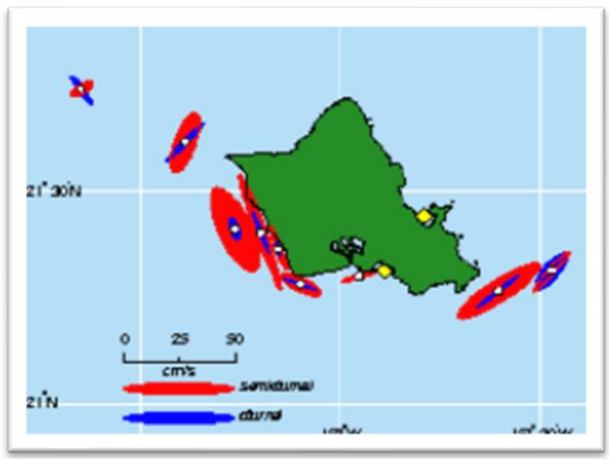
Sediment Transport and Scour

Sediment transport (longshore) and seasonal beach migration (inshore/offshore) are enabled when the water particle velocity is great enough to suspend sediment particles and transport them in agitated water as suspended-load and bed load. Eroded sand may or may not be redeposited at the same level depending on the resultant mean current and the up-current sediment supply.

Scour refers to more localized erosion that includes the depletion of sediment around offshore structures that have readily transportable sediment near their perimeters. The obstruction presented by a structure in the fluid flow causes increased flow velocities around the edges of the obstruction. The velocity of the seawater increases as it passes around the edge of the obstruction causing a localized increase in the energy which allows the seawater to transport more sediment and larger sized particles. At the Waianae WWTP outfall, the sediment available for transport is typically sand. Places such as the toe or end of ballast stones or the edge of the pipe where the flow passes around stationary or non-transportable material will be more susceptible to scour.

Tides

Tidal currents are varied around the coastal waters of Hawaii and range from weak to relatively strong depending on location. These currents are driven by tidal-based differences of sea level elevation. The resulting nearshore currents are typically stronger than the large-scale island-wide circulation patterns. Typical diurnal and semi-diurnal currents around the Island of Oahu tend to be aligned with the shoreline and reverse in direction with the changing tidal phase. Maximum tidal currents in the vicinity of the Waianae WWTP ocean outfall appear to be approximately 0.60 meter per second (m/s).



Tidal Currents around Oahu

Source: Flament et al., 1996

Evidence has suggested that tidal currents are typically much smaller inshore along the shallow reef near the surf zone in comparison to the stronger breaking wave-driven currents (SEI, 2012). Deep water waves approach the shoreline at varying angles, and as they propagate over increasingly shallower water, they begin to transform due to the effects of the following:

- **Shoaling.** Wave shoaling occurs when a wave encounters water less than half a wavelength in depth and causes the wave face to steepen and eventually break.
- **Refraction.** The bending or refracting of a wave due to the differing wave speed along-crest caused by varying bottom contours.
- **Diffraction**. The process that is responsible for wave propagation into what are thought of as shadow zones, such as behind a breakwater or headland.

1.4 Project Schedule

The following provides a timeline of tasks associated with completion of the Proposed Action:

- **December 2021:** Completion of the HRS Chapter 343 process
- **September 2022:** All permits obtained
- **March 2023:** Contractor solicitation
- **May 2023 through May 2024:** Construction

1.5 Permits and Approvals Which May Be Required for the Proposed Action

In addition to the environmental documentation requirements of HRS Chapter 343, implementation of the Proposed Action would require coordination with state and county agencies for permits or approvals as presented in **Table 1**.

Table 1. Permits and Approvals Which May Be Required for the Proposed Action

Permit or Approval	Description	Regulation(s)	Administrative Authority
Special Management Area Permit	Required for any project located within the Special Management Area	• Hawaii Revised Statutes (HRS) Chapter 205A	City & County of Honolulu (CCH), Department of Planning and Permitting (DPP)
Conservation District Use Permit	Required for any project within the designated conservation district, which includes the land and marine waters makai of the certified shoreline.	• Title 13 Hawaii Administrative Rules (HAR) Chapter 5 • HRS Chapter 183C	Department of Land and Natural Resources (DLNR), Land Division
Shoreline Certification	Required to determine the shoreline for purposes of implementing the shoreline setback law.	• Title 13 HAR Chapter 222	DLNR, Land Division
Shoreline Setback Variance	Required for projects located within the shoreline setback (40 feet inland from the certified shoreline)	• HAR Chapter 205A • Revised Ordinances of Honolulu (ROH), Chapter 23	CCH-DPP
Section 404 Individual Permit	Required for any project that will discharge dredged or fill material into waters of the United States.	• Clean Water Act, Section 404	U.S. Army Corps of Engineers (USACE)
Section 10	Required for any structure in or over any navigable water of the United States.	• Rivers and Harbors Act, Section 10	USACE
Section 401 Water Quality Certification	Required for all projects that require a federal permit or may result in discharge into State waters.	• Clean Water Act, Section 401 • HAR Section 11-54	Department of Health (DOH), Clean Water Branch (CWB)

Permit or Approval	Description	Regulation(s)	Administrative Authority
National Pollutant Discharge Elimination System, Notice of Intent	Form C required for stormwater discharge associated with construction activities that disturb one (1) acre or more of total land area.	• Clean Water Act, Section 401 • Title 11 HAR Chapter 55	DOH-CWB
National Pollutant Discharge Elimination System, Dewatering Permit	Form G required for discharges associated with construction activity dewatering.	• Title 11 HAR Chapter 55	DOH-CWB
Community Noise Permit/Community Noise Variance	Required for construction projects exceeding 78 decibels (dBA) or those that have a total cost of more than $250,000.	• HRS Chapter 342F • Title 11 HAR Chapter 46	DOH, Indoor and Radiological Health Branch
Grading Permit	Required when excavating or filling earth materials (rock, coral, gravel, soil, recycled asphalt pavement) greater than 3 feet in height, or greater than 50 cubic yards in volume, or to redirect existing surface runoff patterns with respect to adjacent properties.	• Revised Ordinances of Honolulu, Chapter 14, Articles 13 through 16	CCH-DPP
Permit to Operate Oversized and Overweight Vehicles on State Highways	Required for any use of oversized/overweight equipment or loads on State highways.	• HRS Chapter 291, Section 36	Department of Transportation, Highways Division
Coastal Zone Management Consistency Determination	Required for any projects that affect any coastal use or resource.	• HRS Chapter 205A	State of Hawaii Office of Planning
Land Disposition	Required for projects encroaching on State Land.	• HRS Chapter 171	DLNR, Land Board
Special Activity Permit	Required for removal and relocation of stony corals and/or live rock.	• HRS Chapter 187A-6	DLNR, Division of Aquatic Resources

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2.0 Proposed Action and Alternatives

2.1 Purpose and Need

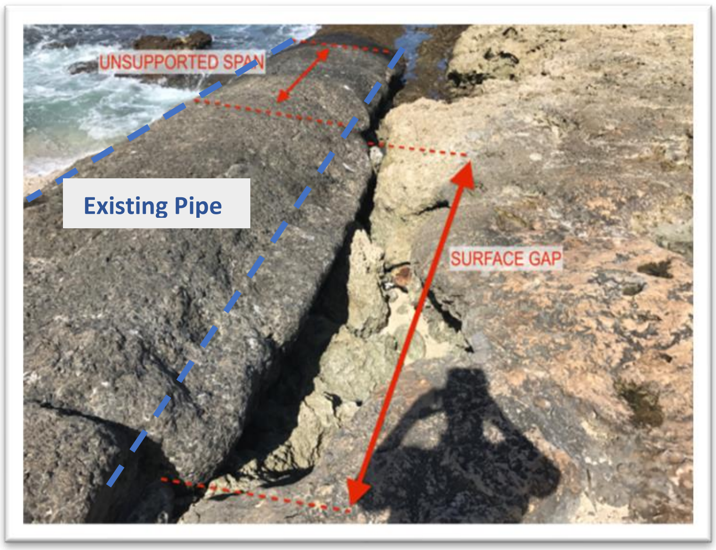
2.1.1 Purpose of the Proposed Action

The Purpose of the Proposed Action is to minimize shoreline erosion at the Waianae WWTP outfall pipeline's ocean entry and to make permanent repairs to the offshore section of the outfall pipeline to ensure the continued operation of the outfall with minimal maintenance.

2.1.2 Need for the Proposed Action

Since the construction of the outfall in 1965, it is estimated that the shoreline south of the pipe has retreated (i.e., eroded) approximately 25 to 30 feet. The existing shoreline adjacent to the outfall pipe has experienced significant erosion since its original construction. The entire mass of rock adjacent to the waterline along the southern flank of the outfall pipe has been fractured, broken up, and eroded away from the pipe.

Sea Engineering, Inc., (SEI) conducted visual inspections of the outfall pipe's landfall and shoreline location on three separate visits: August 2015, June 2017, and July 2017. These observations revealed that an approximate 20-foot-long section of the 36-inch pipe was unsupported with a gap of up to one foot from the bottom of the pipe to the substrate. Approximately 20 to 30 feet landward, on the north flank of the pipeline, a gap or void space between the existing trench wall and grout jacket was also observed. Additional void spaces were observed seaward on the north flank of the pipeline.



Surface gap and voids along north flank of outfall pipe

The outfall's 36-inch-diameter reinforced concrete pipe was designed and intended to be continuously supported on a stable layer of bedding material. Preliminary structural calculations of the bridged pipe span indicated that imminent failure of the outfall pipe was possible. It was determined that an emergency repair of the spanned section of pipe was necessary to restore structural support and protection of the outfall pipe.

Emergency repairs were completed in 2018 to mitigate the immediate hazard of potential failure of the pipeline at the unsupported span. The repair included removal of all loose beach material under the span, creation of a small cofferdam around the repair area using sandbags, installation of wooden forms, placement of strengthening rebar under the pipe, and pouring of marine concrete into the void space. The sandbag cofferdam and wooden forms were removed upon completion of the repair. Although the emergency repairs were implemented, these repairs were only a temporary solution and gradual erosion of the limestone mass poses a legitimate threat to future stability of the land-based segment of the outfall. Continued erosion without significant modifications to the outfall pipe could result in unsupported spans of the outfall pipe and cause damage that takes the outfall pipe out of service. The existing outfall pipe along the shoreline and within the nearshore environment needs to be reinforced to account for erosion, sea level rise, storms, wave action, and other forces. In summary, the Proposed Action is needed to ensure the continued operation of the outfall with minimal maintenance.

Underwater inspections performed by SEI revealed advanced corrosion on the cast iron covers at Manholes 2, 3, and 4. Allowing the corrosion to continue on the pressure manholes could result in significant leaking of effluent. The use of sacrificial anodes is not a potential solution at this point as the corrosion is already too advanced to have any significant effect on the life of the cast iron pressure manhole. The pressure manhole assembly and hardware need to be replaced with a corrosion resistant alloy or capped to mitigate potential leaking.

2.2 Proposed Action

The Proposed Action includes the following:

- Installation of a concrete encasement structure over the land-based portion of the existing outfall at the shoreline (see **Section 2.2.1**)
- Cap three of the cast iron manhole cover plates on the original 36-inch-diameter pipeline (see **Section 2.2.2**)

A construction staging area and contractor office would be located immediately north of the construction area. The existing campground access road would be used as a haul route for equipment and materials. A 50-foot by 30-foot stabilized construction entrance would be installed over the outfall pipe for ingress and egress to/from the construction area. The construction entrance would include a concrete truck wash area on the staging area side of the outfall pipe. Upon completion of construction, the area would be returned to pre-construction conditions to the extent practicable. Construction plans for the Proposed Action are included in **Appendix B**.

2.2.1 Monolithic Concrete Encasement

The outfall pipe would be provided with a new concrete jacket (i.e., monolithic concrete encasement) over the existing emergency repair section. The monolithic concrete encasement repair concept is the simplest of the alternatives considered and discussed in **Section 2.3**. It generally involves encasing the entire at-risk length of pipeline with a continuous, rectangular outer casing of unreinforced concrete that extends vertically below the observed scour depth to cut off further undermining of the pipe. The encasement would also serve to armor the pipe itself from potential kinetic impacts from moving boulders or other massive debris that may become entrained in moving water during large wave events.

The concrete jacket would start at the shoreline at STA 00+00 and extend out for a length of approximately 125 feet to STA 01+25. The new concrete jacket would be sufficiently sized to provide long-term protection from wave action, erosion, aggregation, marine growth, and other forces. Concrete material selection would be chosen to maximize the durability and life of the existing outfall pipe. Special admixtures would be specified for fresh concrete to minimize washout of cement paste and fine aggregate into the seawater. Other admixtures would be added to increase the workability and delay the set time of the concrete mix. Concrete would typically be conveyed via tremie. Typical cross-sections are shown in **Figure 2**. Plan view of the proposed encasement is shown in **Figure 3**.

Figure 2. Typical Cross Sections of the Concrete Encasement Structure

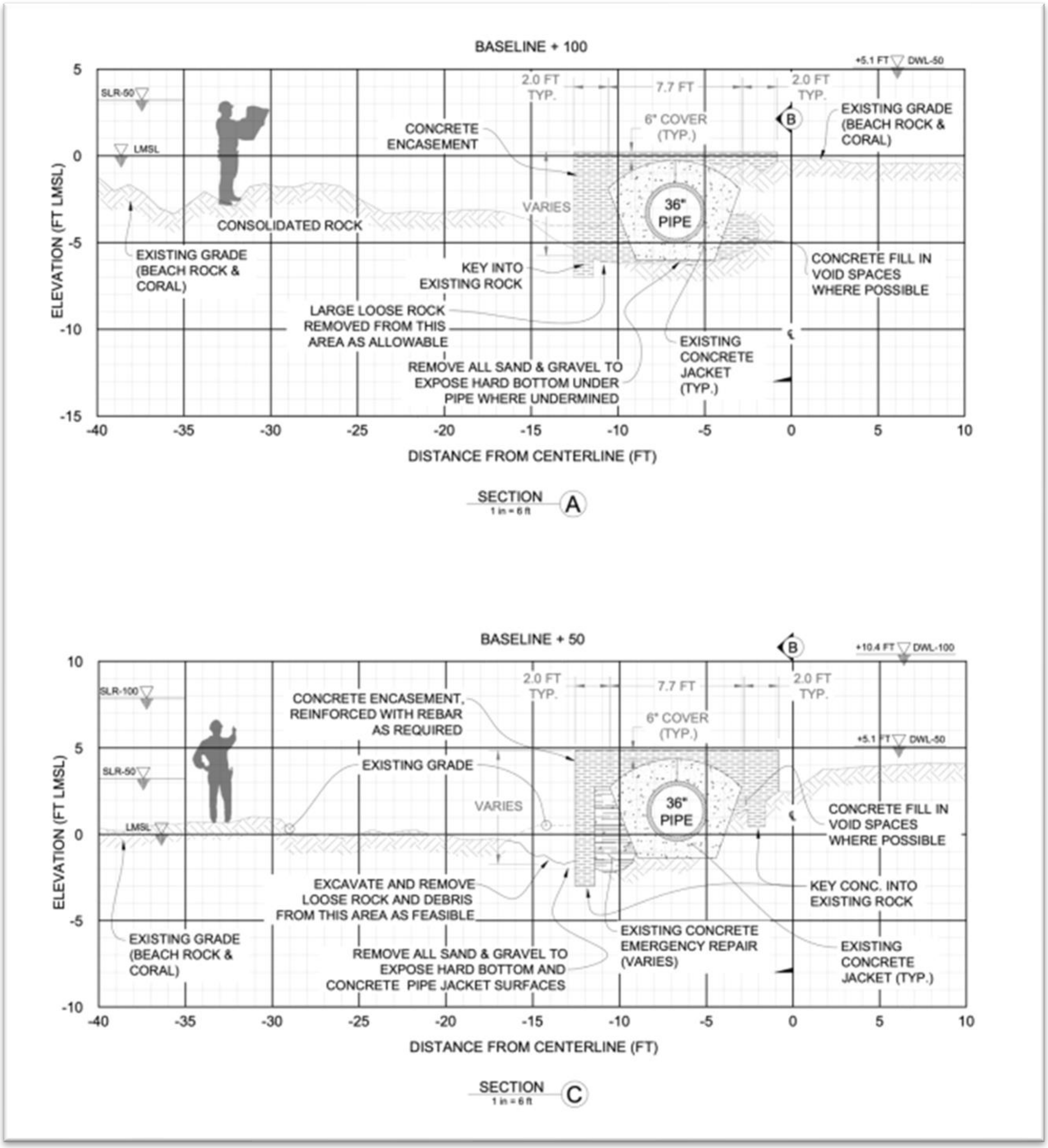
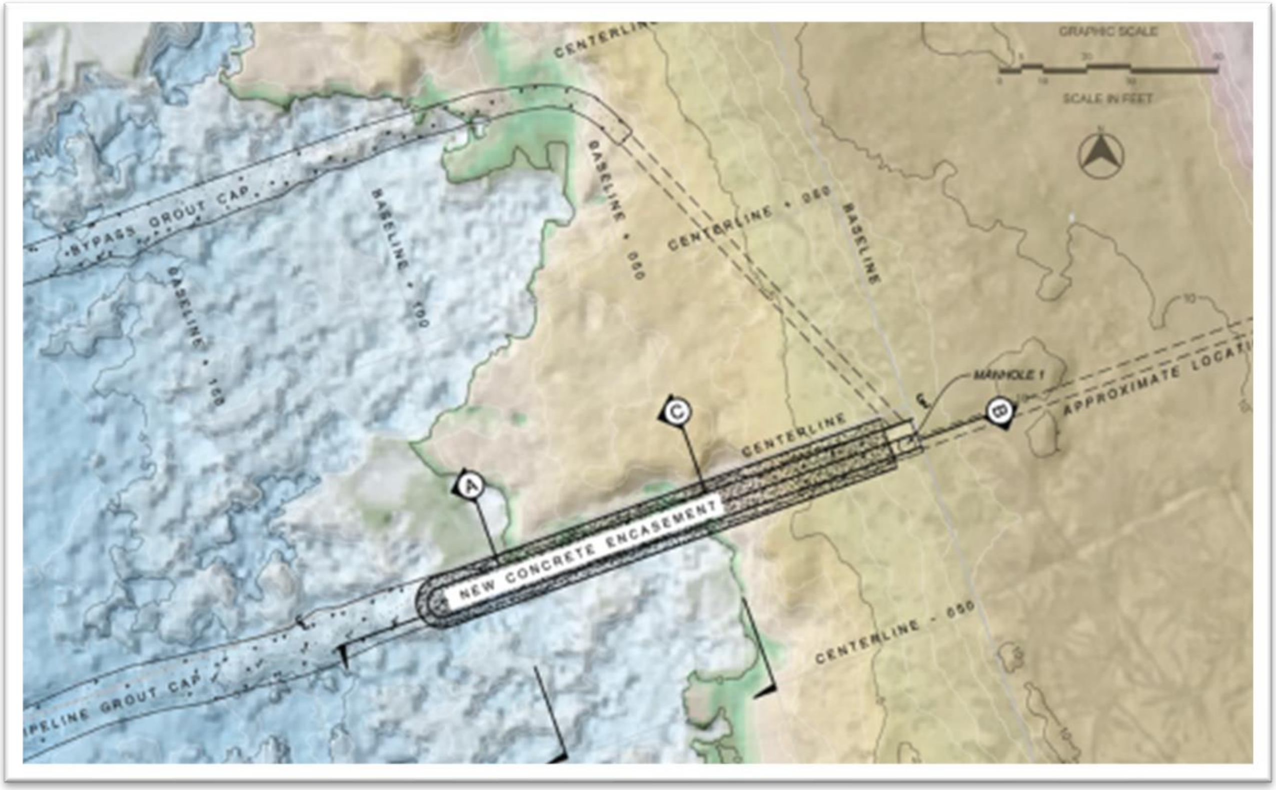


Figure 3. Plan View of the Proposed Concrete Encasement Structure



2.2.2 Manhole Capping

The Proposed Action includes capping existing cast iron Manholes 2 through 4 on the original 36-inch-diameter pipeline. New precast concrete caps would be provided to fit over the existing pressure manhole covers and would be filled with grout. Uplift forces on the new precast concrete caps would be resisted by the dead weight of the cap and grout and by stainless steel hardware anchored into the existing concrete jacket surrounding the outfall pipe with epoxied anchors suitable for underwater applications.

Manhole capping would require the use of a temporary barge over the manhole for equipment and personnel staging. The barge would be anchored to the ocean floor in four spots. Installation of the precast concrete caps would include the following steps:

- Remove existing marine growth, debris, sand, and other deleterious materials to expose the existing concrete surfaces and pressurized cast iron manhole frame cover.
- Provide a clean and level concrete surface.
- Scarify existing concrete surface to 0.25-inch maximum amplitude.
- Provide bonding agent at existing concrete and new precast concrete cap interface suitable for marine environments.
- Provide a gasket at the inner wall of the precast manhole cap to prevent leaking of fresh grout.
- Fill the void between the existing cast iron manhole cover and new precast concrete cap.

The material selection and design of the precast concrete caps would be chosen to maximize service life and durability. All hardware and steel used on the precast concrete caps would be type 316 stainless steel. The gasket material would be capable of compressing or expanding to seal discontinuities on the bottom surface of up to three inches and would prevent leakage of grout from beneath the precast manhole cap at all times. The bonding agent and gasket product information would be provided to CCH-ENV for approval.

Prior to construction, the contractor would determine the size and quantity of grout and vent ports required to ensure that the precast manhole cap is completely fill with grout. The contractor would also determine an appropriate gasket material size and composition.

2.3 No-Action Alternative

The No-Action Alternative would not include construction of a monolithic concrete encasement that would serve to armor the existing outfall pipe from potential kinetic impacts from moving boulders or other massive debris that may become entrained in moving water during large wave events. Additionally, the No-Action Alternative would not include capping three of the cast iron manhole cover plates on the original 36-inch pipeline. The condition of the shoreline and manhole covers would continue to deteriorate which would lead to more intense maintenance requirements and could lead to a catastrophic failure of the outfall.

2.4 Alternatives Considered But Not Carried Forward for Further Analysis

In addition to the Proposed Action, shore protection concepts were developed for three alternatives that were not carried forward for further design and analysis:

- Conventional rock revetment (see **Section 2.4.1**)
- Repair using articulating concrete block mattresses (see **Section 2.4.2**)
- Armoring with a sloped concrete reinforced masonry wall (see **Section 2.4.3**)

2.4.1 Rock Revetment

Rubble mound (rock) revetment design is reliant upon known design wave conditions and/or current velocities to which the armor units would be subjected. Designs of rock revetments typically follow methods and procedures in accordance with national standards provided by the U.S. Army Corps of Engineers (USACE), primarily from the Coastal Engineering Manual, EM-1110-2-1614, *Design of Coastal Revetments, Seawalls, and Bulkheads* (USACE, 1995).

A rubble mound structure such as a breakwater or revetment is composed of several layers of randomly shaped and placed small diameter stones or riprap forming a permeable core, protected with a highly permeable cover layer of armor units which may be either quarry stone or precast concrete units. In the case of the current proposed project, a core layer would be unnecessary and the pipeline itself would serve as the core since the purpose is to armor a fractured base of rock that supports the pipeline from further progressive erosion and undermining.

When comparing the benefits and cost of this concept with the Proposed Action, a rock revetment is cost prohibitive due to the type of shoreline at the site.

2.4.2 Articulating Concrete Block Mattresses

An articulating concrete block mattress is a rectangular matrix of individual concrete block units that are joined together in both horizontal axes typically either by polypropylene or stainless-steel wire ropes. The resulting "mattress" is flexible in both dimensions and available in various lengths, widths, and thicknesses. Multiple mattresses can be joined together along their abutted edges to form a continuous mat over any length. Articulating concrete block mattresses are commonly used as ballast and protection of underwater pipelines and cables, along with scour protection surrounding submerged foundations and footings. In general, they provide a hard armor surface that can be used as an alternative to rock revetments, concrete, or other permanent erosion control measures. There are no conventional or widely accepted design procedures for sizing the individual block units which instead rely on the rope elements and interconnections to form a continuous mass that resists movement or displacement.

Articulating concrete block mats are typically anchored in place or buried under some form of aggregate cover. In the case of this shoreline and substrate, the articulating block mats can be anchored on the ends when placed over the existing outfall pipeline but would not be anchored in the middle where the mat covers the pipeline alignment. The substrate of this area is limestone, coral, and rubble, which will typically lead to slippage of the articulating concrete block mattresses due to wave impact and uplifting without significant anchorage or aggregate cover to hold them in place.

2.4.3 Armoring

Armoring includes installation of a concrete rubble masonry (CRM) revetment which utilizes brick, concrete block, structural clay tile, or stone, with the masonry units held together with mortar. The mortar mix contains lime, sand, and gypsum. The sloping wall concept for the proposed project would consist of a regular grouted rock wall inclined at approximately 45 degrees resting along the side of the pipe and protecting the trench corridor and foundation from further progressive erosion.

In an environment of harsh shoreline conditions and repeated wave impact, CRM will not provide the robust stability required for an armoring effect to protect the existing outfall pipeline. Consistent wave impact and wet dry conditions will promote fissures and cracks between the rubble and mortar that will lead to crumbling of the CRM protection in a short amount of time relative to rock revetment and full concrete encasement.

3.0 Affected Environment, Potential Impacts, and Minimization and Mitigation Measures

3.1 Water Resources

3.1.1 Affected Environment

Groundwater

As shown in **Figure 4**, the Proposed Action is located within the Lualualei aquifer system of the Waianae sector (Aquifer Code 30302). The Waianae sector has a sustainable yield of 16 million gallons per day (MGD); the Lualualei aquifer contributes of 4 MGD. Only approximately 0.54 MGD are withdrawn from the Lualualei aquifer. The Board of Water Supply has judged the Lualuealei aquifer to be impractical to develop for cost effective ground water wells. The U.S. Navy withdraws water from the aquifer for domestic uses. The majority of the wells that tap into the Lualualei aquifer are either unused or used for irrigation (Townscape Inc., 2009).

Groundwater was encountered in the drilled borings completed as part of the subsurface geotechnical exploration discussed in **Section 3.9.1**. The groundwater was at depths ranging from 6.8- to 7.8-feet below the ground surface. Due to the proximity of the project site to the Pacific Ocean, groundwater levels are expected to vary with tidal fluctuations. In addition, groundwater levels may change due to seasonal precipitation, surface water runoff, storm surge, and other factors.

Inland Surface Waters

There are no standing water bodies, streams, or other surface water features in the immediate vicinity of the project site. As shown in **Figure 5**, Mailiili Stream is located approximately 0.4-mile south of the project site, and Kaupuni Stream is located approximately 1.1-miles north of the project site.

Nearshore Waters

Nearshore waters within and adjacent to the project area are classified as "Class A Marine Waters" (DOH-CWB, 2014a). As per HAR Title 11 Chapter 54, Water Quality Standards, Class A Marine Waters are to be protected for recreational purposes and aesthetic enjoyment. Uses are permitted if the use is compatible with the protection and propagation of fish, shellfish, and wildlife, as well as with recreation (DOH-CWB, 2014b).

Wetlands

As shown in **Figure 6**, the project site is located within estuarine and marine wetlands as delineated by the National Wetland Inventory (NWI). Estuarine and marine wetlands are located in the intertidal area where the substrate is flooded and exposed by tides, and there is an unconsolidated shore. Tides alternately flood and expose the substrate at least once daily (Cowardin et. al., 1979).

Figure 4. DOH Aquifers

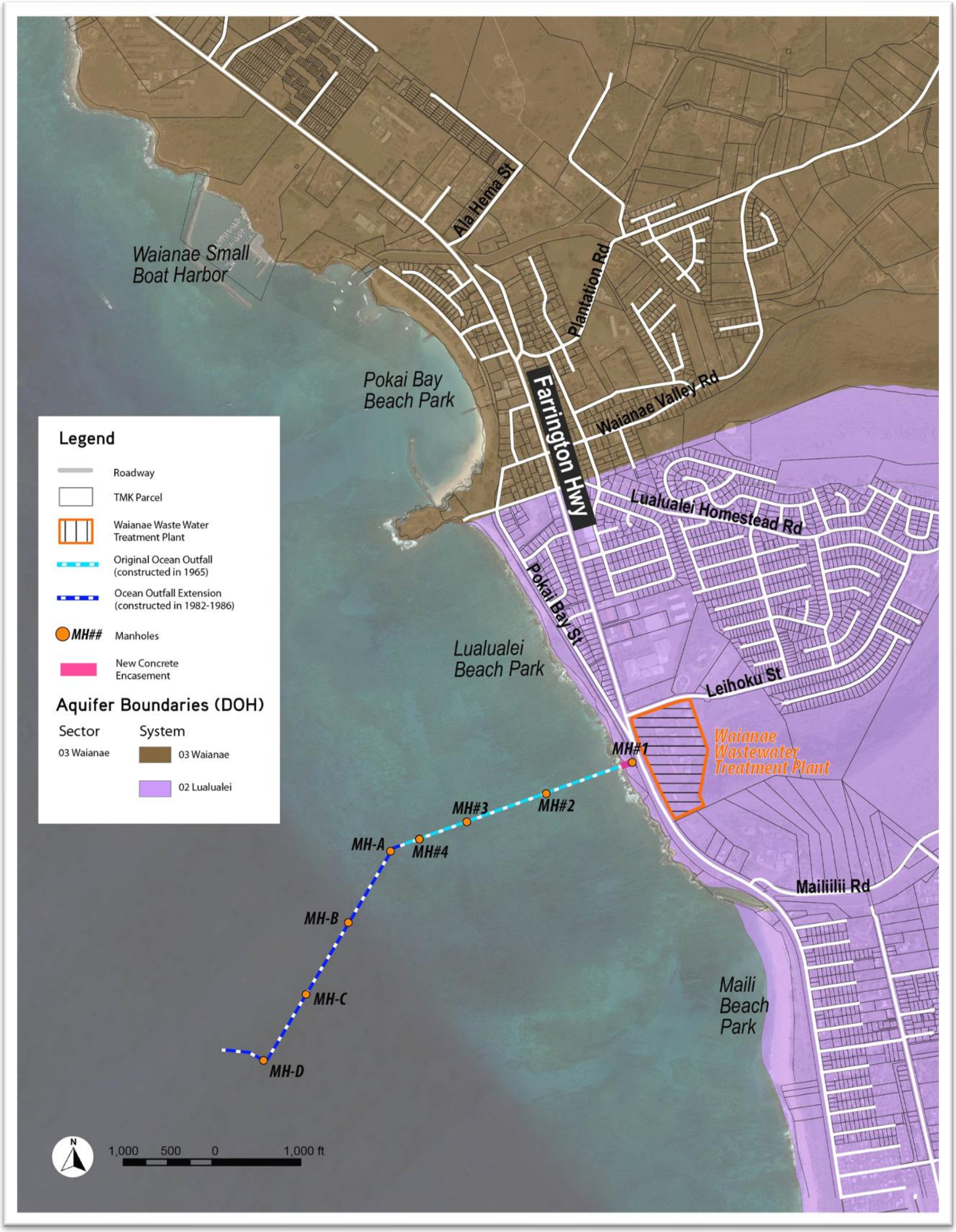


Figure 5. Surface Waters and Streams

Figure 6. NWI Wetlands

3.1.2 Potential Impacts

Based on the significance criteria set forth in HAR Chapter 11-200.1, the Proposed Action would result in a significant impact to water resources if the Proposed Action would involve a substantial degradation of environmental quality or a substantial adverse effect on water quality. Therefore, a significant impact would occur if the Proposed Action affected water resources so that their quality was degraded to the point that they were no longer fit for their designed use and/or the chemical composition exceeded applicable regulatory water standards.

Construction

Construction of the Proposed Action at the shoreline and in nearshore waters would involve ground-disturbing activities that have the potential to release sediment into the nearshore waters and associated NWI wetlands, which could temporarily increase turbidity. All excavation and grading activities would be limited to the area required for installation of the monolithic concrete encasement to minimize erosion potential. Construction activities would also require dewatering. Water would be discharged on land away from the shoreline. Contaminants associated with equipment during construction could impact nearshore waters and groundwater if they are present on the equipment or in the case of an inadvertent leak. All potential impacts would be minimized to the extent practicable by implementing the measures identified in **Section 3.1.3**.

As discussed in **Section 2.2.2**, construction of the offshore portion of the Proposed Action would involve cleaning the existing surfaces, installation of the new precast concrete cap, and filling the void between the existing cast iron manhole cover and new precast concrete cap with grout. Cleaning existing surfaces could cause turbidity in the immediate area. This would be short-term and temporary, and any suspended solids are expected to settle upon completion of the task. Pumping of the grout into the void between the existing cast iron manhole cover and new precast concrete cap with grout could increase turbidity if not sufficiently contained. All potential impacts would be minimized to the extent practicable by implementing the measures identified in **Section 3.1.3**.

Under the No-Action Alternative, no construction activities would occur; therefore, there would be no construction-related impacts to water resources.

Operation

Upon completion of construction, there would be beneficial impacts to water resources. The repairs to the land-based segment of the outfall and the underwater manholes would mitigate the risk of failure of the outfall that could result in a release of effluent in the nearshore waters and at the manhole locations.

Under the No-Action Alternative, no repairs would be made to the outfall pipe and manholes. The limestone mass supporting the outfall pipe would continue to erode, which could result in the need for "emergency repairs" or failure of the pipe and potential release of effluent in nearshore waters. Corrosion would continue on the manholes which could also result in leaking of effluent. Any release of effluent in areas close to shore could pose a potential risk to the marine environment and public health.

3.1.3 Minimization and Mitigation Measures

To minimize potential impacts to water resources, CCH-ENV would obtain and comply with all relevant permits pertaining to water quality. These may include the following:

- National Pollutant Discharge Elimination System (NPDES) General Permit for stormwater discharge associated with construction activities
    - As part of the permit process, a construction site Best Management Practices (BMP) Plan would be prepared and would include an erosion and sediment control plan, a site-specific plan to minimize erosion of soil and discharge of other pollutants into State waters, and descriptions of measures that would minimize the discharge of pollutants via stormwater after construction is complete.
- NPDES Individual Permit Authorizing Discharges Associated with Construction Activity Dewatering
    - As part of the permit process, a site-specific dewatering plan would be prepared that would include the following: a description of proposed dewatering operations from startup to termination of the discharge, a maintenance program, sediment handling and disposal plan, monitoring and visual inspection program, cessation of discharge plan, and effluent control plan.
- Section 401, Clean Water Act
- Section 404, Clean Water Act
- Section 10, Rivers and Harbors Act

The contractor would be required to comply with all permit requirements. These may include, but not be limited to, the following measures:

- The construction contractor would be required to employ BMPs for construction in coastal waters, such as daily inspection of equipment for conditions that could cause spills or leaks; cleaning of equipment prior to operation near or in the water; proper location of storage, refueling, and servicing sites away from the water; implementation of adequate on-site spill response procedures; and stormy weather preparation plans.
- Construction materials and equipment used in the marine environment would be clean of pollutants that may impact water quality.
- Vehicle or equipment refueling would be conducted away from the marine environment with spill prevention measures in place.
- All construction activities would be confined to the immediate area of construction, and no construction material shall be stockpiled in the water.
- Turbidity containment barriers would be installed and maintained to control and contain construction-generated turbidity. The water area around the construction site would be visually monitored, and if monitoring suggests that the turbidity standards are being exceeded, construction would be suspended until the condition is corrected.
- The officer-in-charge would be immediately notified if leakage of effluent is observed during construction.

A Contingency Plan would be included as part of the BMP Plan to prevent or respond to polluted discharges resulting from a severe storm or disaster during construction. The Contingency Plan may include, but not be limited to, the following measures:

- The contractor would regularly monitor local weather reports for forecasted and/or anticipated severe storm events, advisories, watches, warnings, or alerts.
    - The contractor would inspect and document the condition of all erosion control devices the day prior, during, and after the event.
    - The contractor would prepare for forecasted and/or anticipated severe weather events to minimize the potential for polluted discharges.
- Prior to any severe weather, the construction site would be secured. Securing the site would generally include the following:
    - Removing or securing equipment, machinery, and maintenance materials.
    - Cleaning up all construction-related debris.
    - Implementing the BMPs in the BMP Plan for materials management, spill prevention, and erosion and sediment control.
- In the event of a severe weather advisory (e.g., hurricanes, tropical storm, tsunami) or when deemed necessary, regular construction operations would stop, and the work crew would secure the project site and evacuate until the severe weather condition has passed.
- Upon return to the site, all BMPs would be inspected, repaired, and/or re-installed as needed.
    - If repair is necessary, it would be initiated immediately after the inspection and repairs or replacement would be completed prior to resuming construction activities.
    - To facilitate repair or replacement of BMPs, the contractor would store surplus material at the construction staging area adjacent to the construction site.
- If there is a discharge or there is an imminent threat of discharge that violates Hawaii Water Pollution Rules and/or endangers human and/or environmental health, the following steps would be executed:
    - Assess whether construction needs to stop or if additional BMPs are needed to stop or prevent a violation.
    - Take all reasonable measures to protect human and environmental health.
    - Notify CCH-ENV and DOH-CWB.
    - Document corrective actions and take photographs or discharge and receiving waters.
    - Revise the BMP Plan to prevent future discharges of a similar nature.

In addition, the Proposed Action would comply with the CCH's Rules Relating to Water Quality.

3.2 Biological Resources

3.2.1 Affected Environment

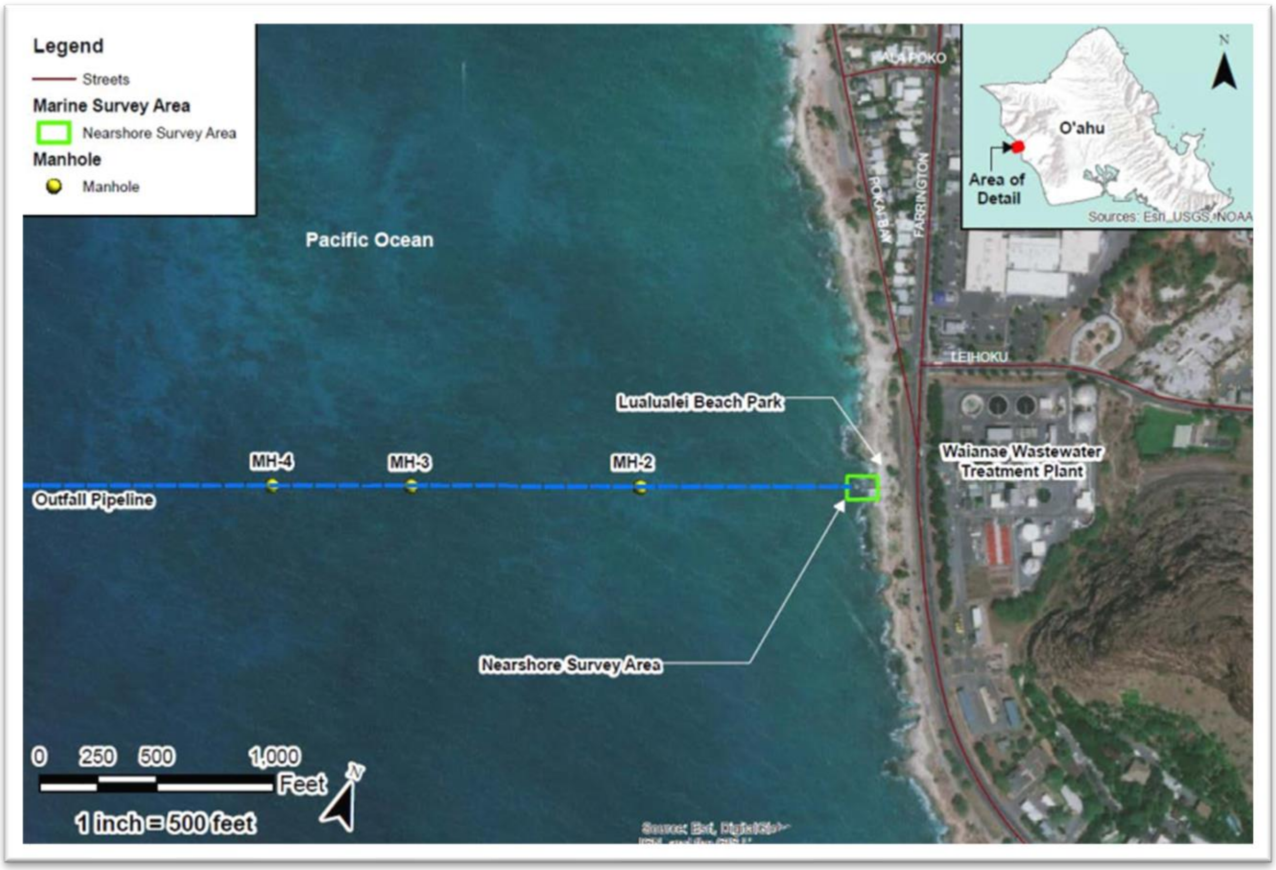
A terrestrial flora and fauna survey was conducted in February 2021 by SWCA Environmental Consultants (SWCA). The survey covered approximated 1.5 acres of coastal property between Farrington Highway and the shoreline as shown in **Figure 7**. The flora survey documented all vascular plant species and vegetation types in the survey area. The fauna survey included visual and auditory observations. All observed birds, mammals, reptiles, amphibians, and invertebrate species were noted. Before conducting the survey, available scientific and technical literature regarding natural resources in the area were reviewed. The *Waianae Wastewater Treatment Plant Flora and Fauna Report* is included in **Appendix C**.

Figure 7. Terrestrial Flora and Fauna Survey Area

Source: SWCA, 2021

A marine survey was conducted in May 2021 by Oceanit. The nearshore survey encompassed a 100-foot by 130-foot area surrounding the outfall pipe that was surveyed using five transects perpendicular to the shoreline. Transects were designed to capture representative bottom type, macroinvertebrates, algae, and fish in the survey area. The survey of the manhole covers included a 10-foot diameter around each manhole. A Blue Robotics BlueROV2® remote-operated vehicle (ROV) was used for the survey. A technician operated the ROV and recorded photographs and videos of the manholes directed by a biologist who later analyzed the ROV images and videos. Coral abundance and size-class distribution and relative abundance of fish and macroinvertebrates were documented. Survey areas are shown in **Figure 8**. The *Marine Biological Survey, Waianae Wastewater Treatment Plant Ocean Outfall Improvements* report is included in **Appendix D**.

Figure 8. Marine Survey Area



Source: Oceanit, 2021

Flora

Vegetation in the survey area consists of two vegetation types: ruderal vegetation and landscaped vegetation. The ruderal vegetation type occurs throughout most of the vegetated portions of the survey area. It is composed of a mixture of grasses and weedy, mostly herbaceous, species. The dominant species is buffelgrass (*Cenchrus ciliaris*). Other species include *Sida ciliaris* and swollen fingergrass (*Chloris barbata*). Landscaped areas are present at the southern margin of the survey area. They consist of infrequently mowed herbaceous vegetation with occasional coconut (*Cocos nucifera*) trees. Bermuda grass (*Cynodon dactylon*) and buffelgrass are the most abundant herbaceous species in the landscaped areas.

Eighteen (18) plant species were recorded in the survey area (see **Table 2**). Of these, four species are native or possibly native to Hawaii. All four are common throughout the Hawaiian Islands.

Table 2. Plant Species Observed in the Survey Area

Common and/or Hawaiian Name	Scientific Name	Status
Niu, Coconut	*Cocos nucifera*	Non-native
Buffelgrass	*Cenchrus ciliaris*	Non-native
Swollen fingergrass	*Chloris barbata*	Non-native
Bermuda grass	*Cynodon dactylon*	Non-native
Guinea grass	*Urochloa maxima*	Non-native
Khaki weed	*Alternanthera pungens*	Non-native
--	*Calyptocarpus vialis*	Non-native
Sourbush	*Pluchea carolinensis*	Non-native
Indian fleabane, Indian Pluchea, marsh fleabane	*Pluchea indica*	Non-native
Tree heliotrope	*Tournefortia argentea*	Non-native
Australian saltbush	*Atriplex semibaccata*	Non-native
Koa haole	*Leucaena leucocephala*	Non-native
Kiawe, algaroba	*Prosopis pallida*	Non-native
Naupaka kahakai	*Scaevola taccada*	Indigenous
--	*Sida ciliaris*	Non-native
Milo	*Thespesia populnea*	Indigenous
Naio	*Myoporum sandwicense*	Indigenous
Uhaloa, alaala pu loa, hala uhaloa, hialoa, kanakaloa	*Waltheria indica*	Possibly Indigenous

Source: SWCA, 2021

Terrestrial Fauna

Birds

The bird species observed in the survey area are species commonly found in disturbed, low- to mid-elevation areas on Oahu. Five bird species were documented (see **Table 3**). None of the species are federal- and/or state-listed threatened, endangered, or candidate species, and none are protected by the Migratory Bird Treaty Act.

Table 3. Bird Species Observed in the Survey Area

Common and/or Hawaiian Name	Scientific Name	Status
Common myna	*Acridotheres tristis*	Non-native
Rock pigeon	*Columba livia*	Non-native
Feral chicken	*Gallus gallus*	Non-native
Zebra dove	*Geopelia striata*	Non-native
House sparrow	*Passer domesticus*	Non-native

Source: SWCA, 2021

Mammals

Mammals observed in the survey area include dogs (*Canis familiaris*) and Indian mongoose (*Herpestes javanicus*). Although not observed, the house mouse (*Mus musculus*) and rats (*Rattus* spp.) are likely to occur in the survey area because of its proximity to development and recreation areas.

Reptiles and Amphibians

All terrestrial reptiles and amphibians in Hawaii are non-native introductions. No reptiles or amphibians were observed during the survey.

Terrestrial Insects and Other Invertebrates

No native invertebrates were observed during the survey. Non-native invertebrates observed include the housefly (*Musca domestica*) and an unidentified grasshopper.

Marine Flora and Fauna

Nearshore

The nearshore area is comprised of a rocky beach that transitions into a limestone shelf with tidepools and a bed of macroalgae in the intertidal zone. The most common macroalgae is the brown algae ornate seaweed (*Turbinaria ornata*) and endemic sargassum species (*Sargassum echinocarpum* and *S. polyphyllum*). The green algae, sea lettuce (*Ulva lactuca*) and filamentous green algae (*Cladophora* sp.), as well as the hard bubble seaweed (*Dictyosphaeria cavernosa*) and the ringed finger seaweed (*Neomeris annulate*) are interspersed in the algal mat. Two endemic red algal species, McDermid's laurencia (*Laurencia mcdermidae*) and ogo (*Gracilaria coronopifolia*) were noted, as well as the introduced hooked seaweed (*Hypnea musciformis*) were observed. A complete species list of algae observed in the nearshore area is provided in the *Marine Survey Report* (**Appendix D, Table B-1 of Attachment B**).

Corals are rare in the nearshore area, as shown in **Table 4**. The most abundant coral in the nearshore area is the endemic blue soft coral (*Sarcothelia edmondsonii*) with 32 individuals observed and the cauliflower coral (*Pocillopora meandrina*) with 14 individuals observed.

Table 4. Coral Colony Abundance in Nearshore Area

Scientific Name	Size Class (cm)					Total
	1-5	6-10	11-20	21-40	41-80	
Porites lobata	2	1	2	3	--	8
Porites evermanni	1	--	--	--	--	1
Pocillopora meandrina	5	--	3	6	--	14
Pocillopora acuta	1	--	--	--	--	1
Pocillopora damicornis	2	--	--	--	--	2
Sarcothelia edmondsonii	8	4	4	14	2	32
Palythoa caesia	--	--	--	--	1	1
Total Count	**19**	**5**	**9**	**23**	**3**	**59**
Area Surveyed	**120.8 m²**					
Corals per m²	**0.16**	**0.04**	**0.07**	**0.19**	**0.02**	**0.41**

Source: Oceanit, 2021

Small macroinvertebrates are abundant in the intertidal zone. The most abundant species include the endemic pipipi (*Nerita picea*), dotted periwinkle (*Littoraria pintado*), and the endemic Hawaiian periwinkle (*Echinolittoria hawaiiensis*) that inhabit the beach rock in the splash zone and shallow tidepools. Closer to the surf zone, urchins (*Echinometra oblonga, E. mathaei,* and *Diadema paucispinum*) and the flat helmet urchin (*Colobocentrotus atratus*) have bored into the pipeline concrete and reside on vertical faces and in crevices of the limestone shelf. Hermit crabs (*Calcinus* spp.), cowries (*Monetaria caputophidii*), and several drupe species (*Morula granulata* and *Thais intermedia*) reside in the tidepool areas. A complete species list of macroinvertebrates observed in the nearshore area is provided in the *Marine Survey Report* (**Appendix D, Table B-2 of Attachment B**).

The most common fish seen in the nearshore area were the brown surgeonfish (*Acanthurus nigrofuscus*) and mamo (*Abudefduf abdominalis*). Several wrasse species (*Thalassoma duperrey*, *T. trilobatum*, *T. purpureum*, and *Halichoeres ornatissimus*) and spottedboxfish (*Ostracion meleagris*) were also observed. The endemic marbled blenny (*Entomacrodus marmoratus*) and cloudy goby (*Opua nephodes*) were commonly seen in shallow tidepools. A complete species list of algae observed in the nearshore area is provided in the *Marine Survey Report* (**Appendix D, Table B-3 of Attachment B**).

Manhole 2 (MH-2)

Manhole 2 (MH-2) is located approximately 1,050 feet offshore at a depth of 20 feet. A complete species list of observed species in the survey area for MH-2 is provided in the *Marine Survey Report* (**Appendix D, Table B-4 of Attachment B**).

- **Corals:** One cauliflower coral individual resided directly on the manhole cover. Three other individuals were observed in the 10-foot radius around MH-2. The largest individual was about 40 cm in diameter, while the other three are smaller and less than 20 cm in diameter. The density of corals is about 0.01 corals/ft². Maps of the approximate coral locations are included in the *Marine Survey Report* (**Appendix D, Attachment C**).
- **Fish:** Three species of fish were observed around MH-2. Orange-band surgeonfish (*Acanthurus olivaceus*) was seen occasionally, while a few ring-tail surgeonfish (*A. blochii*) and bridled triggergish (*Sufflama fraenatum*) individuals were also observed.
- **Invertebrates:** One collector urchin (*Tripneustes gratilla*) and one wana (*Diadema paucispinum*) were observed within the 10-foot radius around MH-2.

Manhole 3 (MH-3)

Manhole 3 (MH-3) is located approximately 2,000 feet offshore at a depth of 26 feet. A complete species list is provided in the *Marine Survey Report* (**Appendix D, Table B-5 of Attachment B**).

- **Corals:** Corals seen around MH-3 are patchy and small. Six *Porites lobata* individuals, all less than 10 cm in diameter, inhabited the top of the manhole cover. There were approximately 20 other lobe coral (*Porites lobata*) individuals and three cauliflower coral individuals residing on the concrete block around the manhole cover. The density of corals is approximately 0.07 corals/ft^2. Maps of the approximate coral locations are included in the *Marine Survey Report* (**Appendix D, Attachment C**).
- **Fish:** MH-3 had the highest fish species diversity of the three manholes. Twenty-five (25) fish species were observed. The most common species seen were mamo (*Abudefduf abdominalis*), kole (*Ctenochaetus strigosus*), Hawaiian dascyllus (*Dascyllus ablisella*), manybar goatfish (*Parupeneus multifasiatus*), and saddle wrasse (*Thalassoma duperrey*). In addition, schools of bluestripe snapper (*Lutjanus kasmira*) traversed across the MH-3 survey area during the survey.
- **Invertebrates:** Two species of spiny urchins, pale rock-boring urchin (*Echinometra mathaei*) and needle-spined urchin (*E. arciulatus*), occur occasionally around MH-3. A few collector urchins (*Tripneustes gratilla*) were also identified. The encrusting red algae *Hydrolithon onkodes* was common on the hard concrete surfaces.

Manhole 4 (MH-4)

Manhole 4 (MH-4) is located approximately 2,600 feet offshore at a depth of 30 feet. A complete species list of observed species in the survey area for MH-4 is provided in the *Marine Survey Report* (**Appendix D, Table B-6 of Attachment B**).

- **Corals:** MH-4 has the largest coral population of the manhole locations. Three lobe coral individuals are growing directly on the manhole cover, while two other individuals and one brown lobe coral (*Porites evermanni*) individuals are growing on the vertical side of the manhole cover. Several other cauliflower coral individuals appeared to be damaged or partially dead. Most of the brown lobe coral individuals are growing on the sides of large boulders. The density of corals is approximately 0.17 corals/ft^2. Maps of the approximate coral locations are included in the *Marine Survey Report* (**Appendix D, Attachment C**).
- **Fish:** Fish were common around MH-4 during the survey, although not as abundant as around MH-3. The most abundant species seen were Hawaiian dascyllus, manybar goatfish, and saddle wrasse. Several types of butterfly fish (*Chaetodon luuula*, *C. multicinctus*, and *C. quadrimaculatus*), surgeonfish (*Acanthurus blochii* and *A. nigroris*), goatfish (*Parupeneus multifasciatus*), and big-eye bream (*Monotaxis grandoculis*) were also observed.
- **Invertebrates:** Two species of sea urchins, wana and pale rock-boring urchin (*Echinometra mathaei*), were observed.

Special-Status Species

No federal- and/or state-listed threatened, endangered, or candidate plant species proposed for listing were observed in the survey area.

No federal- and/or state-listed threatened, endangered, or candidate terrestrial wildlife species proposed for listing were observed during pedestrian surveys. However, there are areas of suitable habitat for the endangered Hawaiian hoary bat (*Aeorestes semotus*), which may forage or roost in the area. The endangered Hawaiian hoary bat is the only native terrestrial mammal species that is still extant within the Hawaiian Islands. Hawaiian hoary bats are known to occur on Oahu in native, non-native, agricultural, and developed landscapes. Hawaiian hoary bats forage in open, wooden, and linear habitats with a wide range of vegetation types. These animals are insectivores and are regularly observed foraging over streams, reservoirs, and wetlands up to 300 feet offshore. Hawaiian hoary bats typically roost in trees greater than 16-feet-tall with dense canopy foliage with open access to launching into flight. Suitable foraging habitat exists within the survey area. Roosting habitat is present in areas immediately surrounding the survey area.

The survey area is directly adjacent to Hawaiian monk seal (*Neomonachus schauinslandi*) critical marine habitat. Hawaiian monk seals spend most of their life at sea, but they also rely on land habitat for resting, molting, pupping, nursing, and avoiding marine predators. Monk seals can often be seen hauling out on sand, corals, and volcanic rock to rest during the day and to give birth, preferring protected surrounded by shallow waters when pupping. The endangered Hawaiian monk seal was not observed during the survey. However, habitat exists for the Hawaiian monk seal directly adjacent to the survey area in the marine waters and may bask on the shore in the immediate project area.

Adult green sea turtles (*Chelonia mydas*) commonly forage in the shallow and nearshore areas and coral reefs. Sea turtles use both terrestrial habitats (beaches for nesting and/or basking) and offshore open ocean habitats. Nesting usually occurs between May through September, peaking in June and July, with hatchlings usually emerging through November and December. Several macroalgal species, including the invasive algae *Acanthophora spicifera* and introduced hooked seaweed (*Hypnea musciformis*), are known to be grazed by green sea turtles and are present in the project area. Several sea turtles were observed swimming approximately 30 feet offshore during the nearshore marine survey.

Three special-status seabirds have potential to occur in the area based on their movement patterns: Hawaiian petrel (*Pterodroma sandwichensis*), Newell's shearwater (*Puffinus newelli*), and band-rumped storm-petrel (*Oceanodroma castro*). Major threats to these species include attraction of adults and newly fledged juveniles to bright lights while they transit between their nest sites and the ocean. Juvenile birds are particularly vulnerable to light attraction and are sometimes grounded when they become disoriented by lights, rendering them vulnerable to mammalian predators or being struck by vehicles.

Humpback whales (*Megaptera novaeangliae*) are transient protected species that frequent Hawaiian waters annually from November to May with a peak in February and March. Humpback whales may be observed offshore of the project area during this time.

The state-protected opihi (*Cellana* spp.) occurs within the project area. Opihi are protected by HAR Title 13, Subtitle 4, Part V, Chapter 92, which prohibits harvesting opihi with shells less than 1.25 inches in diameter.

None of the 20 coral species listed as threatened under the August 17, 2017, Final Rule Endangered Species Act occur in Hawaii.

3.2.2 Potential Impacts

Based on the significance criteria set forth in HAR Chapter 11-200.1, the Proposed Action would result in a significant impact to biological resources if it would irrevocably commit a natural resource or have a substantial adverse effect on a rare, threatened, or endangered species, or its habitat. A significant impact would occur if the Proposed Action resulted in the following:

- Long-term loss or impairment of a substantial portion of local habitat of indigenous Hawaiian species
- Substantial reduction in the population of a protected species, as designated by Federal and State agencies, or a species with regional and local significance
- Introduction or increase of the prevalence of undesirable non-native species
- Curtail the range of native Hawaiian species
- Reduce the range of beneficial uses of the environment

Construction

Flora

Construction of the Proposed Action would involve minimal clearing of vegetation in the area immediately adjacent to the existing outfall pipe. Overall, the vegetation in the survey area is disturbed from previous and current land use activities. The vegetation types and species identified are not considered unique. The four indigenous/possibly indigenous species are common throughout the Hawaiian Islands. No special-status plants were observed during the survey, and no designated plant critical habitat occurs in the area. Therefore, the Proposed Action is not expected to have a significant, adverse effect on flora resources.

Under the No-Action Alternative, no construction would occur and there would be no construction-related impacts to flora.

Terrestrial Fauna

Construction of the Proposed Action would have limited short-term impacts to the existing terrestrial fauna species that reside or forage within the project vicinity. All the species observed during fauna surveys are non-native and common and can temporarily relocate or forage in nearby areas during the construction period. Therefore, impacts to terrestrial fauna species during construction of the Proposed Action would be insignificant, short-term, and temporary.

Under the No-Action Alternative, no construction would occur and there would be no construction-related impacts to terrestrial fauna.

Marine Flora and Fauna

Construction of the Proposed Action would likely have direct impacts and result in the loss of marine benthos in the immediate nearshore area and within the construction footprints of the manhole covers. The anchoring of the silt curtains or other BMPs in nearshore waters may also impact marine benthos. The direct impact area was previously disturbed when the outfall pipe was installed and during the emergency repairs completed in 2018. Corals are rare in the nearshore area and around MH-2. Corals are more numerous around MH-3 and MH-4, but they are mostly small (less than 20 cm in diameter). With time, similar coral, algae, and macroinvertebrate communities would recruit to the new concrete structures and host similar assemblages seen on the existing structures. Measures to minimize impacts would be implemented, as discussed in **Section 3.2.3**.

Under the No-Action Alternative, no construction activities would occur and there would be no construction-related impacts to marine flora and fauna.

Special-Status Species

Construction of the Proposed Action would not involve trimming or removing trees greater that 15-feet-tall; therefore, there would be no impacts to roosting juvenile bats. During construction of the Proposed Action, the Hawaiian hoary bat may be temporarily displaced from the project area. The temporary displacement of these individuals at the project site is not expected to affect individual survival or overall species populations.

Hawaiian monk seals and green sea turtles typically avoid human activity; therefore, it is unlikely that monk seals and turtles would frequent the project area during construction activities. Construction of the Proposed Action may temporarily displace these species, but long-term effects are not expected. Monk seals and turtles that haul out and bask in the area are expected to find suitable beach in nearby areas. The temporary displacement of these individuals at the project site is not expected to affect individual survival or overall species populations. Additionally, measures to minimize potential impacts to the Hawaiian monk seal and green sea turtle would be implemented during construction (see **Section 3.2.3**).

Hawaiian seabirds are attracted to lights. After circling the lights, they may collide with nearby wires, buildings, or other structures, or they may land on the ground due to exhaustion. Downed seabirds are subject to increased mortality due to collision with automobiles, starvation, and predation by dogs, cats, and other predators. Outdoor lighting during construction of the Proposed Action could result in seabird disorientation, fallout, and injury or mortality. It is not expected that there would be any nighttime construction or outdoor lighting. If nighttime construction is required, the measures described in **Section 3.2.3** would be implemented. Therefore, construction of the Proposed Action is not expected to impact Hawaiian seabirds.

Under the No-Action Alternative, no construction activities would occur and there would be no construction-related impacts to special-status species. However,

Operation

Upon completion of construction, there would be beneficial impacts to biological resources associated with the Proposed Action. The repairs to the land-based segment of the outfall and the underwater manholes would mitigate the risk of failure of the outfall that could result in a release of effluent in the nearshore waters and at the manhole locations. As discussed in **Section 2.1.2**, gradual erosion of the limestone mass supporting the outfall pipe poses a legitimate threat to the future stability of the land-based segment of the outfall. Underwater inspections performed by SEI revealed advanced corrosion on the cast iron covers at Manholes 2, 3, and 4. Allowing the corrosion to continue on the pressure manholes could result in significant leaking of effluent.

Under the No-Action Alternative, no repairs would be made to the outfall pipe and manholes. The limestone mass supporting the outfall pipe would continue to erode, which could result in failure of the pipe and potential release of effluent in nearshore waters. Corrosion would continue on the manholes which could also result in leaking of effluent. Any release of effluent in marine waters could have a significant impact on marine flora and fauna, including corals. In addition, the continued eroding of the limestone mass supporting the outfall pipe may lead to conditions requiring "emergency repairs" which could have more detrimental impacts on marine flora and fauna, including corals.

3.2.3 Minimization and Mitigation Measures

There are no minimization or mitigation measures proposed for terrestrial flora and fauna, and none are expected to be required.

The following measures would be implemented to minimize impacts to marine flora and fauna:

- The minimization and mitigation measures proposed for water resources, described in **Section 3.1.3**, would also minimize impacts to marine flora and fauna species.
- Prior to construction, rare or protected benthos such as corals and opihi may be carefully removed from the substrate and relocated to an equivalent habitat outside the project area. Any relocation activities would be coordinated with the Department of Land and Natural Resources (DLNR) Division of Aquatic Resources (DAR) and a Special Activity Permit would be obtained.
- Any temporary tethering, anchoring, mooring, or similar in-water structural components would be placed in a manner to avoid direct physical impact to coral.

The following measure would be implemented to minimize potential impacts to the Hawaiian hoary bat:

- Any fences that are erected during construction of the Proposed Action would have barbless top-strand wire to prevent Hawaiian hoary bats from becoming entangled on barbed wire.

The following measures would be implemented to minimize potential impacts to Hawaiian monk seals and green sea turtles:

- Before work begins for the day, inspections for Hawaiian monk seals and green sea turtles that may have entered the project site would be conducted.
    - Construction activities would not occur if a Hawaiian monk seal or green sea turtle is in the construction area or within 150 feet of the construction area. Construction would only begin after the animal voluntarily leaves the area. If a seal or pup pair is present, a 300-foot buffer would be observed.
    - If a Hawaiian monk seal or green sea turtle enters the work area after work has begun, that work may continue only if, in the best judgment of the project supervisor, there is no way for the activity to adversely affect the animal.
- Equipment operators would employ "soft starts" when initiating work that directly impacts the bottom. Buckets and other equipment would be sent to the bottom in a slow and controlled manner for the first several cycles before achieving full operational impact strength or tempo.
- All objects lowered to the bottom would be lowered in a controlled manner. This may be achieved by the use of buoyancy controls such as lift bags, or the use of cranes, winches, or other equipment that affect positive control over the rate of descent.
- Any construction-related debris that may pose an entanglement threat to monk seals and turtles would be removed from the construction area at the end of each day.
- Workers would not attempt to feed, touch, ride, or otherwise intentionally interact with monk seals or turtles.

- Any incidental take of Hawaiian monk seals or injury to sea turtles would be reported immediately to NOAA Fisheries' 24-hour hotline and would include the name and phone number of the point of contact, location of the incident, and nature of the take and/or injury.

The following measures would be implemented to minimize potential impacts to seabirds:

- Construction activity would be restricted to daylight hours as much as practicable during the seabird peak fledgling fallout period (September 15 to December 15) to avoid the use of nighttime lighting that could attract seabirds.
- All outdoor lights, if used, would be shielded to prevent upward radiation to reduce the potential for seabird attraction.
- Outside lights not needed for security or safety would be turned off from dusk through dawn during the fledgling fallout period.

3.3 Archaeological and Historic Resources

3.3.1 Affected Environment

An Archaeological Literature Review and Field Inspection (ALFRI) was completed in April 2021 by PCSI. The ALRFI included a field inspection and a historical, cultural, and archaeological background study to evaluate any potential effect on historic properties and to recommend mitigation of any adverse effects, if warranted. The work was carried out in accordance with HRS Chapter 6E and Title 13 HAR, Subtitle 13, Chapter 275. The *Archaeological Literature Review Report in Support of the Waianae Wastewater Treatment Plan (WWTP) Outfall Improvements and Rehabilitation Project, Waianae Ahupuaa, Waianae District, Island of Oahu, Hawaii* is included in **Appendix E**.

Literature Review

Background research indicates that the project area was not intensively used during the pre-Contact or early historic periods. Archaeological and historical documentation suggest that Waianae was first occupied around AD 1200 when population pressure on the windward coast and in the Kona Moku pushed people to expand across the island. A shift from temporary to permanent settlement likely began in the coastal and well-watered areas by the 1300s. The arid climate of Waianae Moku would have made the well-watered valleys the most attractive locations for settlement on the west side of Oahu.

During the post-contact period, the area has been used for sandalwood logging in the early 1800s. During the mid-1800s, Waianae Moku became dominated by cattle grazing. More recent land use in the project area includes construction of the ocean outfall in the mid-1960s and recreation and camping in the modern era.

Available historical maps show few features in the vicinity of the project area. Between the late 1800s and late 1900s, the following features are identified:

- **1884:** OR&L Railway (SIHP Site 50-80-04-07597)
- **1884:** Government Road or Old Waianae Road (SIHP Site 50-50-04-07520)
- **1902:** Waianae Plantation
- **1902:** Former ranching land
- **1914:** Land Grant 5006 to Willard E. Brown
- **1914:** Land Grant 5263 to Makaha Coffee Co. Ltd.

- **1928:** Railway spur to Waianae Lime Company quarry
- **1956:** Access road to quarry
- **1976:** Village Pokai Bay subdivision under construction at former quarry site
- **1993:** Parking stalls within the project area

Seven (7) archaeological investigations have occurred within 500 feet of the project area. None of the investigations recorded historic properties within or adjacent to the project site.

Field Investigation

An archaeological field inspection was conducted by PCSI on September 10, 2020. The purpose of the field inspection was to ensure that no traditional Hawaiian pre-Contact or historical archaeological materials or features were present on the surface. No traditional Hawaiian pre-Contact or historical archaeological materials were observed in the survey area. Four modern features were present, all of which consisted of stacked or intentionally arranged rocks, including one memorial.

3.3.2 Potential Impacts

Based on the significance criteria set forth in HAR Chapter 11-200.1, the Proposed Action would result in a significant impact to archaeological and historic resources if it would irrevocably commit a natural, cultural, or historic resource. Significant impacts would occur if any of the identified historic properties discussed in **Section 3.3.1** were physically altered or disturbed by the Proposed Action or if the Proposed Action substantially compromises the integrity of an historic property.

Construction

Based on previous archaeological investigations in the vicinity, there is low potential for traditional Hawaiian subsurface cultural deposits. However, the lack of development and the beach location suggests the possibility of encountering traditional Hawaiian human burials. In addition, historical maps indicate that a portion of the OR&L Railroad (SIHP Site 50-80-04-09714) may be present in the project area. Construction of the Proposed Action would have no impacts to known archaeological and historic resources since none exist within the project site. There is the potential for traditional Hawaiian burials in subsurface sand deposits. Additionally, buried remnants of the OR&L Railroad (SIHP Site 50-80-04-09714) may be extant. Therefore, the Proposed Action may impact subsurface archaeological and historic resources. These impacts would be minimized with the implementation of the measures in **Section 3.4.3**.

Under the No-Action Alternative, no construction activities would occur; therefore, there would be no construction-related impacts to cultural practices and beliefs or archaeological and historic resources.

Operation

Upon completion of construction there would be no impacts to archaeological and historic resources. The outfall would continue to operate and be maintained as it has since it became operational in 1965.

Under the No-Action Alternative, no repairs would be made to the outfall pipe and manholes. There would be no construction-related impacts to archaeological and historic resources. The continued eroding of the limestone mass supporting the outfall pipe may lead to conditions requiring “emergency repairs” which could result in impacts to nearby archaeological and historic resources.

3.3.3 Minimization and Mitigation Measures

CCH-ENV will consult with the State Historic Preservation Division (SHPD) under HRS Chapter 6E-8 regarding project effects and would incorporate any mitigation measures required. It is expected that archeological monitoring may be required during ground disturbing activities. Any monitoring would be executed in accordance with a SHPD-approved Archaeological Monitoring Plan.

In addition to any requirements by SHPD, the following measures would be implemented to minimize potential impacts to cultural practices and beliefs and archaeological and historic resources:

- If human remains or burials are identified, all earth-moving activities in the area would stop, the area would be cordoned off, and SHPD and the Honolulu Police Department would be notified pursuant to HAR Section 13-300-40.
- If any potential historic properties are identified during construction activities, all activities in the area would cease and SHPD would be notified pursuant to HAR Section 13-280-3.

3.4 Cultural Practices and Beliefs

3.4.1 Affected Environment

A Cultural Impact Assessment (CIA) was completed in August 2021 by Pacific Consulting Services Inc. (PCSI). The CIA was conducted pursuant to Act 50 and in accordance with the Office of Environmental Quality Control's *Guidelines for Assessing Cultural Impacts*, adopted by the Environmental Council, State of Hawaii, on November 19, 1997.

The *Cultural Impact Assessment in Support of the Waianae Wastewater Treatment Plant (WWTP) Outfall Improvements and Rehabilitation Project, Waianae Ahupuaa, Waianae District, Island of Oahu, Hawaii* is provided in **Appendix F** and includes discussion of the following:

- Historical Background (see **Section 3.3.1**)
- Field Inspection Results (see **Section 3.3.1**)
- Consultation Methods, Constraints, and Results
- Recommendations

Community Consultation

To more completely understand the cultural and historical background within and around the project area, PCSI sought community input. Nine organizations and individuals were invited to provide input through two rounds of email and one phone call. No responses were returned to the two rounds of email. Two individuals were reached via phone who requested the information be resent. No additional response was received. In addition to the nine individuals initially contacted, one unsolicited individual contacted PCSI and answered questions regarding cultural practices and beliefs in the project vicinity.

It must be noted that there were unavoidable constraints for the consultation process due to the COVID-19 pandemic. PCSI followed mandates from Federal, State, and local government agencies, as well as internal mandates. The primary result of the COVID-19 pandemic mandates is restrictions on the types, duration, and sizes of gatherings. Therefore, PCSI was limited to alternative means of consultation: email and phone calls.

Consultation Results

The unsolicited individual, who requested to remain anonymous, noted that camping, day parties, and shoreline fishing are popular to the south of the project site. The individual also confirmed that traditional human burial occurred along the Waianae shoreline, but was not aware of any specific locations.

3.4.2 Potential Impacts

Based on the significance criteria set forth in HAR Chapter 11-200.1, the Proposed Action would result in a significant impact to cultural practices and beliefs if it would have a substantial adverse effect on the cultural practices of the community or state. Significant impacts would occur if the Proposed Action were to cause the following:

- Substantially alter or remove a location where cultural practices take place
- Unduly restrict or prevent a cultural practice from taking place
- Introduce new elements that substantially alter the setting in which cultural practices take place. This can include visual elements, noise, traffic, and human presence

Construction

During construction of the Proposed Action, beach use and lateral access at the project site would be restricted. Approximately 0.9-acre of beach would be used for construction and staging area. Construction of the monolithic concrete encasement would occur immediately north of the designated camping area at Lualualei Beach Park. There would be an increase in noise and dust from short-term construction activities; however, the impacts would be temporary and minimized to the extent possible. In addition, the project site is located immediately adjacent to Farrington Highway; therefore, noise impacts would be similar to existing conditions. In addition, there would be intermittent and temporary impacts to the designated camping area as the existing campground access road would be used as a haul route for equipment and materials. This disruption would be temporary and impacts to cultural practices such as day parties, camping, and shoreline fishing would be less than significant.

Under the No-Action Alternative, no construction activities would occur; therefore, there would be no construction-related impacts to cultural practices.

Operation

Upon completion of construction, there would be no changes to use of the beach or offshore areas. The monolithic concrete encasement would reduce beach erosion in the immediate vicinity of the outfall pipe and protect the pipe from potential damage or failure. Impacts associated with the monolithic concrete encasement would be beneficial to cultural practices since it would protect the beach from further erosion and potential contamination from the release of effluent.

Under the No-Action Alternative, no repairs would be made to the outfall pipe and manholes. The limestone mass supporting the outfall pipe would continue to erode, which could result in failure of the pipe and potential release of effluent in nearshore waters. The existing manhole covers would continue to corrode, which could also result in leaking of effluent. Any release of effluent in areas close to shore could pose a potential risk to the marine environment, and thereby impact cultural practices such as day recreation, shoreline fishing, and camping. In addition, the continued eroding of the limestone mass supporting the outfall pipe may lead to conditions requiring “emergency repairs” which could have more detrimental impacts on cultural practices.

3.4.3 Minimization and Mitigation Measures

The following measures would be implemented to minimize impacts to cultural practices during construction of the Proposed Action:

- BMPs would be implemented to minimize dust and noise that could adversely impact visitors to the park.
- Upon completion of construction, the construction staging area and ingress/egress site would be restored to pre-construction conditions to the extent practicable.
- If human remains or burials are identified, all earth-moving activities in the area would stop, the area would be cordoned off, and SHPD and the Honolulu Police Department would be notified pursuant to HAR Section 13-300-40.

3.5 Climate Change and Sea Level Rise

3.5.1 Affected Environment

Climate change is a long-term shift in patterns of temperature, precipitation, humidity, wind, and seasons. Scientific data show that earth's climate has been warming. This warming is mostly attributable to rising levels of carbon dioxide and other greenhouse gases (GHG) generated by human activity. These changes are already impacting Hawaii through rising sea levels, increasing ocean acidity, changing rainfall patterns, decreasing stream flows, and changing wind and wave patterns. While the earth's climate experiences natural change and variability over geologic time, the changes that have occurred over the last century due to human input of GHG into the atmosphere are unprecedented (HCCMAC, 2017).

Sea levels are rising at increasing rates due to global warming of the atmosphere and oceans and melting of glaciers and ice sheets (HCCMAC, 2017). These rising seas and the projection for more increased tropical storms in the Pacific Ocean would increase Hawaii's vulnerability from coastal inundation and erosion. According to the Intergovernmental Panel on Climate Change, if global GHG were to continue at a "business as usual" scenario, it is expected that a 3.2-foot sea level rise could occur by the year 2100 and, to some projections, as early as the year 2060, and would continue to rise in the future. Therefore, the *Hawaii Sea Level Rise Vulnerability and Adaptation Report (2017)* adopted by the State of Hawaii suggests that planning for a 3.2-foot sea level rise should happen now (HCCMAC, 2017).

As such, the sea level rise exposure area (SLR-XA) has been developed for the State to model and determine the potential future exposure of each island to multiple coastal hazards as a result of sea level rise. The SLR-XA is the footprint of three coastal hazards: passive "bathtub" flooding, annual high wave flooding, and coastal erosion. Using the SLR-XA to assess sea level rise impacts and coastal hazard exposure supports efforts to encourage Hawaii's adaptation to sea level rise. The impacts of sea level rise on the communities of Oahu have the potential to exacerbate existing challenges such as aging infrastructure, planning for future growth, and the lack of affordable housing (HCCMAC, 2017). According to the *Hawaii Sea Level Rise Vulnerability and Adaptation Report (2017),* approximately 9,400 acres of land on Oahu is estimated to be located in the SLR-XA with 3.2 feet of sea level rise by the mid- to latter-half of the century. It is noted that while specific responses to sea level rise would need to be place-based, larger regional issues should also be considered, such as determining whether to armor the coastline or to relocate roads and other critical infrastructure inland (HCCMAC, 2017).

3.5.2 Potential Impacts

Based on the significance criteria set forth in HAR Chapter 11-200.1, the Proposed Action would result in a significant impact to climate change and sea level rise if it would have a substantial adverse effect on or be likely to suffer damage by being in an environmentally sensitive area, such as the SLR-XA, or if it would require substantial energy consumption or emit substantial greenhouse gases.

Construction

Construction of the Proposed Action would result in emissions of greenhouse gases (GHGs) from operation of construction equipment. These emissions would be short-term and temporary and would not be substantial; therefore, construction of the Proposed Action would not have significant impacts that would exacerbate climate change.

Under the No-Action Alternative, no construction activities would occur; therefore, there would be no construction-related impacts to climate change.

Operation

Coastal hazards were modeled using the Intergovernmental Panel on Climate Change's (IPCC) global sea level rise projections. The IPCC model provides projections of global mean sea level rise for four GHG emissions scenarios, called representative concentration pathways (IPCC 2014). Results of the four scenarios are shown in **Table 5**.

Table 5. Upper Boundaries of Global Sea Level Rise Projections

Year	Global Seal Level Rise Projection	
	Feet	Meters
2030	0.5	0.1660
2050	1.1	0.3224
2075	2.0	0.5991
2100	3.2	0.9767

Source: HCCMAC, 2017

As shown in **Figure 9**, the Proposed Action is located at the shoreline in an area that would be impacted by 0.5-foot of sea level rise, which is projected to occur by 2030. The shoreline area would be impacted by annual high wave flooding with 0.5-feet of sea level rise (HCCMAC, 2021), which could further advance shoreline erosion and threaten the outfall pipe's stability at its shoreline landing. The Proposed Action would minimize shoreline erosion and protect the outfall pipe at its shoreline landing. Therefore, the Proposed Action would have beneficial impacts by protecting the outfall pipe from the effects of climate change and sea level rise.

Under the No-Action Alternative, no repairs would be made to the outfall pipe and manholes. The limestone mass supporting the outfall pipe would continue to erode, which could result in the need for "emergency repairs" or failure of the pipe and potential release of effluent in nearshore waters.

3.5.3 Minimization and Mitigation Measures

The Proposed Action is a mitigation measure against sea level rise. No other measures are proposed to minimize potential impacts associated with climate change and sea level rise, and none are expected to be required.

Figure 9. Sea Level Rise Exposure Area (SLR-XA)

3.6 Natural Hazards

3.6.1 Affected Environment

Hurricanes and Tropical Storms

Tropical storms and hurricanes have historically had a relatively low probability of occurrence in the vicinity of the Hawaiian Islands. Since construction of the Waianae WWTP and its original ocean outfall in the mid-1960s, two powerful hurricanes have impacted Oahu: Iwa (1982) and Iniki (1992). Storm waves produced by Hurrican Iwa were found to have caused significant damage to the submerged oil pipelines from the Single Point Mooring at Barbers Point where a concrete-jacketed 30-inch steel pipeline was laterally displaced up to 140 feet in water depths of 45 to 60 feet by wave and current forces. The damage sustained by Hurricane Iwa and the occurrence of Hurricane Iniki a decade later highlighted the potential risk to submerged pipelines and other seafloor infrastructure from extreme wave events such as those caused by hurricanes.

Hurricanes have become more frequent in Hawaiian waters, which is likely exacerbated by climate change. In recent years, several hurricanes and tropical storms have made close approaches to Oahu. The 2018 Pacific hurricane season produced a total of 23 named storms and is the fourth most active hurricane season on record. Five of the storms threatened the Hawaiian Islands by either close approach or direct landfall. This includes Category 3 Hector, which pounded south and west shores with dangerously large surf, and Category 5 Lane, which was forecast to make landfall but weakened unexpectedly and veered into the open ocean just hours before predicted landfall. In late July 2020, Hurricane Douglas made an extremely close pass with its weak southern eyewall crossing Oahu causing minor effects.

Tsunami and Floods

A tsunami involves the generation of a series of destructive ocean waves that can affect all shorelines. These waves can occur at any time with limited or no warning and are most commonly generated by earthquakes in marine and coastal regions (NOAA, 2017). As shown in **Figure 10**, the landfall portion of the outfall is located within the tsunami evacuation zone.

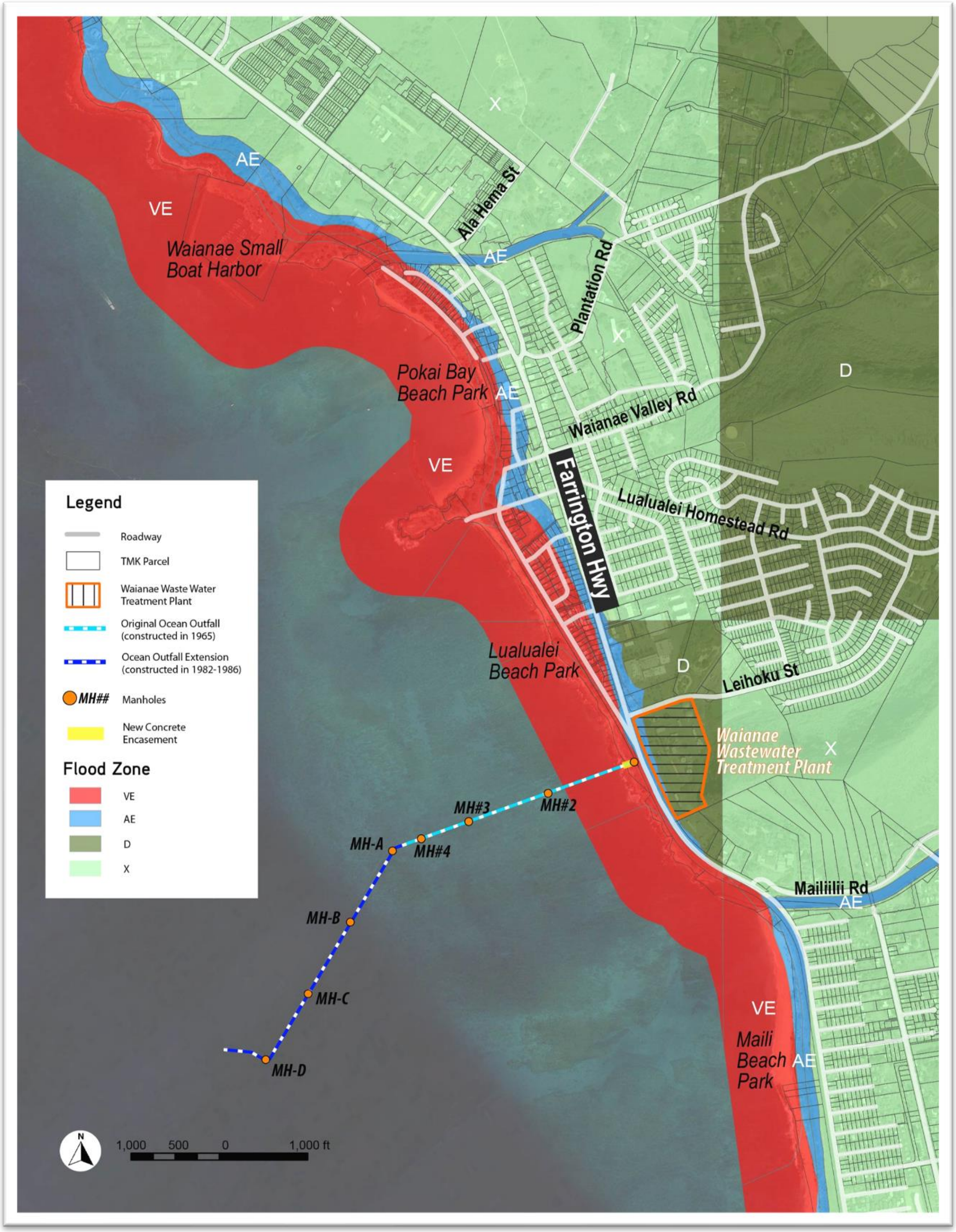
Coastal High Hazard Areas (CHHA) represent the area subject to inundation by 1-percent-annual chance flood, extending from offshore to the inland limit along an open coast and any other area subject to high velocity wave action from storms or seismic sources. The CHHA is delineated into two Flood Hazard Zones: V and VE.

- **Flood Hazard Zone V.** Areas along coasts subject to inundation by the 1-percent-annual-chance flood event with additional hazards associated with storm-induced waves. Because detailed coastal analyses have not been performed, no base flood elevations (BFEs) or flood depths are shown.
- **Flood Hazard Zone VE.** Areas along coasts subject to inundation by the 1-percent-annual-chance flood event with additional hazards due to storm-induced velocity wave action. BFEs derived from detailed hydraulic coastal analyses are shown within these zones.

As shown in **Figure 11**, the landfall portion of the outfall is located with Flood Hazard Zone VE.

Figure 10. Tsunami Evacuation Zone

Figure 11. Flood Hazard Zones



Earthquakes

As a series of islands formed by volcanoes, the Islands of Hawaii are very seismically active. Most of the earthquakes in Hawaii occur on the Big Island and are associated with volcanic activity. However, other earthquakes are caused by the weight of the Hawaiian Islands on the Pacific lithosphere. Earthquakes that have been felt on Oahu include the following: the magnitude 6.2 Honomu event (1973), the magnitude 6.5 Maui earthquake (1938), and the 6.8 Lanai earthquake (1871) (Freyer, G., 2009).

3.6.2 Potential Impacts

Based on the significance criteria set forth in HAR Chapter 11-200.1, the Proposed Action would result in a significant impact if it would have a substantial adverse effect on or be likely to suffer damage by being located in an environmentally sensitive area such as a flood plain. Therefore, a significant impact would occur if the Proposed Action was substantially adversely impacted by natural hazards.

Construction

Natural hazards cannot be controlled; rather, they can only be remediated for after the events occur. Construction of the revetment would not create conditions that would exacerbate natural hazards. The CCH Department of Emergency Management coordinates the emergency management activities and functions of the island of Oahu with State, Federal, and other public and private organizations. In the event of a hurricane or tsunami, watches and/or warnings are issued by the Central Pacific Hurricane Center and the Pacific Tsunami Warning Center, respectively. In the event of a hurricane or tsunami warning, construction would halt and loose construction material and equipment would be removed from the site or secured until such time as the warning is lifted.

Under the No-Action Alterative, no construction activities would occur and there would be no impacts to construction activities from natural hazards.

Operation

The Proposed Action has been designed to withstand the level of forces necessary to minimize the likelihood that an extreme event would damage the structures. The Proposed Action does not involve habitable uses, nor would it encourage such uses. Therefore, there are no anticipated adverse impacts associated with natural hazards. The Proposed Action would have beneficial impacts by protecting the landfall section of the outfall pipe from potential damage and/or failure, as well as the manholes from potentially leaking effluent into nearshore and offshore waters.

Under the No-Action Alternative, the repairs would not be made to the outfall pipe rendering it vulnerable to damage from natural hazards. Erosion and subsequent trench wall failure at the outfall’s landing site would continue to expose and undermine the pipe. Hurricanes with their associated high winds and elevated water levels have the potential for creating localized extreme surf, possibly resulting in wave heights that could far surpass the usual seasonally high surf episodes that shorelines in Hawaii typically experience on an annual basis, which could result in more damage at the outfall’s landing site. In addition, tsunami may potentially exert forces on the outfall that exceed those during hurricane conditions. Direct wave action, sediment movement, and potential impact hazards from nearby large stones or boulders displaced during periods of high surf would continue to make the outfall pipe vulnerable to potential damage or failure. The continued eroding of the limestone mass supporting the outfall pipe may lead to conditions requiring “emergency repairs” or failure of the pipe. Failure of the pipe would result in a release of effluent into nearshore waters.

3.6.3 Minimization and Mitigation Measures

The following measures would be implemented to minimize potential impacts associated with natural hazards:

- In the event of a severe weather advisory (e.g., hurricanes, tropical storm, tsunami) or when deemed necessary, regular construction operations would stop, and the work crew would secure the project site and evacuate until the severe weather condition has passed.
- The Proposed Action has been designed to withstand natural hazards.

In addition, the Proposed Action is a mitigation measure to protect the outfall pipe from damage associated with coastal hazards.

3.7 Parks and Recreation Areas

3.7.1 Affected Environment

The Waianae WWTP ocean outfall crosses through Lualualei Beach Park (see **Figure 12)**, which is managed by the CCH Department of Parks and Recreation. This is a narrow 18-acre park located along Farrington Highway in Waianae that consists of a comfort station, picnic tables and six camping spots. The beach is sandy, but there is a rocky limestone shelf along the shoreline, which makes entering the ocean difficult. For this reason, the beach park is mainly used by local fishermen. However, there are several tents and encampments in the proximity of the landfall portion of the outfall pipe where the houseless currently camp. Offshore of the beach park, recreational and fishing boats launched from the Waianae Small Boat Harbor often pass through the area. A surf site called Sewers is also located offshore.

3.7.2 Potential Impacts

Based on the significance criteria set forth in HAR Chapter 11-200.1, the Proposed Action would result in a significant impact to public facilities such as parks and recreation areas if the Proposed Action involves substantial secondary impacts such as population changes or effects on public facilities that would impact public health. Therefore, a significant impact on parks and recreation areas would occur if the Proposed Action caused a substantial change in population or adversely affected public facilities.

Construction

During construction of the Proposed Action, beach use and lateral access at the project site would be restricted. Approximately 0.9 acre of beach would be used for construction and staging area. However, this disruption would be temporary. Access to the beach to the north and south of the construction site would not be restricted as there are access points from Pokai Bay Street and Farrington Highway on the north and south sides of the construction work area, respectively.

Construction of the monolithic concrete encasement would occur immediately north of the designated camping area at Lualualei Beach Park. There would be intermittent and temporary impacts to the designated camping area as the existing campground access road would be used as a haul route for equipment and materials. A 50-foot by 30-foot stabilized construction entrance would be installed over the outfall pipe for ingress and egress to/from the construction area. The construction entrance would include a concrete truck wash area on the staging area side of the outfall pipe. Upon completion of construction, the area would be returned to pre-construction conditions to the extent practicable. Measures to minimize impacts would be implemented, as discussed in **Section 3.7.3**.

Figure 12. Parks and Recreation Areas

During construction of the monolithic concrete encasement, there would be an increase in noise and dust from short-term construction activities; however, the impacts would be temporary and minimized to the extent possible. In addition, the project site is located immediately adjacent to Farrington Highway; therefore, noise impacts would be similar to existing conditions. Therefore, impacts associated with construction of the Proposed Action would be less than significant.

Construction of the monolithic concrete encasement would include the installation of a turbidity curtain around the outfall pipe to create a 45-foot-wide workspace over the outfall pipe. In addition, a double row of silt fence would be installed along the shoreline for the width of the project area. Surfers and boaters would not be able to access the 45-foot-wide by 125-foot-long area over the outfall pipe. Shoreline fishermen would need to use care to not get their lines tangled in the turbidity curtain.

Construction activities associated with the manhole covers would require anchoring of a barge over the existing manhole(s). While the barge is in place, surfers and boaters would not be able to access the area immediately around the barge. These impacts would be short-term and temporary. Other offshore areas would not be impacted.

Under the No-Action Alternative, no construction activities would occur; therefore, there would be no construction-related impacts to parks and recreation areas.

Operation

Upon completion of construction, there would be no changes to recreational use of the beach or offshore areas. The monolithic concrete encasement would reduce beach erosion in the immediate vicinity of the outfall pipe and protect the pipe from potential damage or failure. Impacts associated with the monolithic concrete encasement would be beneficial to recreation since it would protect the beach from further erosion and potential contamination from the release of effluent. Capping of the manholes would mitigate the risk leaking of effluent at the manhole locations and protect water quality for surfers and fishermen.

Under the No-Action Alternative, no repairs would be made to the outfall pipe and manholes. The limestone mass supporting the outfall pipe would continue to erode, which could result in failure of the pipe and potential release of effluent in nearshore waters. Corrosion would continue on the manholes which could also result in leaking of effluent. Any release of effluent in areas close to shore could pose a potential risk to public health. In addition, the continued eroding of the limestone mass supporting the outfall pipe may lead to conditions requiring “emergency repairs” which could have more detrimental impacts to parks and recreation areas and associated activities.

3.7.3 Minimization and Mitigation Measures

The following measures would be implemented to minimize impacts to parks and recreation areas during construction of the Proposed Action:

- BMPs would be implemented to minimize dust and noise that could adversely impact visitors to the park.
- Upon completion of construction, the construction staging area and ingress/egress site would be restored to pre-construction conditions to the extent practicable.

3.8 Visual Resources

3.8.1 Affected Environment

Waianae is considered one of the most scenic regions of the Island of Oahu. Major elements of the landscape are the deep blue of the ocean, white sand beaches, green valleys, puu and ridges along the coast, and valleys. Along most of Farrington Highway, residential and commercial development blocks mauka views. Significant stationary views include Makaha Beach Park, Mauna Lahilahi Beach Park, Pokai Bay Beach Park, and Maili Beach Park (CCH-DPP, 2012).

3.8.2 Potential Impacts

Based on the significance criteria set forth in HAR Chapter 11-200.1, the Proposed Action would result in a significant impact to visual resources if it has a substantial adverse effect on scenic vistas and viewplanes, during day or night, identified in County or State plans or studies. The Proposed Action would have a significant impact if it would block or substantially obstruct a vista by placing a structure in the foreground so as to prevent a view of an identified resource from an identified area or create a structure that would be so incongruous with existing structures currently in the vista or viewplane.

Construction

Construction of the Proposed Action would introduce construction equipment and activity along a part of the shoreline. Although construction activities would be visible from Farrington Highway and visitors and transient residents of the area, the project area is not in within a "Significant Stationary View" as identified in the *Waianae Sustainable Communities Plan* (CCH-DPP, 2012). Designated "Significant Stationary Views" are north and south of the project site at Pokai Bay Beach Park and Maili Beach Park, respectively. Construction activities would be short-term and temporary and would not have significant impacts to the existing scenic and visual environmental.

Under the No-Action Alternative, no construction activities would occur; therefore, there would be no construction-related impacts to visual resources.

Operation

The Proposed Action, limited in scope to the construction of a monolithic concrete encasement around approximately 125 feet of the shoreline portion of the outfall pipe and manhole covers offshore, is not anticipated to affect the aesthetic and visual character of the surrounding area. Although it would present a new, visible structure at the shoreline, it would not be significantly different from the exposed pipe already present at the shoreline. The Proposed Action would not include structures that would block viewplanes or be incongruous with existing conditions of the site. Therefore, the Proposed Action would not have significant impacts to visual resources.

Under the No-Action Alternative, no repairs would be made to the outfall pipe. The limestone mass supporting the outfall pipe would continue to erode, resulting in a change to the visual environment, and which could result in the need for "emergency repairs" or failure of the pipe and potential release of effluent in nearshore waters.

3.8.3 Minimization and Mitigation Measures

No measures are proposed or expected to be required to minimize impacts to visual resources.

3.9 Geology and Soils

3.9.1 Affected Environment

The project site slopes down gradually from east to west and is covered predominantly by beach sand and coral reef closer to the shoreline. The shoreline area is comprised of beachrock (limestone), sand, and concrete where the outfall pipe and stabilization exist. The rocky beach transitions into a limestone shelf with tidepools. Past the limestone shelf, the nearshore submerged area is rocky with large boulders and rubble with sand interspaces. The nearshore area south of the outfall pipe is predominantly sand, whereas north of the pipeline is comprised of a limestone shelf.

To determine subsurface conditions, three borings were drilled to a depth of approximately 36.5 feet. These borings revealed that the project site is generally underlain by beach sands and coral formation over coralline deposits. The beach sand is generally loose at the ground surface and grades to medium dense extending to depths of 3.5 to 5.5 feet below the ground surface. Underlying the beach sand, a medium hard coral formation extends to depths between 8 and 12 feet below the ground surface. This coral formation is exposed at the ground surface closer to the ocean. Below the coral formation is coralline detritus consisting of medium dense to dense silty sands and gravel with zones of loose sands extending to depths between 27 and 28 feet below the ground surface. One boring encountered alluvium consisting of soft sandy silts within the coralline detritus at depths between 20 and 23 feet below the ground surface. A soft to hard coral formation is below the coralline detritus extending to the maximum depth of the borings (i.e., 36.5 feet below the ground surface).

As shown in **Figure 13**, the project site is underlain by Mtb soil system, Mokuleia Clay, which is a part of the Mokuleia Series. The Mokuleia Series consists of well-drained soils along the coastal plains on Oahu and Kauai. These soils formed in recent alluvium deposited over coral sand and are shallow and nearly level. Permeability is moderate, and runoff is slow.

3.9.2 Potential Impacts

Based on the significance criteria set forth in HAR Chapter 11-200.1, the Proposed Action would result in a significant impact to geological and soil resources if it would involve a substantial degradation of environmental quality or would have a substantial adverse effect on or be likely to suffer damage by being located in an environmentally sensitive area such as geologically hazardous land. Therefore, a significant impact would occur if the Proposed Action caused a substantial degradation of environmental quality through erosion or affected or suffered damage by being located in an environmentally sensitive area.

Construction

Construction of the Proposed Action at the shoreline and in nearshore waters would involve ground-disturbing activities that have the potential to cause minor soil loss and erosion. All excavation and grading activities would be limited to the area required for installation of the monolithic concrete encasement to minimize erosion potential. Measures to minimize impacts would be implemented, as discussed in **Section 0**.

Under the No-Action Alternative, no construction activities would occur; therefore, there would be no construction-related impacts to geology and soil resources.

Figure 13. Soils

Operation

Upon completion of construction, the monolithic concrete encasement would reduce beach erosion in the immediate vicinity of the outfall pipe and protect the pipe from potential damage or failure. Impacts associated with the monolithic concrete encasement would be beneficial to geology and soil resources since it would protect the beach from further erosion

Under the No-Action Alternative, no repairs would be made to the outfall pipe and manholes. The limestone mass supporting the outfall pipe would continue to erode, which could lead to damage or failure of the outfall pipe. The continued eroding of the limestone mass supporting the outfall pipe may lead to conditions requiring "emergency repairs" which could result in impacts to geological and soil resources.

3.9.3 Minimization and Mitigation Measures

The following measures would be implemented to minimize potential impacts to geology and soil resources:

- CCH-ENV would obtain coverage under the NPDES General Permit for stormwater discharge associated with construction activities, if required. The NPDES permit application would include a site-specific BMP plan that includes an erosion and sediment control plan. BMPs may include, but not be limited to, the following:
    - Temporary soil stabilization techniques throughout construction to minimize disturbed soils being carried away by water or wind.
    - Watering or applying dust suppressants at the project site and ingress/egress, as needed.
    - Cleaning nearby pavements and paved roads after construction.
    - Covering open trucks carrying construction materials and debris.
    - Limiting area to be disturbed to the minimum necessary.
    - All project construction-related materials and equipment would be inspected for pollutants and cleaned to remove pollutants prior to use at the project site.
    - A contingency plan for accidental spills of petroleum products would be developed and retained on-site. Absorbent pads and containment booms would be stored on-site to facilitate clean-up of accidental petroleum releases to the soil.
- CCH-ENV would obtain coverage under the NPDES Individual Permit Authorizing Discharges Associated with Construction Activity Dewatering:
    - As part of the permit process, a site-specific dewatering plan would be prepared that would include the following: a description of proposed dewatering operations from startup to termination of the discharge, a maintenance program, sediment handling and disposal plan, monitoring and visual inspection program, cessation of discharge plan, and effluent control plan.
- BMPs would be installed prior to ground-disturbing activities and would be inspected and maintained throughout the construction period.
- The Proposed Action would comply with the CCH's Rules Relating to Water Quality.

3.10 Air Quality

3.10.1 Affected Environment

The Clean Air Act of 1972 and its 1990 Amendments and subsequent legislation regulate air emissions from area, stationary, and mobile sources. Both the U.S. Environmental Protection Agency and the State of Hawaii have instituted Ambient Air Quality Standards (AAQS) to maintain air quality in the interest of public health and secondary public welfare. At the present time, seven parameters are regulated: particulate matter, sulfur dioxide, hydrogen sulfide, nitrogen dioxide, carbon monoxide, ozone and lead. The Hawaii AAQS are in some cases considerably more stringent than the comparable National Ambient Air Quality Standards (NAAQS). In particular, the Hawaii 1-hour AAQS for carbon monoxide is four times more stringent than the comparable national limit. **Table 6** illustrates the NAAQS and State AAQS and the units of measure (micrograms per cubic meter [μg/m^3] and parts per million [ppm]).

Table 6. State of Hawaii and National Ambient Air Quality Standards

Pollutant	Units	Averaging Time	Maximum Allowable Concentration		
			National Primary	National Secondary	State of Hawaii
Particulate Matter <10 microns (PM_{10})	μg/m^3	Annual 24 Hours	- 150[a]	- 150[a]	50 150[b]
Particulate Matter <2.5 microns ($PM_{2.5}$)	μg/m^3	Annual 24 Hours	12[c] 35[d]	15[c] 35[d]	- -
Sulfur Dioxide (SO_2)	ppm	Annual 24 Hours 3 Hours 1 Hour	- - - 0.075[e]	- - 0.5[b] -	0.03 0.14[b] 0.5[b] -
Nitrogen Dioxide (NO_2)	ppm	Annual 1 Hour	0.053 0.100[f]	0.053 -	0.04 -
Carbon Monoxide (CO)	ppm	8 Hours 1 Hour	9[b] 35[b]	- -	4.4[b] 9[b]
Ozone (O_3)	ppm	8 Hours	0.070[g]	0.070[g]	0.08[g]
Lead	μg/m^3	3 Months Quarter	0.15[h] 1.5[i]	0.15[h] 1.5[i]	- 1.5[i]
Hydrogen Sulfide	ppb	1 Hour	-	-	25[b]

Notes: [a]Not to be exceeded more than once per year on average over three years.
[b]Not to be exceeded more than once per year.
[c]Three-year average of the weighted annual arithmetic mean.
[d]98th percentile value averaged over three years.
[e]Three-year average of fourth-highest daily 1-hour maximum.
[f]98th percentile value of the daily 1-hour maximum averaged over three years.
[g]Three-year average of annual fourth-highest daily 8-hour maximum.
[h]Rolling 3-month average.
[i]Quarterly average.
Source: DOH, 2015

The prevailing winds throughout the year in Hawaii are the northeasterly trade winds. Trade wind frequency varies from more than 90% of the time during the summer season to only 50% in January, with an overall frequency of 70%. These trade winds keep the air quality generally good. Westerly, or Kona, winds occur primarily during the winter months, generated by low pressure systems near the islands.

The Department of Health (DOH) operates a network of air quality monitoring stations at various locations around the state. The closest air quality monitoring station to the project site is approximately 11 miles south of the project area in Kapolei Business Park, southeast of the Kapolei Fire Station. The station was established in July 2002 and monitors SO_2, CO, NO_2, PM_{10}, $PM_{2.5}$, $PM_{2.5}$ speciation, and NCore. The purpose of the monitoring is population exposure. The 2018 data obtained from the Kapolei air quality monitoring station shows that the area is in attainment for all monitored pollutants. Measurements indicate that all pollutants are well below the NAAQS and AAQS (DOH, 2020).

In addition to the NAAQS and the State AAQS, the DOH regulates fugitive dust. HAR Chapter 11-60.1-33, Fugitive Dust, states that no person shall cause or permit visible fugitive dust to become airborne without taking reasonable precautions, and no person shall cause or permit the discharge of visible fugitive dust beyond the property lot line on which the fugitive dust originates (DOH, 2014). This rule applies to construction projects and would, therefore, be applicable to the Proposed Action.

3.10.2 Potential Impacts

Based on the significance criteria set forth in HAR Chapter 11-200.1, the Proposed Action would result in a significant impact to air quality if it would result in a substantial degradation of environmental quality, have a substantial adverse effect on air quality, or require substantial energy consumption or emit substantial greenhouse gases. Therefore, the Proposed Action's impact to air quality would be considered significant if it would result in emissions of air pollutants that could substantially impair the existing air quality through generation of substantial pollutant concentrations, lead to the area becoming a non-attainment area for State AAQS and NAAQS, or substantially emit greenhouse gases.

Construction

During construction, there would be short-term and temporary emission sources that may affect air quality at the construction site. These include the following:

- Diesel and/or gasoline-powered construction equipment and motor vehicles would contribute to additional CO and CO_2 in the air.
- Fugitive dust emissions resulting from excavation to rehabilitate the reservoirs, bury the proposed upper and lower penstocks and electric power lines, and repair the unpaved access roads.

Because levels of criteria pollutants in Hawaii are consistently below the NAAQS and AAQS, and because the prevailing trade winds rapidly carry pollutants offshore limiting the effect on receptors, increases in levels of criteria pollutants at the project sites from construction activities are not expected to be significant. With the implementation of the measures identified in **Section 3.10.3**, it is not anticipated that NAAQS or AAQS would be exceeded during construction activities.

Under the No-Action Alternative, no construction activities would occur; therefore, there would be no construction-related air quality impacts.

Operation

The Proposed Action would not add an emission source; therefore, there would be no impact to air quality upon the completion of construction.

Under the No-Action Alternative, no changes to existing conditions would occur; therefore, there would be no additional impacts to air quality. The continued eroding of the limestone mass supporting the outfall pipe may lead to conditions requiring "emergency repairs" which would require construction equipment that would have similar impacts to air quality as the Proposed Action construction impacts.

3.10.3 Minimization and Mitigation Measures

A dust control plan, to be approved by the DOH, would be developed and implemented to minimize fugitive dust during construction. The plan would include, but not be limited to, the following measures:

- Watering of active work areas
- Screening piles of materials from wind, if appropriate
- Cleaning nearby paved roads affected by construction
- Covering open trucks carrying construction materials
- Limiting areas to be disturbed at any given time
- Mulching or chemically stabilizing inactive areas that have been disturbed

Additionally, contractors would be required to maintain equipment with emissions controls.

3.11 Noise

3.11.1 Affected Environment

Noise is defined as unwanted sound and is one of the most common environmental issues of concern to the public. Several factors affect sound as it is perceived by the human ear. These include the actual level of the sound (i.e., noise), the frequencies involved, the period of exposure to the noise, and changes or fluctuations in the noise levels during exposure. The accepted unit of measure for noise levels is the decibel (dB).

The State of Hawaii regulates noise exposure in the following statutes and rules:

- HRS, Section 342F – Noise Pollution
- HAR, Section 11-46 – Community Noise Control
- HAR, Section 12-200.1 – Occupational Noise Exposure

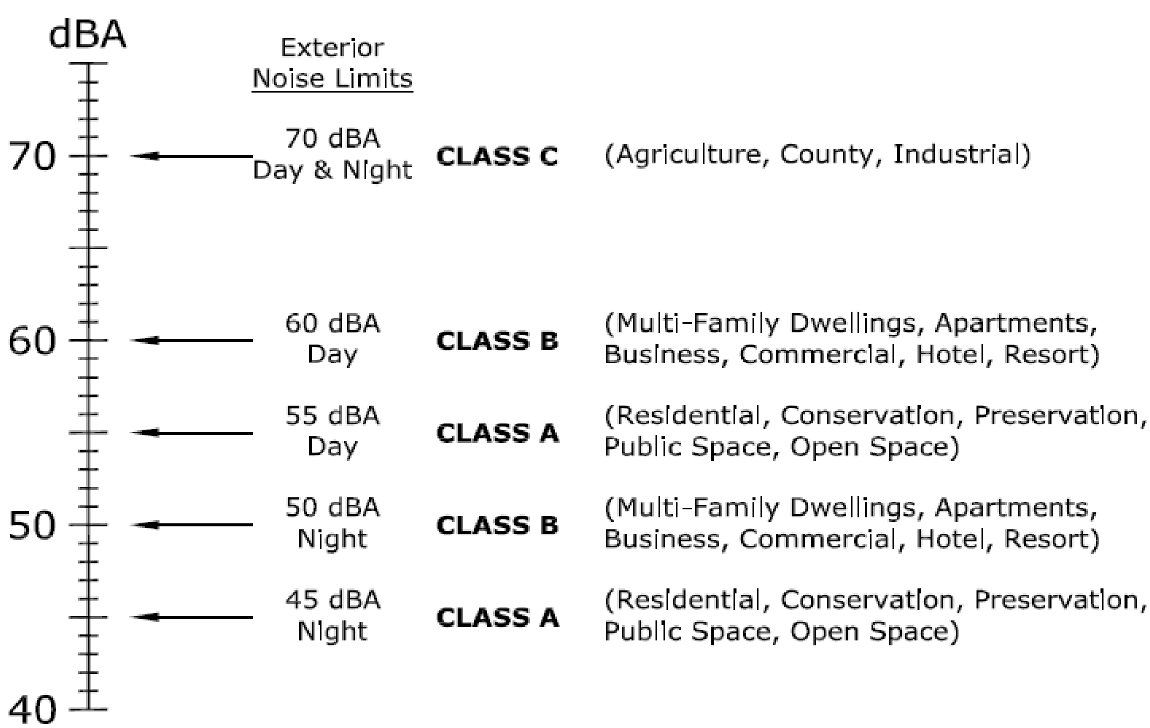
The State of Hawaii Community Noise Control Rule (HAR Chapter 11-46) defines three classes of zoning districts and specifies corresponding maximum permissible sound levels due to stationary noise sources such as air-conditioning units, exhaust systems, generators, compressors, pumps, etc. The Community Noise Control Rule does not address most moving sources, such as vehicular traffic noise, air traffic noise, or rail traffic noise. However, the Community Noise Control Rule does regulate noise related to construction activities, which may not be stationary.

The maximum permissible noise levels are enforced by the DOH for any location at or beyond the property line and shall not be exceeded for more than 10% of the time during any 20-minute period. The specified noise limits which apply are a function of the zoning and time of day as shown in **Figure 14**. With respect to mixed zoning districts, the rule specifies that the primary land use designation shall be used to determine the applicable zoning district class and the maximum permissible sound level. In determining the maximum permissible sound level, the background noise level is considered by the DOH.

As discussed in **Section 4.2.2**, the Proposed Action is located in zone P-2, General Preservation District, which is Class A. The project site is subject to noise generated from the Waianae WWTP and traffic on Farrington Highway.

Figure 14. Hawaii Maximum Permissible Sound Levels for Various Zoning Districts

Zoning District	**Day Hours** (7 AM to 10 PM)	**Night Hours** (10 PM to 7 AM)
CLASS A Residential, Conservation, Preservation, Public Space, Open Space	55 dBA (Exterior)	45 dBA (Exterior)
CLASS B Multi-Family Dwellings, Apartments, Business, Commercial, Hotel, Resort	60 dBA (Exterior)	50 dBA (Exterior)
CLASS C Agriculture, Country, Industrial	70 dBA (Exterior)	70 dBA (Exterior)



3.11.2 Potential Impacts

Based on the significance criteria set forth in HAR Chapter 11-200.1, the Proposed Action would result in a significant noise impact if it has a substantial adverse effect on ambient noise levels. Therefore, a significant noise impact would occur if the Proposed Action would result in increased ambient noise levels to the extent that noise-sensitive receptors would be exposed to noise exceeding regulatory levels.

Construction

During construction, noise would be generated from the equipment used to install the monolithic concrete encasement at the shoreline. Construction equipment may include excavators, trucks, and other heavy equipment. Typical noise emission levels for construction equipment are provided in **Table 7.**

The project site is located within Lualualei Beach Park. Noise generated during construction could impact the enjoyment of visitors to the park, including campers. However, these impacts would be short-term and temporary. In addition, the measures provided in **Section 3.11.3** would be implemented to minimize potential noise impacts.

Under the No-Action Alternative, no construction activities would occur; therefore, there would be no impact to the existing noise environment.

Table 7. Typical Noise Emission Levels for Construction Equipment

Equipment Type	Noise Level at 50 feet (dBA)
Air Compressor	81
Backhoe	80
Bulldozer	82
Chain Saw	85
Concrete/Grout Pumps	82
Crawler Service Crane (100-ton)	83
Dump Truck	88
Excavator	85
Front End Loader	80
Generator	81
Jackhammer (compressed air)	85
Lift Booms	85
Pick-Up Truck	55
Power-Actuated Hammer	88
Water Pump	76
Water Truck	55

Source: FHWA, 2015

Operation

The Proposed Action would not add a noise source; therefore, there would be no impact to the existing noise environment upon completion of construction. The continued eroding of the limestone mass supporting the outfall pipe may lead to conditions requiring “emergency repairs” which would require construction equipment that would have similar impacts to the existing noise environment as the Proposed Action construction impacts.

Under the No-Action Alternative, no changes to existing conditions would occur; therefore, there would be no additional impacts to the existing noise environment.

3.11.3 Minimization and Mitigation Measures

The following measures would be implemented to minimize noise impacts during construction of the Proposed Action:

- Contractors would be required to adhere to state and county noise regulations.
- Construction activities would be conducted on weekdays and in daytime hours.
- The construction contractor would be required to obtain a Community Noise Permit from the DOH Indoor and Radiological Health Branch.
- In the event that work occurs after normal working hours (i.e., at night or on weekends), or if permissible noise levels are exceeded, the contractor would be required to obtain a Community Noise Variance from DOH and comply with any permit conditions.

3.12 Roadways and Traffic

3.12.1 Affected Environment

The project site is located along the shoreline on the west side of Farrington Highway. Materials and equipment would be transported to the site from Honolulu via H-1 and Farrington Highway. The project site would be accessed via the existing parking lot at Lualualei Beach Park.

3.12.2 Potential Impacts

Based on the significance criteria set forth in HAR Chapter 11-200.1, the Proposed Action would result in a significant impact if it involves a substantial degradation of environmental quality. Therefore, the Proposed Action would have a significant impact if it would increase traffic resulting in a substantial deterioration of traffic conditions and/or requiring additional road improvements beyond minor modifications at the access point and routine maintenance.

Construction

The Proposed Action would have minor, short-term direct and indirect impacts on Farrington Highway from project-related vehicles, equipment, materials delivery, and personnel access to the project site. It is expected that the majority of personnel would be traveling to the site from south/east of the project area (e.g. Central Oahu, Honolulu, etc); therefore, travel to/from the project site would be in the opposite direction of the AM/PM peak hours.

Project-related traffic would enter the parking lot adjacent to the site, then onto an ingress/egress pad to enter the project site. There would be no impacts to local traffic because project-related traffic would queue within the parking lot and not on Farrington Highway or other public roads.

Transportation of equipment and materials to and from the project site would require oversized and/or overweight loads. The contractor would be required to obtain a permit from the Hawaii Department of Transportation (HDOT) to transport oversized and/or overweight materials and equipment on State highways.

Under the No-Action Alternative, no construction activities would occur; therefore, there would be no construction-related impacts to roadways and traffic.

Operation

Upon completion of construction, there would be no impact to roadways or traffic. The outfall pipe would be inspected and maintained as under current operations.

Under the No-Action Alternative, no changes to existing conditions would occur; therefore, there would be no additional impacts to roadways and traffic. The continued eroding of the limestone mass supporting the outfall pipe may lead to conditions requiring “emergency repairs” which would require construction equipment, materials, and personnel be transported to the site. Depending on the scale of the required “emergency repairs,” impacts to roadways and traffic could be similar to those of the Proposed Action.

3.12.3 Minimization and Mitigation Measures

The following measures would be implemented to minimize impacts to roadways and traffic:

- The contractor would be required to keep all construction vehicles in proper operating condition and ensure that material loads are properly secured to prevent dust, debris, leakage, or other adverse conditions from affecting public roadways.
- The contractor would be required to obtain a permit from HDOT to transport oversized and/or overweight materials and equipment on State highways.
- All construction materials and equipment would be transferred to and from the project staging area and project site during off-peak traffic hours (8:30 a.m. to 3:30 p.m.) to minimize potential disruption to traffic on the local streets.
- The contractor would be required to clean nearby pavements and paved roads after construction.

3.13 Public Facilities and Services

3.13.1 Affected Environment

Utilities

There are no electric, cable, phone, or water utilities serving the project site. The project site is the location of the existing Waianae WWTP outfall pipe. The areas adjacent to the project site do have utility service including electric, phone, water, and wastewater. Electric service in the area is provided by the Hawaiian Electric Company (HECO). Water service is provided by the CCH Board of Water Supply (BWS). Wastewater service is provided by the Waianae WWTP. Telephone, cable, and internet services are provided by both Hawaiian Telcom and Spectrum.

Solid Waste Disposal

Solid waste collection, transport, and disposal operations are the responsibility of the CCH-ENV’s Refuse Division. Solid waste is collected and disposed of at the Waimanalo Gulch Landfill in Waianae. PVT Land Company operates a privately owned and operated, licensed solid waste facility for recovery of recyclable materials and disposal of construction and demolition materials: the PVT Landfill. The PVT Landfill accepts waste on a pre-arranged basis from registered contractors. Waste loads are screened to remove recyclable materials and the remaining wastes are landfilled.

Emergency Services

Waianae has two fire stations: Honolulu Fire Department (HFD) Station 26 and HFD Station 28. The closest station to the project site is HFD Station 26, which is located 1.3 miles north of the project site on Farrington Highway.

Police protection is provided by the Honolulu Police Department. The project site is located in District 8, Kapolei, which serves the Ewa, Makakilo, Nanakuli, Waianae, and Makaha areas. The Waianae Police Station is located 0.7 mile north of the project site on Farrington Highway.

The Waianae Coast Comprehensive Health Center is located 0.4 mile south of the project site on Farrington Highway. The health center offers comprehensive care including adult medicine, family practice, pediatrics, women's health, emergency medicine, dental care, vision, and a pharmacy. The health center provides 24-hour emergency services and is recognized as a Trauma Support Facility by the state of Hawaii.

Emergency medical service (i.e., ambulance) is provided by the CCH Emergency Services Department, Emergency Medical Services (EMS) Division. The department has 21 ambulance units in three districts. All ambulance units are designated as life support units and are staffed by at least one paramedic. The project area is served by District 1, which includes the western region of Oahu. Paramedics work closely with other emergency responders to provide high-quality pre-hospital patient care. Ocean and land rescues are coordinated between the CCH Ocean Safety and Lifeguard Services, EMS, the U.S. Coast Guard, and HFD. HFD also co-responds to medical emergencies with personnel trained at the basic life support level.

Fire, police, and medical facilities are shown on **Figure 15**.

3.13.2 Potential Impacts

Based on the significance criteria set forth in HAR Chapter 11-200.1, the Proposed Action would result in a significant impact to public facilities and services if the Proposed Action involves substantial secondary impacts such as population changes or effects on public facilities that would impact public health. Therefore, a significant impact on public facilities or services would occur if the Proposed Action caused a substantial change in population or adversely affected public facilities.

Construction

Utilities

During construction, the contractor would utilize a portion of the beach adjacent to and on the north side of the project site as a contractor yard and staging area. It is expected that the contractor would require utility services, including electric, phone, and internet. The existing utility systems would be able to provide these services if required. The contractor would be required to provide Port-a-Johns at the construction staging area.

Under the No-Action Alternative, no construction would occur; therefore, there would be no construction-related impacts to utilities.

Solid Waste Disposal

Construction activities associated with the Proposed Action would result in the generation of small amounts of construction debris and excess soil, which would be disposed of at the PVT Landfill in accordance with CCH and State DOH regulations and provisions of the PVT facility license. Non-construction solid waste would be collected and disposed of at either of the City's landfills.

Under the No-Action Alternative, no construction would occur; therefore, there would be no construction-related impacts to solid waste facilities.

Figure 15. Emergency Services

Emergency Services

It is not anticipated that construction activities associated with the Proposed Action would result in an increase in calls for fire, police, or medical services. However, if an incident were to occur during construction that required fire, police, or medical attention, the level of demand could be met by the existing emergency service providers located in Waianae (see **Section 3.13.1**).

Under the No-Action Alternative, no construction activities would occur; therefore, there would be no construction-related impacts to emergency services.

Operation

Utilities

Upon completion of construction, any temporary utility connections would be disconnected, and the Proposed Action would not result in the use of any utilities. The Proposed Action would have a beneficial impact to the wastewater utility by protecting and repairing the existing outfall pipe.

Under the No-Action Alternative, no repairs would be made to the outfall pipe and manholes. The limestone mass supporting the outfall pipe would continue to erode, which could result in the need for "emergency repairs" or failure of the pipe. Failure of the outfall pipe could result in the release of effluent in nearshore waters and would result in the shut-down of the Waianae WWTP, which would impact customers over a large part of West Oahu from Makaha to Nanakuli (i.e., the service area of the Waianae WWTP). The release of effluent in nearshore waters and shutdown of the WWTP could impact public health.

Solid Waste Disposal

Upon completion of construction, the Proposed Action would not result in the generation of solid waste; therefore, there would be no impact to existing solid waste facilities from operation of the Proposed Action.

Under the No-Action Alternative, the area would remain under its existing use. Solid waste disposal activities would continue as under current conditions. The continued eroding of the limestone mass supporting the outfall pipe may lead to conditions requiring "emergency repairs" which could generate small amounts of construction debris and excess soil that would need to be disposed of similar to that of the Proposed Action during construction.

Emergency Services

The Proposed Action does not require additional personnel to operate; therefore, there would be no impact to emergency services upon completion of construction, and the area would revert to its existing use. Calls for emergency services are expected to be the same as current levels.

Under the No-Action Alternative, the area would remain under its existing use. Calls for emergency services would be the same as current conditions.

3.13.3 Minimization and Mitigation Measures

No minimization measures are proposed or expected to be required.

3.14 Socioeconomic Characteristics

3.14.1 Affected Environment

The Waianae WWTP is a secondary treatment facility serving the Waianae Coast, which consists of the communities of Nanakuli, Lualualei, Maili, Waianae, and Makaha, as shown in **Figure 16**. In fiscal year 2020, the Waianae WWTP processed 3.40 MGD. The resident population within the Waianae WWTP service area is approximately 50,000 (DBEDT, 2020).

3.14.2 Potential Impacts

Based on the significance criteria set forth in HAR Chapter 11-200.1, the Proposed Action would result in a significant impact to socioeconomics if the Proposed Action would have a substantial adverse effect on the economic or social welfare of the community or State. Therefore, a significant socioeconomic impact would occur if the Proposed Action adversely affected the revenue, employment, or overall economic conditions of the island community or the state as a whole.

Construction

Construction of the Proposed Action would not increase the population of the area, nor would it have a substantial adverse effect on the economic or social welfare of the community or State. Construction would result in temporary, positive economic activity in the form of construction jobs and material procurements.

Under the No-Action Alternative, no construction activities would occur; therefore, there would be no construction-related socioeconomic impacts.

Operation

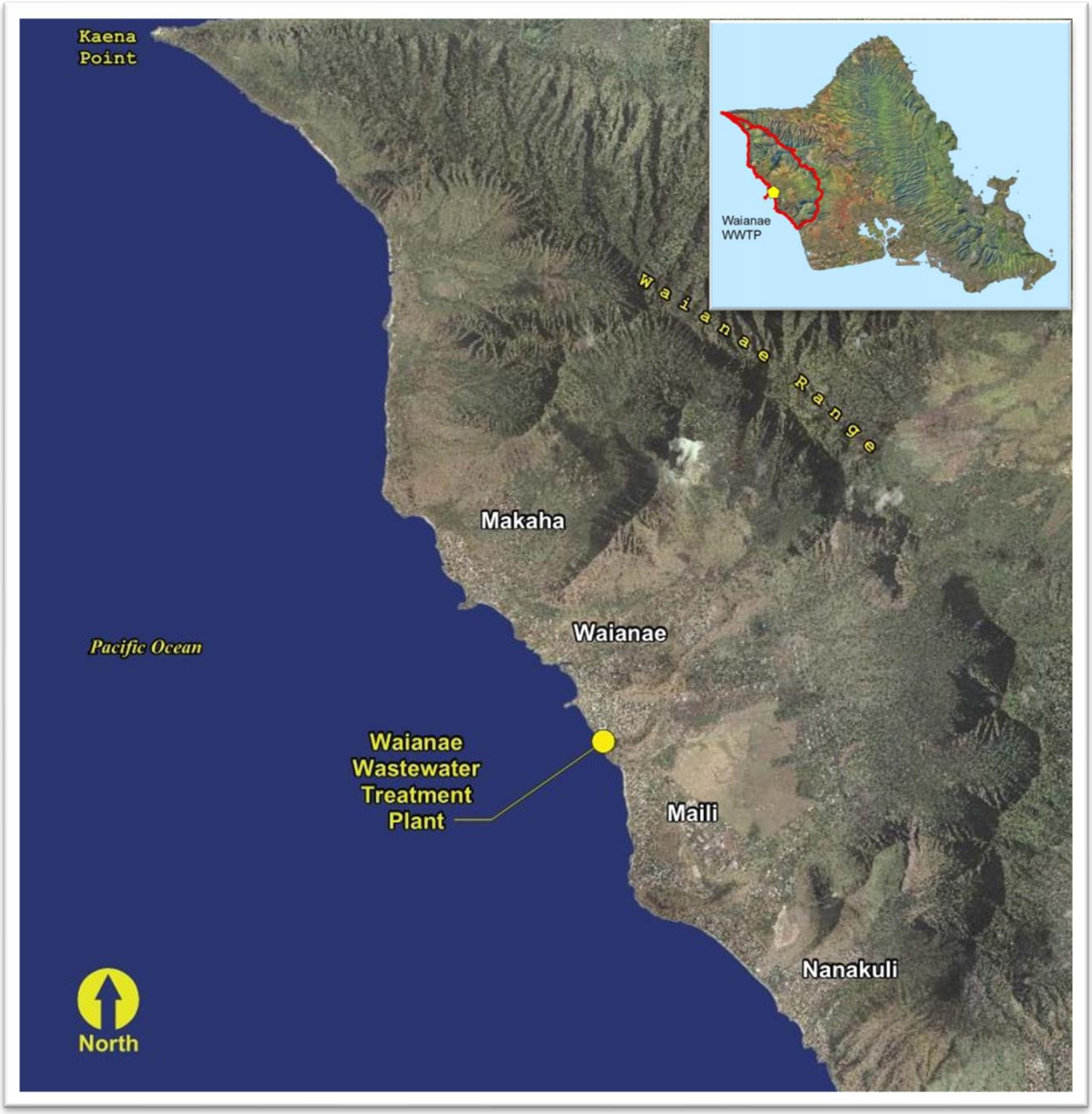
The Waianae WWTP is critical infrastructure for the island of Oahu. The Proposed Action is necessary to ensure that the shoreline section of the Waianae WWTP outfall pipe is not further undermined, which could cause damage that results in a release of effluent and takes the outfall pipe out of service. The installation of the monolithic concrete encasement and manhole covers would not affect the revenue, employment, or overall economic conditions of the island community or the state as a whole. Overall, the Proposed Action would be beneficial to the community as it would ensure the continued operation of the outfall and minimize maintenance costs to the CCH.

Under the No-Action Alternative, the outfall pipe would continue to be susceptible to shoreline erosion and corrosion of the existing manhole covers. The progressive shoreline erosion is a serious threat that could result in the need for “emergency repairs” or failure of the pipe. Failure of the outfall pipe could result in the release of effluent in nearshore waters and would result in the shut-down of the Waianae WWTP, which would impact customers over a large part of West Oahu from Makaha to Nanakuli (i.e., the service area of the Waianae WWTP). Emergency repairs would be required, which would have a negative impact on CCH’s budget.

3.14.3 Minimization and Mitigation Measures

No minimization measures are proposed or expected to be required.

Figure 16. Waianae WWTP Service Area



Source: CCH-ENV (http://www.honolulu.gov/rep/site/env/wwm_docs/wwm_Website-Service-Area-Waianae.pdf)

3.15 Secondary and Cumulative Impacts

3.15.1 Secondary Impacts

Secondary impacts are those effects that are caused by an action and are later in time or farther removed in distance but are reasonably foreseeable. They may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density, or growth rate, and related effects on air and water or other natural systems.

The Proposed Action would not involve a change in land use, would not induce growth, and would not change the capacity of the WWTP. Therefore, the Proposed Action would not have secondary impacts.

3.15.2 Cumulative Impacts

Cumulative impacts refer to the impact on the environment that results from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such actions. Cumulative effects can result from individually minor yet collectively significant actions taking place over time.

Land use in the vicinity of the Proposed Action is recreation and open space. No other past, present, or planned actions have been identified that would contribute to cumulative impacts for any resource. Therefore, no cumulative impacts are anticipated from implementation of the Proposed Action.

4.0 Relationship to State and County Land Use Plans and Policies

4.1 State Planning Documents

4.1.1 HRS Chapter 226, The Hawaii State Plan

The Hawaii State Plan, codified as HRS Chapter 226, provides goals, objectives, policies, and priorities for the State. The Hawaii State Plan also provides a basis for determining priorities, allocating limited resource, and improving coordination of State and County plans, policies, programs, projects, and regulatory activities. It establishes a set of themes, goals, objectives, and policies that are meant to guide the State's long-range growth and development activities. Applicable sections of HRS Chapter 226 to the Proposed Action are shown in **Table 8**. Applicable sections are further discussed below.

Table 8. Summary of Applicability of HRS Chapter 226 to the Proposed Action

HRS Chapter 226 Hawaii State Planning Act	Applicability to Project
Part I. Overall Theme, Goals, Objectives, and Policies	
§226-5 Objective and policies for population	Not applicable
§226-6 Objectives and policies for the economy--in general	Not applicable
§226-7 Objectives and policies for the economy-- agriculture	Not applicable
§226-8 Objective and policies for the economy--visitor industry	Not applicable
§226-9 Objective and policies for the economy--federal expenditures	Not applicable
§226-10 Objective and policies for the economy--potential growth and innovative activities	Not applicable
§226-10.5 Objectives and policies for the economy--information industry	Not applicable
§226-11 Objectives and policies for the physical environment--land-based, shoreline, and marine resources	**Applicable**
§226-12 Objective and policies for the physical environment--scenic, natural beauty, and historic resources	**Applicable**
§226-13 Objectives and policies for the physical environment--land, air, and water quality	**Applicable**
§226-14 Objective and policies for facility systems--in general	Not applicable
§226-15 Objectives and policies for facility systems--solid and liquid wastes	**Applicable**
§226-16 Objective and policies for facility systems--water	Not applicable
§226-17 Objectives and policies for facility systems--transportation	Not applicable
§226-18 Objectives and policies for facility systems--energy	Not applicable
§226-18.5 Objectives and policies for facility systems--telecommunications	Not applicable
§226-19 Objectives and policies for socio-cultural advancement--housing	Not applicable
§226-20 Objectives and policies for socio-cultural advancement--health	Not applicable
§226-21 Objective and policies for socio-cultural advancement--education	Not applicable

HRS Chapter 226 Hawaii State Planning Act	Applicability to Project
§226-22 Objective and policies for socio-cultural advancement--social services	Not applicable
§226-23 Objective and policies for socio-cultural advancement--leisure	**Applicable**
§226-24 Objective and policies for socio-cultural advancement--individual rights and personal well-being	Not applicable
§226-25 Objective and policies for socio-cultural advancement--culture	Not applicable
§226-26 Objective and policies for socio-cultural advancement--public safety	Not applicable
§226-27 Objective and policies for socio-cultural advancement--government	**Applicable**
Part II.	
The themes of Part II of the Hawaiʻi State Plan are not applicable to the Proposed Action since the Proposed Action does not involve the preparation of planning documents.	
Part III. Priority Guidelines	
§226-103 Economic priority guidelines	**Applicable**
§226-104 Population growth and land resources priority guidelines	Not applicable
§226-105 Crime and criminal justice	Not applicable
§226-106 Affordable housing	Not applicable
§226-107 Quality education	Not applicable
§226-108 Sustainability	Not applicable
§226-109 Climate change adaptation priority guidelines	**Applicable**

Section 226-11. Objectives and policies for the physical environment – land-based, shoreline, and marine resources.

(a) Planning for the State's physical environment with regard to land-based, shoreline, and marine resources shall be directed towards achievement of the following objectives:
  (1) Prudent use of Hawaii's land-based, shoreline, and marine resources.
  (2) Effective protection of Hawaii's unique and fragile environmental resources.
(b) To achieve the land-based, shoreline, and marine resources objectives, it shall be the policy of this State to:
  (3) Take into account the physical attributes of areas when planning and designing activities and facilities.
  (4) Manage natural resources and environs to encourage their beneficial and multiple use without generating costly or irreparable environmental damage.
  (8) Pursue compatible relationships among activities, facilities, and natural resources.

Discussion: The Proposed Action is located directly on the shoreline in an area that has been subject to erosion. The repairs to the land-based segment of the outfall pipe and the underwater manholes would mitigate the risk of failure of the outfall that could result in a release of effluent in the nearshore waters and at the manhole locations. Specifically, the monolithic concrete encasement would reduce beach erosion in the immediate vicinity of the outfall pipe and protect the pipe from potential damage or failure. Impacts associated with the monolithic concrete encasement would be beneficial to land-based, shoreline, and marine resources since it would protect the beach from further erosion and potential contamination from the release of effluent. Capping of the manholes would mitigate the risk leaking of effluent at the manhole locations and protect the marine environment.

Section 226-12. Objective and policies for the physical environment – scenic, natural beauty, and historic resources.

(a) Planning for the State's physical environment shall be directed towards achievement of the objective of enhancement of Hawaii's scenic assets, natural beauty, and multi-cultural/historical resources.
(b) To achieve the scenic, natural beauty, and historic resources objective, it shall be the policy of the State to:
    (1) Promote the preservation and restoration of significant natural and historic resources.
    (5) Encourage the design of developments and activities that complement the natural beauty of the islands.

Discussion: The Proposed Action is located directly on the shoreline in an area that has been subject to erosion. The Proposed Action includes the installation of a monolithic concrete encasement over the outfall pipe to protect the shoreline from further erosion. The encasement has been designed in such a manner to be unobtrusive to the natural beauty of the area.

Section 226-13. Objectives and policies for the physical environment – land, air, and water quality.

(a) Planning for the State's physical environment with regard to land, air, and water quality shall be directed towards achievement of the following objectives:
    (1) Maintenance and pursuit of improved quality in Hawaii's land, air, and water resources.
(b) To achieve the land, air, and water quality objectives, it shall be the policy of the State to:
    (5) Reduce the threat to life and property from erosion, flooding, tsunamis, hurricanes, earthquakes, volcanic eruptions, and other natural or man-induced hazards and disasters.

Discussion: The Proposed Action includes the installation of a monolithic concrete encasement over the outfall pipe to protect the shoreline from further erosion from extreme wave and storm events and climate change factors, including sea level rise, that are likely to increase the nearshore wave exposure of the outfall. The Proposed Action has been designed to withstand the level of forces necessary to minimize the likelihood that an extreme event would damage the structures. The Proposed Action would have beneficial impacts by protecting the landfall section of the outfall pipe from potential damage and/or failure, as well as the manholes from potentially leaking effluent into offshore waters.

Section 226-15. Objectives and policies for facility systems – solid and liquid wastes.

(a) Planning for the State's facility systems with regard to solid and liquid wastes shall be directed towards the achievement of the following objectives.
    (1) Maintenance of basic public health and sanitation standards relating to treatment and disposal of solid and liquid wastes.

Discussion: The Proposed Action is a mitigation measure to protect the outfall pipe from damage associated with ongoing shoreline erosion and corrosion of the underwater manhole covers. The Waianae WWTP is critical infrastructure for the island of Oahu. The Proposed Action is necessary to ensure that the shoreline section of the Waianae WWTP outfall pipe is not further undermined, which could cause damage that results in a release of effluent and takes the outfall pipe out of service. Overall, the Proposed Action would be beneficial to the community as it would ensure the continued operation of the outfall and minimize maintenance costs to the CCH.

Section 226-23. Objective and policies for socio-cultural advancement – leisure.

(a) Planning for the State's socio-cultural advancement with regard to leisure shall be directed towards the achievement of the objective of the adequate provision of resources to accommodate diverse cultural, artistic, and recreational needs for present and future generations.

(b) To achieve the leisure objective, it shall be the policy of this State to:

    (3) Enhance the enjoyment of recreational experiences through safety and security measures, educational opportunities, and improved facility design and maintenance.

    (4) Promote the recreational and educational potential of natural resources having scenic, open space, cultural, historical, geological, or biological values while ensuring that their inherent values are preserved.

    (10) Assure adequate access to significant natural and cultural resources in public ownership.

Discussion: During construction of the Proposed Action, beach use and lateral access at the project site would be restricted. Approximately 0.9-acre of beach would be used for construction and staging area. However, this disruption would be temporary. Access to the beach to the north and south of the construction site would not be restricted as there are access points from Pokai Bay Street and Farrington Highway on the north and south sides of the construction work area, respectively.

Construction of the monolithic concrete encasement would include the installation of a turbidity curtain around the outfall pipe to create a 45-foot-wide workspace over the outfall pipe. In addition, a double row of silt fence would be installed along the shoreline for the width of the project area. Surfers and boaters would not be able to access the 45-foot-wide by 125-foot-long area over the outfall pipe. Shoreline fishermen would need to use care to not get their lines tangled in the turbidity curtain.

Construction activities associated with the manhole covers would require anchoring of a barge over the existing manhole(s). While the barge is in place, surfers and boaters would not be able to access the area immediately around the barge. These impacts would be short-term and temporary. Other offshore areas would not be impacted.

Upon completion of construction, there would be no changes to recreational use of the beach or offshore areas. The monolithic concrete encasement would reduce beach erosion in the immediate vicinity of the outfall pipe and protect the pipe from potential damage or failure. Impacts associated with the monolithic concrete encasement would be beneficial to recreation since it would protect the beach from further erosion and potential contamination from the release of effluent. Capping of the manholes would mitigate the risk leaking of effluent at the manhole locations and protect water quality for surfers and fishermen.

The Proposed Action would be beneficial to the community as it would ensure the continued operation of the outfall and minimize maintenance costs to the CCH.

Section 226-27. Objectives and policies for socio-cultural advancement – government.

(a) Planning the State's socio-cultural advancement with regard to government shall be directed towards the achievement of the following objectives:
   (1) Efficient, effective, and responsive government services at all levels in the State.
   (2) Fiscal integrity, responsibility, and efficiency in the state government and county governments.

(b) To achieve the government objectives, it shall be the policy of this State to:
   (1) Provide for necessary public goods and services not assumed by the private sector.

Discussion: The Waianae WWTP is critical infrastructure for the island of Oahu. The Proposed Action is necessary to ensure that the shoreline section of the Waianae WWTP outfall pipe is not further undermined, which could cause damage that results in a release of effluent and takes the outfall pipe out of service. Overall, the Proposed Action would be beneficial to the community as it would ensure the continued operation of the outfall and minimize maintenance costs to the CCH.

Section 226-109. Climate change adaptation priority guidelines.

Priority guidelines to prepare the State to address the impacts of climate change, including impacts to the areas of agriculture; conservation lands; coastal and nearshore marine areas; natural and cultural resources; education; energy; higher education; health; historic preservation; water resources; the built environment, such as housing, recreation, transportation; and the economy shall:

(2) Ensure that Hawaii's people are educated, informed, and aware of the impacts climate change may have on their communities;
(3) Encourage community stewardship groups and local stakeholders to participate in planning and implementation of climate change policies;
(4) Invest in continued monitoring and research of Hawaii's climate and the impacts of climate change on the State;
(5) Consider native Hawaiian traditional knowledge and practices in planning for the impacts of climate change;
(6) Encourage the preservation and restoration of natural landscape features, such as coral reefs, beaches and dunes, forests, streams, floodplains, and wetlands, that have the inherent capacity to avoid, minimize, or mitigate the impacts of climate change;
(7) Explore adaptation strategies that moderate harm or exploit beneficial opportunities in response to actual or expected climate change impacts to the natural and built environments;
(8) Promote sector resilience in areas such as water, roads, airports, and public health, by encouraging the identification of climate change threats, assessment of potential consequences, and evaluation of adaptation options;
(9) Foster cross-jurisdictional collaboration between County, State, and Federal agencies and partnerships between government and private entities and other nongovernmental entities, including nonprofit entities;
(10) Use management and implementation approaches that encourage the continual collection, evaluation, and integration of new information and strategies into new and existing practices, policies, and plans; and

(11) Encourage planning and management of the natural and built environments that effectively integrate climate change policy.

Discussion: The CCH supports the Hawaii State Plan Climate Change Adaption Priority Guidelines and acknowledges the importance of planning for potential impacts. Full support and participation will be provided towards ongoing efforts to better understand, plan, and ultimately adapt to Hawaii's changing climate.

4.1.2 HRS Chapter 205, State Land Use Law

Hawaii was the first of the fifty States to have a State Land Use Law and a State Plan. Today, Hawaii remains unique among the fifty states with respect to the extent of control that the state exercises in land use regulation. The State Land Use Law, HRS Chapter 205, was originally adopted by the State Legislature in 1961. This law establishes an overall framework of land use management whereby all lands in the State of Hawaii are classified into one of four land use districts: Urban, Agricultural, Conservation, and Rural.

Discussion: As shown in **Figure 17**, the Proposed Action is located in the Urban State Land Use District. However, it must be noted that the land and marine waters makai of the certified shoreline are considered a part of the Conservation state land use district. Therefore, a portion of the project site is located within the Conservation district in the Resource Subzone (DLNR, 2011).

The Urban land use district permits "any and all uses permitted by the counties."

Shoreline erosion control is a permitted use in the Resource subzone of the Conservation district, provided the following:

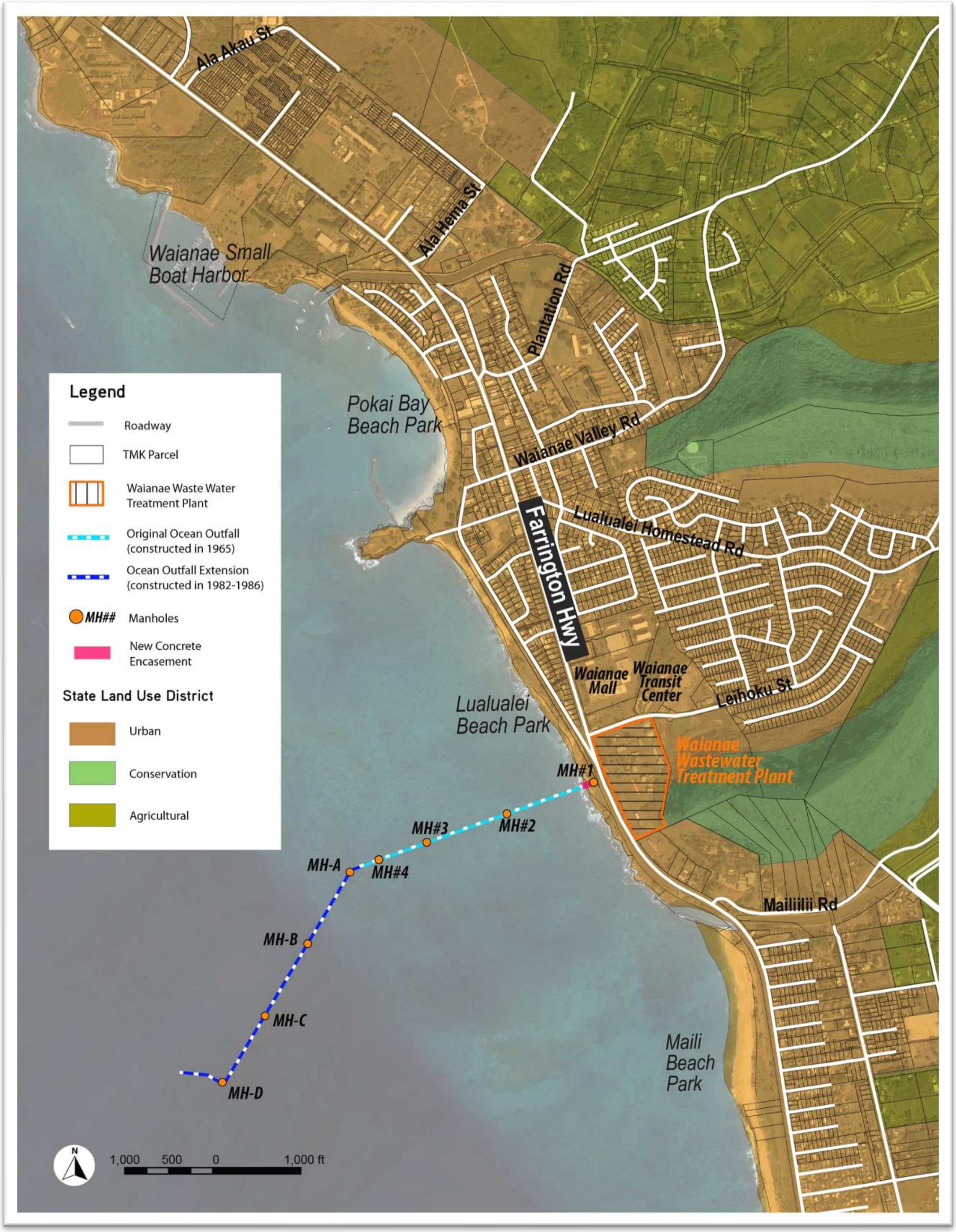
1. The use would not adversely affect beach processes or lateral public access along the shoreline.
2. Public facilities critical to public health, safety, and welfare would be severely damaged or destroyed without a shoreline erosion control structure, and there are no reasonable alternatives (DLNR, 2011).

Any shoreline erosion control structures require a Shoreline Certification and a Conservation District Use Permit. A Shoreline Certification and Conservation District Use Permit will be obtained by the project proponent. Therefore, the Proposed Action is consistent with the State Land Use Law.

4.1.3 HRS Chapter 205A, Hawaii Coastal Zone Management Program

The National Coastal Zone Management (CZM) Program was created with the passage of the Coastal Zone Management Act of 1972 (CZMA). Hawaii's CZM Program, established pursuant to HRS Chapter 205A, as amended, is administered by the State of Hawaii Office of Planning and Sustainable Development and provides for the beneficial use, protection, and development in the State's coastal zone. The objectives and policies of the Hawaii CZM Program encompass a wide array of concerns including impacts to recreational resources, historic and archaeological resources, coastal scenic resources and open space, coastal ecosystems, coastal hazards, and the management of development. The Hawaii CZM area includes all lands within the State and the areas seaward to the extent of the State's management jurisdiction. Therefore, the Proposed Action is located within the CZM area.

Figure 17. State Land Use Districts



The Proposed Action is consistent with the following objectives and policies of the Hawaii CZM Program:

RECREATIONAL RESOURCES

Objective: Provide coastal recreational opportunities accessible to the public.

Policies:

1) Improve coordination and funding of coastal recreational planning and management.
2) Provide adequate, accessible, and diverse recreational opportunities in the coastal zone management area by:
    a) Protecting coastal resources uniquely suited for recreational activities that cannot be provided in other areas.
    b) Requiring replacement of coastal resources having significant recreational value including, but not limited to surfing sites, fishponds, and sand beaches, when such resources will be unavoidably damaged by development; or requiring reasonable monetary compensation to the State for recreation when replacement is not feasible or desirable.
    c) Providing and managing adequate public access, consistent with conservation of natural resources, to and along shorelines with recreational value.
    d) Providing an adequate supply of shoreline parks and other recreational facilities suitable for public recreation.
    e) Ensuring public recreational uses of county, state, and federally owned or controlled shoreline lands and waters having recreational value consistent with public safety standards and conservation of natural resources.
    f) Adopting water quality standards and regulating point and non-point sources of pollution to protect, and where feasible, restore the recreational value of coastal waters.
    g) Developing new shoreline recreational opportunities, where appropriate, such as artificial lagoons, artificial beaches, and artificial reefs for surfing and fishing.
    h) Encouraging reasonable dedication of shoreline areas with recreational value for public use as part of discretionary approvals or permits by the land use commission, board of land and natural resources, and county authorities; and crediting such dedication against the requirements of Hawaii Revised Statutes, section 46-6.

Discussion: During construction of the Proposed Action, beach use and lateral access at the project site would be restricted. Approximately 0.9 acre of beach would be used for construction and staging area. However, this disruption would be temporary. Access to the beach to the north and south of the construction site would not be restricted as there are access points from Pokai Bay Street and Farrington Highway on the north and south sides of the construction work area, respectively.

During construction of the monolithic concrete encasement, there would be an increase in noise and dust from short-term construction activities; however, the impacts would be temporary and minimized to the extent possible. In addition, the project site is located immediately adjacent to Farrington Highway; therefore, noise impacts would be similar to existing conditions. Therefore, impacts associated with construction of the Proposed Action would be less than significant.

Construction of the monolithic concrete encasement would include the installation of a turbidity curtain around the outfall pipe to create a 45-foot-wide workspace over the outfall pipe. In addition, a double row of silt fence would be installed along the shoreline for the width of the project area. Surfers and boaters would not be able to access the 45-foot-wide by 125-foot-long area over the outfall pipe. Shoreline fishermen would need to use care to not get their lines tangled in the turbidity curtain.

Construction activities associated with the manhole covers would require anchoring of a barge over the existing manhole(s). While the barge is in place, surfers and boaters would not be able to access the area immediately around the barge. These impacts would be short-term and temporary. Other offshore areas would not be impacted.

Upon completion of construction, there would be no changes to recreational use of the beach or offshore areas. The monolithic concrete encasement would reduce beach erosion in the immediate vicinity of the outfall pipe and protect the pipe from potential damage or failure. Impacts associated with the monolithic concrete encasement would be beneficial to recreation since it would protect the beach from further erosion and potential contamination from the release of effluent. Capping of the manholes would mitigate the risk leaking of effluent at the manhole locations and protect water quality for surfers and fishermen.

HISTORIC RESOURCES
Objective: Protect, preserve, and, where desirable, restore those natural and manmade historic and prehistoric resources in the coastal zone management area that are significant in Hawaiian and American history and culture.

Policies:

1) Identify and analyze significant archaeological resources.
2) Maximize information retention through preservation of remains and artifacts or salvage operations.
3) Support state goals for protection, restoration, interpretation, and display of historic resources

<u>Discussion</u>: Based on previous archaeological investigations in the vicinity, there is low potential for traditional Hawaiian subsurface cultural deposits. However, the lack of development and the beach location suggests the possibility of encountering traditional Hawaiian human burials.

CCH-ENV will consult with the State Historic Preservation Division (SHPD) under HRS Chapter 6E-8 regarding project effects and would incorporate any mitigation measures required. It is expected that archeological monitoring may be required during ground disturbing activities. Any monitoring would be executed in accordance with a SHPD-approved Archaeological Monitoring Plan.

In addition to any requirements by SHPD, the following measures would be implemented to minimize potential impacts to cultural practices and beliefs and archaeological and historic resources:

- If human remains or burials are identified, all earth-moving activities in the area would stop, the area would be cordoned off, and SHPD and the Honolulu Police Department would be notified pursuant to HAR Section 13-300-40.
- If any potential historic properties are identified during construction activities, all activities in the area would cease and SHPD would be notified pursuant to HAR Section 13-280-3.

SCENIC AND OPEN SPACE RESOURCES

Objective: Protect, preserve, and, where desirable, restore or improve the quality of coastal scenic and open space resources.

Policies:

1) Identify valued scenic resources in the coastal zone management area.
2) Ensure that new developments are compatible with their visual environment by designing and locating such developments to minimize the alteration of natural landforms and existing public views to and along the shoreline.
3) Preserve, maintain, and, where desirable, improve and restore shoreline open space and scenic resources.
4) Encourage those developments that are not coastal dependent to locate in inland areas.

Discussion: Construction of the Proposed Action would introduce construction equipment and activity along a part of the shoreline. Although construction activities would be visible from Farrington Highway and visitors and transient residents of the area, the project area is not in the viewshed of the significant panoramic views from or to Lualualei Beach Park as identified in the *Waianae Sustainable Communities Plan* (CCH-DPP, 2012).

The Proposed Action, limited in scope to the construction of a monolithic concrete encasement around approximately 125 feet of the shoreline portion of the outfall pipe and manhole covers offshore, is not anticipated to affect the aesthetic and visual character of the surrounding area. Although it would present a new, visible structure at the shoreline, it would not be significantly different from the exposed pipe already present at the shoreline. The Proposed Action would not include structures that would block viewplanes or be incongruous with existing conditions of the site.

COASTAL ECOSYSTEMS

Objective: Protect valuable coastal ecosystems, including reefs, from disruption and minimize adverse impacts on all coastal ecosystems.

Policies:

1) Exercise an overall conservation ethic, and practice stewardship in the protection, use, and development of marine and coastal resources.
2) Improve the technical basis for natural resource management.
3) Preserve valuable coastal ecosystems, including reefs, of significant biological or economic importance.
4) Minimize disruption or degradation of coastal water ecosystems by effective regulation of stream diversions, channelization, and similar land water uses, recognizing competing water needs.
5) Promote water quantity and quality planning and management practices that reflect the tolerance of fresh water and marine ecosystems and maintain and enhance water quality through the development and implementation of point and nonpoint source water pollution control measures.

Discussion: Construction of the Proposed Action would likely have direct impacts and result in the loss of marine benthos in the immediate nearshore area and within the construction footprints of the manhole covers. The anchoring of the silt curtains or other BMPs in nearshore waters may also impact marine benthos. The direct impact area was previously disturbed when the outfall pipe was installed and during the emergency repairs completed in 2018. Corals are rare in the nearshore area and around MH-2. Corals are more numerous around MH-3 and MH-4, but they are mostly small (less than 20 cm in diameter). With time, similar coral, algae, and macroinvertebrate communities would recruit to the new concrete structures and host similar assemblages seen on the existing structures.

Upon completion of construction, there would be beneficial impacts to coastal resources. The repairs to the land-based segment of the outfall and the underwater manholes would mitigate the risk of failure of the outfall that could result in a release of effluent in the nearshore waters and at the manhole locations. Allowing the corrosion to continue on the pressure manholes could result in significant leaking of effluent, which could impact the marine environment.

ECONOMIC USES
Objective: Provide public or private facilities and improvements important to the State's economy in suitable locations.

Policies:

1) Concentrate coastal development in appropriate areas.
2) Ensure that coastal dependent development such as harbors and ports, and coastal related development such as visitor industry facilities and energy generating facilities, are located, designed, and constructed to minimize adverse social, visual, and environmental impacts in the coastal zone management area.
3) Direct the location and expansion of coastal dependent developments to areas presently designated and used for such development and permit reasonable long-term growth at such areas, and permit coastal dependent development outside of presently designated areas when:
   a) Use of presently designated locations is not feasible;
   b) Adverse environmental effects are minimized; and
   c) The development is important to the State's economy.

Discussion: The Waianae WWTP is critical infrastructure for the island of Oahu. The Proposed Action would ensure that the shoreline section of the Waianae WWTP outfall pipe is not further undermined, which could cause damage that results in a release of effluent and takes the outfall pipe out of service. The installation of the monolithic concrete encasement and manhole covers would not affect the revenue, employment, or overall economic conditions of the island community or the state as a whole. Overall, the Proposed Action would be beneficial to the community as it would ensure the continued operation of the outfall and minimize maintenance costs to the CCH.

COASTAL HAZARDS
Objective: Reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion, subsidence, and pollution.

Policies:

1) Develop and communicate adequate information about storm wave, tsunami, flood, erosion, subsidence, and point and nonpoint source pollution hazards.
2) Control development in areas subject to storm wave, tsunami, flood, erosion, hurricane, wind, subsidence, and point and nonpoint source pollution hazards.
3) Ensure that developments comply with requirements of the Federal Flood Insurance Program.

4) Prevent coastal flooding from inland projects.

Discussion: The Proposed Action is a mitigation measure to protect the outfall pipe from damage associated with coastal hazards. The Proposed Action has been designed to withstand the level of forces necessary to minimize the likelihood that an extreme event would damage the structures.

MANAGING DEVELOPMENT

Objective: Improve the development review process, communication, and public participation in the management of coastal resources and hazards.

Policies:

1) Use, implement, and enforce existing law effectively to the maximum extent possible in managing present and future coastal zone development.
2) Facilitate timely processing of applications for development permits and resolve overlapping or conflicting permit requirements.
3) Communicate the potential short and long-term impacts of proposed significant coastal developments early in their life cycle and in terms understandable to the public to facilitate public participation in the planning and review process.

Discussion: The Draft Environmental Assessment is being provided for public comment and review. To facilitate the agency review process for the required permits for the Proposed Action, ENV would meet with the various agencies prior to submitting permit application packages. The permit review process would provide additional opportunities for public involvement.

PUBLIC PARTICIPATION

Objective: Stimulate public awareness, education, and participation in coastal management.

Policies:

1) Promote public involvement in coastal zone management processes.
2) Disseminate information on coastal management issues by means of educational materials, published reports, staff contact, and public workshops for persons and organizations concerned with coastal issues, developments, and government activities.
3) Organize workshops, policy dialogues, and site-specific mediations to respond to coastal issues and conflicts.

Discussion: Opportunities for public awareness, education, and participation in coastal management are provided through the regulatory review processes. The Draft Environmental Assessment is being provided for public comment and review. Additional opportunities for review would come during the permit review process.

BEACH PROTECTION

Objective: Protect beaches for public use and recreation.

Policies:

1) Locate new structures inland from the shoreline setback to conserve open space, minimize interference with natural shoreline processes, and minimize loss of improvements due to erosion.
2) Prohibit construction of private erosion-protection structures seaward of the shoreline, except when they result in improved aesthetic and engineering solutions to erosion at the sites and do not

interfere with existing recreational and waterline activities.

3) Minimize the construction of public erosion-protection structures seaward of the shoreline.
4) Prohibit private property owners from creating a public nuisance by inducing or cultivating the private property owner's vegetation in a beach transit corridor.
5) Prohibit private property owners from creating a public nuisance by allowing the private property owner's unmaintained vegetation to interfere or encroach upon a beach transit corridor.

Discussion: During construction of the Proposed Action, beach use and lateral access at the project site would be restricted. Access to the beach to the north and south of the construction site would not be restricted as there are access points from Pokai Bay Street and Farrington Highway on the north and south sides of the construction work area, respectively.

Construction of the monolithic concrete encasement would occur immediately north of the designated camping area at Lualualei Beach Park. There would be intermittent and temporary impacts to the designated camping area as the existing campground access road would be used as a haul route for equipment and materials. In addition, there would be an increase in noise and dust from short-term construction activities; however, the impacts would be temporary and minimized to the extent possible.

Construction of the monolithic concrete encasement would include the installation of a turbidity curtain around the outfall pipe to create a 45-foot-wide workspace over the outfall pipe. In addition, a double row of silt fence would be installed along the shoreline for the width of the project area. Surfers and boaters would not be able to access the 45-foot-wide by 125-foot-long area over the outfall pipe. Shoreline fishermen would need to use care to not get their lines tangled in the turbidity curtain.

Construction activities associated with the manhole covers would require anchoring of a barge over the existing manhole(s). While the barge is in place, surfers and boaters would not be able to access the area immediately around the barge. These impacts would be short-term and temporary. Other offshore areas would not be impacted.

Upon completion of construction, there would be no changes to recreational use of the beach or offshore areas. The monolithic concrete encasement would reduce beach erosion in the immediate vicinity of the outfall pipe and protect the pipe from potential damage or failure. Impacts associated with the monolithic concrete encasement would be beneficial to recreation since it would protect the beach from further erosion and potential contamination from the release of effluent. Capping of the manholes would mitigate the risk leaking of effluent at the manhole locations and protect water quality for surfers and fishermen.

MARINE RESOURCES

Objective: Promote the protection, use, and development of marine and coastal resources to assure their sustainability.

Policies:

1) Ensure that the use and development of marine and coastal resources are ecologically and environmentally sound and economically beneficial.
2) Coordinate the management of marine and coastal resources and activities to improve effectiveness and efficiency.
4) Assert and articulate the interests of the State as a partner with federal agencies in the sound

management of ocean resources within the United States exclusive economic zone.

5) Promote research, study, and understanding of ocean processes, marine life, and other ocean resources to acquire and inventory information necessary to understand how ocean development activities relate to and impact upon ocean and coastal resources.

6) Encourage research and development of new, innovative technologies for exploring, using, or protecting marine and coastal resources.

Discussion: Construction of the Proposed Action at the shoreline and in nearshore waters would involve ground-disturbing activities that have the potential to release sediment into the nearshore waters and associated NWI wetlands, which could temporarily increase turbidity. All excavation and grading activities would be limited to the area required for installation of the monolithic concrete encasement to minimize erosion potential. All potential impacts would be minimized to the extent practicable through the implementation of BMPs.

Construction of the offshore portion of the Proposed Action could cause turbidity in the immediate area. This would be short-term and temporary, and any suspended solids are expected to settle upon completion of the task.

Upon completion of construction, there would be beneficial impacts to marine resources. The repairs to the land-based segment of the outfall and the underwater manholes would mitigate the risk of failure of the outfall that could result in a release of effluent in the nearshore waters and at the manhole locations.

4.1.4 HAR Section 13-5, Hawaii Conservation District Use

The Board of Land and Natural Resources (BLNR) administers land use regulations for the Conservation District pursuant to the State Land Use Law, discussed above. As it relates to the State Land Use Law, Conservation is defined as “the protection of watersheds and water supplies; preserving scenic areas; providing park lands; wilderness and beach reserves; conserving endemic plants, fish, and wildlife; preventing floods and soil erosion; forestry; and other related activities” (DLNR, 2017a). The Conservation District has five subzones: Protective, Limited, Resource, General, and Special. The first four subzones are ranked by environmental sensitivity from highest to lowest. The Special subzone defines a unique land use on a specific site.

Lands and state marine waters seaward of the shoreline to the extent of the State’s jurisdiction are located in the Resource subzone of the Conservation District. The use of Conservation District lands is regulated by HAR §13-5 and HRS §183C. Shoreline erosion control is an allowable use in the Resource subzone and requires a Conservation District Use Permit from the BLNR. In evaluating projects (i.e., proposed land use) during the permitting process, the BLNR applies eight criteria. The Proposed Action is consistent with the criteria as follows:

(1) The proposed land use is consistent with the purpose of the conservation district.

Discussion: The purpose of the Conservation District is to conserve, protect, and preserve the important natural and cultural resources of the State through appropriate management and use to promote their long-term sustainability and the public health, safety, and welfare. The Proposed Action would minimize shoreline erosion at the Waianae WWTP outfall pipeline’s ocean entry in order to ensure the continued operation of the outfall. Failure of or damage to the outfall could have catastrophic health, environmental, and economic consequences.

(2) The proposed land use is consistent with the objectives of the subzone of the land on which the use will occur.

Discussion: Lands and state marine waters seaward of the shoreline to the extent of the State's jurisdiction are located in the Resource subzone of the Conservation District. Shoreline erosion control is an allowable use in the Resource subzone under three conditions: (1) the applicant would be deprived of all reasonable use of the land or building without the permit; (2) the use would not adversely affect beach processes or lateral public access along the shoreline; or (3) public facilities critical to public health, safety, and welfare would be severely damaged or destroyed without a shoreline erosion control structure and there are no reasonable alternatives, such as relocation. The Proposed Action would minimize shoreline erosion at the Waianae WWTP outfall pipeline's ocean entry and to make permanent repairs to the offshore section of the outfall pipeline to ensure the continued operation of the outfall with minimal maintenance.

(3) The proposed land use complies with provisions and guidelines contained in Chapter 205A, HRS, entitled "Coastal Zone Management", where applicable.

Discussion: The Proposed Action is consistent with HRS Chapter 205A, as discussed in **Section 4.1.3**.

(4) The proposed land use will not cause substantial adverse impact to existing natural resources within the surrounding area, community, or region.

Discussion: Construction of the Proposed Action at the shoreline and in nearshore waters would involve ground-disturbing activities that have the potential to release sediment into the nearshore waters and associated NWI wetlands, which could temporarily increase turbidity. Construction of the offshore portion of the Proposed Action could cause turbidity in the immediate area. This would be short-term and temporary, and any suspended solids are expected to settle upon completion of the task. Measures to minimize impacts would be implemented, as discussed in **Section 3.2.3**.

Construction of the Proposed Action would involve minimal clearing of vegetation in the area immediately adjacent to the existing outfall pipe. There would also be limited short-term impacts to the existing terrestrial fauna species that reside or forage within the project vicinity. Measures to minimize impacts would be implemented, as discussed in **Section 3.2.3**.

Construction of the Proposed Action would likely have direct impacts and result in the loss of marine benthos in the immediate nearshore area and within the construction footprints of the manhole covers. Measures to minimize impacts would be implemented, as discussed in **Section 3.2.3**.

Upon completion of construction, there would be beneficial impacts to natural resources. The repairs to the land-based segment of the outfall and the underwater manholes would mitigate the risk of failure of the outfall that could result in a release of effluent in the nearshore waters and at the manhole locations.

(5) The proposed land use, including buildings, structures, and facilities, shall be compatible with the locality and surrounding areas, appropriate to the physical conditions and capabilities of the specific parcel or parcels.

Discussion The Proposed Action, limited in scope to the construction of a monolithic concrete encasement around approximately 125 feet of the shoreline portion of the outfall pipe and manhole covers offshore, is not anticipated to affect the aesthetic and visual character of the surrounding area.

(6) The existing physical and environmental aspects of the land, such as natural beauty and open space characteristics, will be preserved or improved upon, whichever is applicable.

Discussion: The Proposed Action, limited in scope to the construction of a monolithic concrete encasement around approximately 125 feet of the shoreline portion of the outfall pipe and manhole covers offshore, is not anticipated to affect the aesthetic and visual character of the surrounding area. Although it would present a new, visible structure at the shoreline, it would not be significantly different from the exposed pipe already present at the shoreline. The Proposed Action would not include structures that would block viewplanes or be incongruous with existing conditions of the site. Therefore, the Proposed Action would not have significant impacts to visual resources.

(7) Subdivision of land will not be utilized to increase the intensity of land uses in the conservation district.

Discussion: The Proposed Action does not involve subdivision of land.

(8) The proposed land use will not be materially detrimental to the public health, safety, and welfare.

Discussion: The Waianae WWTP is critical infrastructure for the island of Oahu. The Proposed Action is necessary to ensure that the shoreline section of the Waianae WWTP outfall pipe is not further undermined, which could cause damage that results in a release of effluent and takes the outfall pipe out of service. The installation of the monolithic concrete encasement and manhole covers would be beneficial to the community as it would ensure the continued operation of the outfall and minimize maintenance costs to the CCH.

4.2 City & County of Honolulu Planning Documents

4.2.1 Oahu General Plan

The *Oahu General Plan* (1992) was last amended in 2002. The General Plan is a comprehensive statement of objectives and policies that set forth the long-range aspirations of Oahu's residents and the strategies of actions to achieve them. The General Plan is a guide for all levels of government, private enterprise, neighborhood and citizen groups, organizations, and individual citizens in eleven areas of concern:

I. Population
II. Economic activity
III. Natural environment
IV. Housing
V. Transportation and utilities
VI. Energy
VII. Physical development and urban design
VIII. Public safety

IX. Health and education
X. Cultural and recreation
XI. Government operations and fiscal management

The Proposed Action is relevant and consistent with the following applicable goals, objectives, policies, and actions of the *Oahu General Plan:*

(III) Natural Environment

OBJECTIVE A: To protect and preserve the natural environment

POLICY 2: Seek the restoration of environmentally damaged areas and natural resources.

POLICY 7: Protect the natural environment from damaging levels of air, water, and noise pollution.

Discussion: Since the construction of the outfall in 1965, it is estimated that the shoreline south of the pipe has retreated (i.e., eroded) approximately 25 to 30 feet. The existing shoreline adjacent to the outfall pipe has experienced significant erosion since its original construction. The entire mass of rock adjacent to the waterline along the southern flank of the outfall pipe has been fractured, broken up, and eroded away from the pipe.

The Proposed Action would reduce beach erosion in the immediate vicinity of the outfall pipe and protect the pipe from potential damage or failure. Impacts associated with the monolithic concrete encasement would be beneficial to the natural environment since it would protect the beach from further erosion and potential contamination from the release of effluent. Capping of the manholes would mitigate the risk leaking of effluent at the manhole locations and protect the marine environment. The Proposed Action would also ensure the continued operation of the outfall with minimal maintenance.

(V) Transportation and Utilities

OBJECTIVE C: To maintain a high level of service for all utilities.

POLICY 1: Maintain existing utility systems in order to avoid major breakdowns.

POLICY 2: Provide improvements to utilities in existing neighborhoods to reduce substandard conditions.

OBJECTIVE D: To maintain transportation and utility systems which will help Oahu continue to be a desirable place to live and visit.

POLICY 1: Give primary emphasis in the capital-improvement program to the maintenance and improvement of existing roads and utilities.

Discussion: The Proposed Action is a mitigation measure to protect the outfall pipe from damage associated with ongoing shoreline erosion and corrosion of the underwater manhole covers. The Waianae WWTP is critical infrastructure for the island of Oahu. The Proposed Action is necessary to ensure that the shoreline section of the Waianae WWTP outfall pipe is not further undermined, which could cause damage that results in a release of effluent and takes the outfall pipe out of service. Overall, the Proposed Action would be beneficial to the community as it would ensure the continued operation of the outfall and minimize maintenance costs to the CCH. The Proposed Action is included in and would be funded by the capital-improvement program.

(VIII) Public Safety

OBJECTIVE B: To protect the people of Oʻahu and their property against natural disasters and other emergencies, traffic and fire hazards, and unsafe conditions.

POLICY 2: Require all developments in areas subject to floods and tsunamis to be located and constructed in a manner that will not create any health or safety hazard.

Discussion: The Proposed Action has been designed to withstand the level of forces necessary to minimize the likelihood that an extreme event would damage the structures. The Proposed Action does not involve habitable uses, nor would it encourage such uses. Therefore, there are no anticipated adverse impacts associated with natural hazards. The Proposed Action would have beneficial impacts by protecting the landfall section of the outfall pipe from potential damage and/or failure, as well as the manholes from potentially leaking effluent into offshore waters.

(X) Culture and Recreation

OBJECTIVE D: To provide a wide range of recreational facilities and services that are readily available to all residents of Oʻahu.

POLICY 3: Develop and maintain urban parks, squares, beautification areas in high density urban places.

POLICY 12: Provide for safe and secure use of public parks, beaches, and recreation facilities.

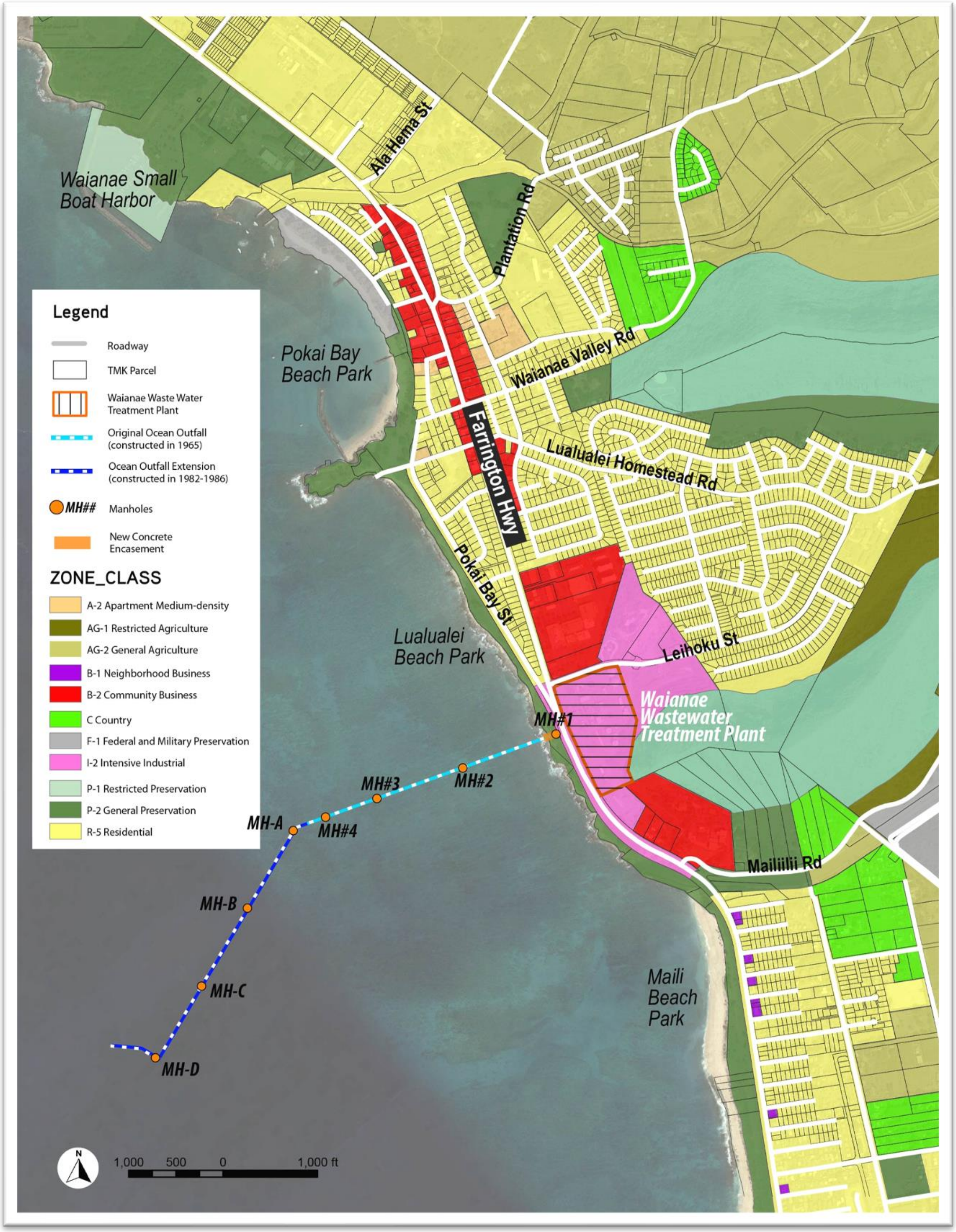
Discussion: There would be no changes to recreational use of the beach or offshore areas. The monolithic concrete encasement would reduce beach erosion in the immediate vicinity of the outfall pipe and protect the pipe from potential damage or failure. Impacts associated with the monolithic concrete encasement would be beneficial to recreation since it would protect the beach from further erosion and potential contamination from the release of effluent. Capping of the manholes would mitigate the risk leaking of effluent at the manhole locations and protect water quality for surfers and fishermen.

4.2.2 Revised Ordinances of Honolulu (ROH) Chapter 21, Land Use Ordinance

The ROH Chapter 21, Land Use Ordinance, contains ordinances regulating the utilization of land in the CCH. Chapter 21 of the ROH is also referred to as the zoning ordinance and includes the establishment of zoning districts and zoning district regulations in Article 3.

Discussion: As shown in **Figure 18**, the project site is located within the P-2 zone, or General Preservation District. The purpose of the preservation district is to preserve and manage major open space and recreation lands and lands of scenic or other natural resource value. The P-2 designation is provided to lands that are designated Urban by the State but are suited to the functions of providing visual relief and contrast to the city's built environment or serving as outdoor space for the public's use and enjoyment. Allowable uses of the P-2 zoning district are use of historic structures and joint development. Any use of the P-2 zoning district requires a Conditional Use Permit – Minor. The Proposed Action is considered a "Public Uses and Structures" use, which is identified as a "Permitted Use"; therefore, a Conditional Use Permit is not expected to be required.

Figure 18. City & County of Honolulu Zoning



4.2.3 City & County of Honolulu Special Management Area

Pursuant to the Hawaii CZM Program, HRS Chapter 205A, the counties have enacted ordinances establishing Special Management Areas (SMA). The CCH enacted its SMA ordinance as Chapter 25 of the ROH. Any "development" within the geographically defined SMA with a valuation of greater than $500,000 requires an SMA Use Permit. The permit is processed by the CCH Department of Planning and Permitting, requires a public hearing, and must be approved by the Honolulu City Council by resolution. Proposed developments are evaluated for consistency with the CZM objectives and policies, as discussed in **Section 4.1.3**, as well as the SMA guidelines set forth in HRS 205A.

Discussion: As shown in **Figure 19**, the project site is located within the SMA. An SMA Use Permit will be obtained by the project proponent. Therefore, the Proposed Action is consistent with the SMA.

4.2.4 City and County of Honolulu Shoreline Setbacks

The ROH Chapter 23, Shoreline Setbacks, contains policies for protecting and preserving the shoreline area, which is defined as "all of the land between the shoreline and the shoreline setback line." The "shoreline" is defined as the upper reaches of the wash of the waves at high tide during the season of the year in which the highest wash of the waves occurs. This area is generally evidenced by the edge of vegetation growth or the upper limit of debris on the beach. The "shoreline setback line" is generally delineated as 40 feet inland of the certified shoreline. With few exceptions, structures and activities are prohibited within the shoreline area without obtaining a Shoreline Setback Variance.

Discussion: The proposed monolithic concrete encasement would be constructed within the shoreline setback area. ENV will prepare and submit an application package to obtain a Shoreline Setback Variance in concurrence with the SMA permitting process.

4.2.5 Waianae Sustainable Communities Plan

The *Waianae Sustainable Communities Plan* (Waianae SCP) implements the *Oahu General Plan's* policy of sustaining modest development patterns and the rural character of the Waianae area. Specifically, the vision of the Waianae SCP is oriented to maintaining and enhancing the region's ability to sustain its unique character, current population, growing families, rural lifestyle, and economic livelihood, all of which contribute to the region's vitality and future potential. The Waianae SCP presents policies and guidelines related to land use. The Proposed Action is consistent with the following applicable land use policies and guidelines:

Open Space and Important Views

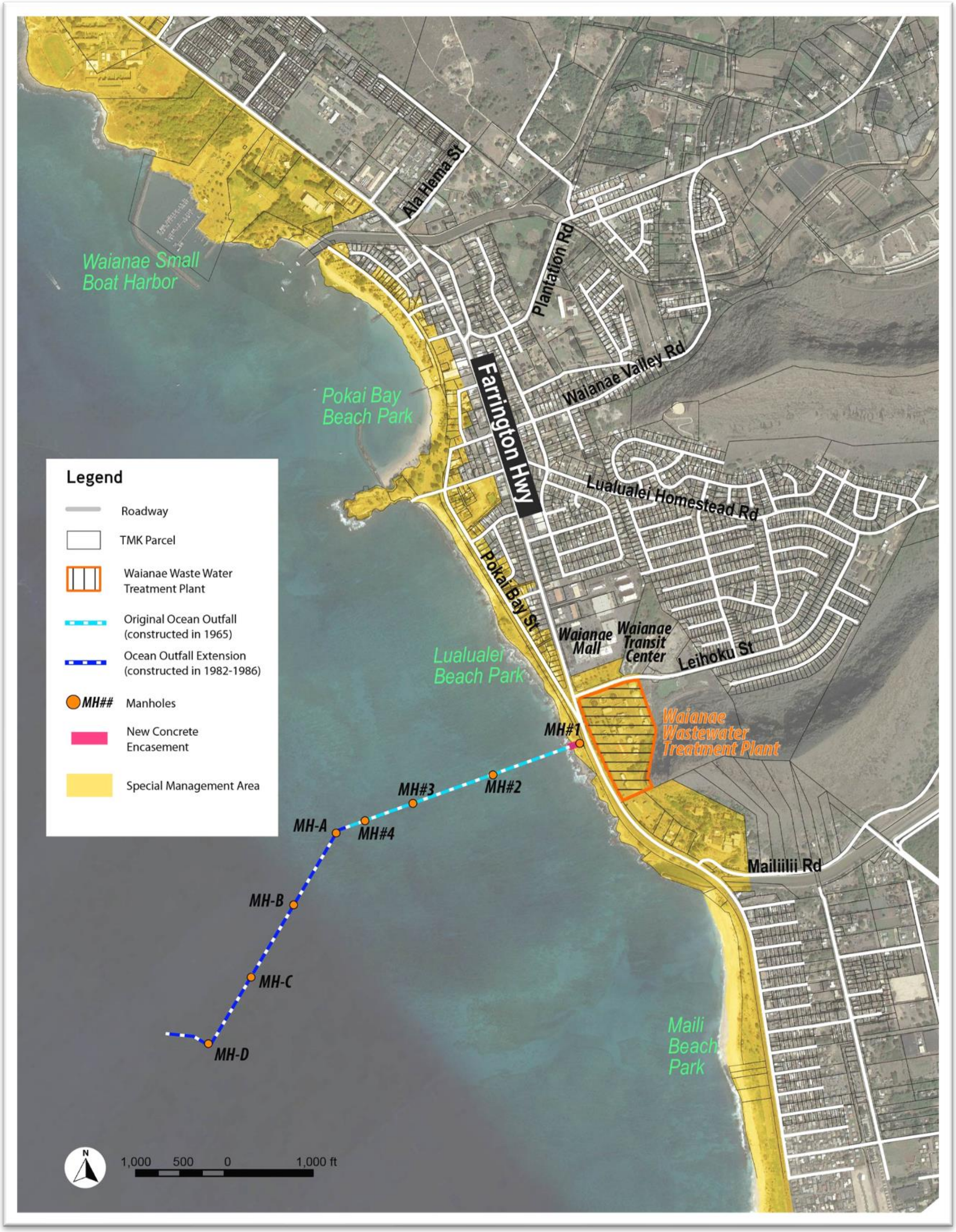
POLICY 1: Do not allow significant negative impacts on large open spaces

POLICY 2: Address project impacts on open space

POLICY 3: Do not allow significant negative impacts on important public views

POLICY 4: Address project impacts on important public views

Figure 19. Special Management Area



Discussion: As discussed in **Section 3.8.2**, the Proposed Action is not anticipated to affect the aesthetic and visual character of the surrounding area. Although it would present a new, visible structure at the shoreline, it would not be significantly different from the exposed pipe already present at the shoreline. The Proposed Action would not include structures that would block viewplanes or be incongruous with existing conditions of the site.

Coastal Lands

POLICY 3: Discourage shore armoring

POLICY 5: Prohibit projects that negatively impact coastal lands

POLICY 7: Maintain beaches/sand

Discussion: The Proposed Action does not include shore armoring; rather, it includes the installation of a monolithic concrete encasement over the existing outfall pipe. The Proposed Action would minimize shoreline erosion at the Waianae WWTP outfall pipeline's ocean entry.

Historic and Cultural Resources

POLICY 2: Do not allow development that negatively impacts important cultural sites or access to such sites

POLICY 5: Protect and allow access for cultural practices at sites on city-owned lands

Discussion: As discussed in **Section 3.4.2**, no specific cultural sites or practices were identified within the project area, although the area is used for day parties, camping, and shoreline fishing. During construction of the Proposed Action, beach use and lateral access at the project site would be restricted. This disruption would be temporary and impacts to cultural practices such as day parties, camping, and shoreline fishing would be less than significant. Upon completion of construction, there would be no changes to use of the beach or offshore areas. Impacts associated with the monolithic concrete encasement would be beneficial to cultural practices since it would protect the beach from further erosion and potential contamination from the release of effluent.

5.0 Findings and Conclusions

5.1 Significance Criteria

HAR Chapter 11-200.1 provides significance criteria for which all projects in Hawaii are assessed. These significance criteria and their relationship to the Proposed Action are as follows:

(1) Irrevocably commit a natural, cultural, or historic resource.

The Purpose of the Proposed Action is to minimize shoreline erosion at the Waianae WWTP outfall pipeline's ocean entry and to make permanent repairs to the offshore section of the outfall pipeline to ensure the continued operation of the outfall with minimal maintenance. The Proposed Action was designed, and the project footprint was determined, to avoid impacts to natural and cultural resources to the extent practicable.

During construction there would be short-term and temporary impacts natural resources. These impacts would be minimized through the implementation of BMPs and other measures. Upon completion of construction, there would be beneficial impacts to natural resources. The repairs to the land-based segment of the outfall and the underwater manholes would mitigate the risk of failure of the outfall that could result in a release of effluent in the nearshore waters and at the manhole locations.

Construction of the Proposed Action would have no impacts to known archaeological and historic resources since none exist within the project site. There is the potential for traditional Hawaiian burials in subsurface sand deposits. Additionally, buried remnants of the OR&L Railroad (SIHP Site 50-80-04-09714) may be extant. Therefore, the Proposed Action may impact subsurface archaeological and historic resources. CCH-ENV will consult with SHPD under HRS Chapter 6E-8 regarding project effects and would incorporate any mitigation measures required. In addition to any requirements by SHPD, the measures identified in **Section 3.3.3** would be implemented.

(2) Curtail the range of beneficial uses of the environment.

The Waianae WWTP ocean outfall crosses through Lualualei Beach, which is mainly used for day parties, camping, and by local fishermen. Offshore of the beach park, recreational and fishing boats launched from the Waianae Small Boat Harbor often pass through the area. A surf site called Sewers is also located offshore.

There would be short-term and temporary impacts to use of the park during construction of the Proposed Action from an increase in noise and dust and restriction of beach use and lateral access at the project site. There would also be intermittent and temporary impacts to the designated camping area as the existing campground access road would be used as a haul route for equipment and materials. Construction of the monolithic concrete encasement would include the installation of a turbidity curtain around the outfall pipe to create a 45-foot-wide workspace over the outfall pipe. Surfers and boaters would not be able to access the 45-foot-wide by 125-foot-long area over the outfall pipe. Shoreline fishermen would need to use care to not get their lines tangled in the turbidity curtain. Construction activities associated with the manhole covers would require anchoring of a barge over the existing manhole(s). While the barge is in place, surfers and boaters would not be able to access the area immediately around the barge. These short-term impacts would not curtail the range of beneficial uses of the environment.

Upon completion of construction, there would be no changes to recreational use of the beach or offshore areas. The monolithic concrete encasement would reduce beach erosion in the immediate vicinity of the outfall pipe and protect the pipe from potential damage or failure. Impacts associated with the monolithic concrete encasement would be beneficial to recreation since it would protect the beach from further erosion and potential contamination from the release of effluent. Capping of the manholes would mitigate the risk leaking of effluent at the manhole locations and protect water quality for surfers and fishermen.

(3) Conflict with the State's environmental policies or long-term environmental goals established by law.

HRS Chapter 344 states that "It shall be the policy of the State, through its programs, authorities, and resources to:

(1) Conserve the natural resources, so that land, water, mineral, visual, air and other natural resources are protected by controlling pollution, by preserving or augmenting natural resources, and by safeguarding the State's unique natural environmental characteristics in a manner which will foster and promote the general welfare, create and maintain conditions under which humanity and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of the people of Hawaii.
(2) Enhance the quality of life by:
  (A) Setting population limits so that the interaction between the natural and artificial environments and the population is mutually beneficial;
  (B) Creating opportunities for the residents of Hawaiʻi to improve their quality of life through diverse economic activities which are stable and in balance with the physical and social environments;
  (C) Establishing communities which provide a sense of identity, wise use of land, efficient transportation, and aesthetic and social satisfaction in harmony with the natural environment which is uniquely Hawaiian; and
  (D) Establishing a commitment on the part of each person to protect and enhance Hawai'i's environment and reduce the drain on nonrenewable resources."

As discussed in **Chapter 3.0**, the Proposed Action would have no significant impact on environmental resources. All impacts would be short-term and temporary during the construction period. BMPs and other measures would be implemented to minimize impacts. Upon completion of construction, there would be beneficial impacts to the environment. The repairs to the land-based segment of the outfall and the underwater manholes would mitigate the risk of failure of the outfall that could result in a release of effluent in the nearshore waters and at the manhole locations that could impact water resources, biological resources, and cultural practices.

(4) Have a substantial adverse effect on the economic welfare, social welfare, or cultural practices of the community or State.

The Waianae WWTP is critical infrastructure for the island of Oahu. The Proposed Action is necessary to ensure that the shoreline section of the Waianae WWTP outfall pipe is not further undermined, which could cause damage that results in a release of effluent and takes the outfall pipe out of service.

Construction of the Proposed Action would result in temporary, positive economic activity in the form of construction jobs and material procurements. The repairs to the land-based segment of the outfall and the underwater manholes would mitigate the risk of failure of the outfall that could result in a release of effluent in the nearshore waters and at the manhole locations that could impact cultural practices. Overall, the Proposed Action would be beneficial to the community as it would ensure the continued operation of the outfall and minimize maintenance costs to the CCH.

(5) Have a substantial adverse effect on public health.

The repairs to the land-based segment of the outfall and the underwater manholes would mitigate the risk of failure of the outfall pipe that could result in the release of effluent in nearshore waters and would result in the shut-down of the Waianae WWTP, which would impact customers over a large part of West Oahu from Makaha to Nanakuli (i.e., the service area of the Waianae WWTP). The release of effluent in nearshore waters and shutdown of the WWTP could impact public health.

(6) Involve adverse secondary impacts, such as population changes or effects on public facilities.

The Proposed Action would not involve a change in land use, would not induce growth, and would not change the capacity of the WWTP. Therefore, the Proposed Action would not have secondary impacts.

(7) Involve a substantial degradation of environmental quality.

As discussed in **Chapter 3.0**, the Proposed Action would have no significant impact on environmental resources. All impacts would be short-term and temporary during the construction period. BMPs and other measures would be implemented to minimize impacts. Upon completion of construction, there would be beneficial impacts to the environment. The repairs to the land-based segment of the outfall and the underwater manholes would mitigate the risk of failure of the outfall that could result in a release of effluent in the nearshore waters and at the manhole locations that could impact water resources, biological resources, and cultural practices.

(8) Is individually limited but cumulatively has a considerable effect upon the environment or involves a commitment for larger actions.

Land use in the vicinity of the Proposed Action is recreation and open space. No other past, present, or planned actions have been identified that would contribute to cumulative impacts for any resource. Therefore, no cumulative impacts are anticipated from implementation of the Proposed Action.

(9) Have a substantial adverse effect on a rare, threatened, or endangered species, or its habitat.

Construction of the Proposed Action would not involve trimming or removing trees greater that 15-feet-tall; therefore, there would be no impacts to roosting juvenile bats. During construction of the Proposed Action, the Hawaiian hoary bat may be temporarily displaced from the project area. The temporary displacement of these individuals at the project site is not expected to affect individual survival or overall species populations.

Hawaiian monk seals and green sea turtles typically avoid human activity; therefore, it is unlikely that monk seals and turtles would frequent the project area during construction activities. Construction of the Proposed Action may temporarily displace these species, but long-term effects are not expected. Monk seals and turtles that haul out and bask in the area are expected to find suitable beach in nearby areas.

Outdoor lighting during construction of the Proposed Action could result in seabird disorientation, fallout, and injury or mortality. It is not expected that there would be any nighttime construction or outdoor lighting. Therefore, construction of the Proposed Action is not expected to impact Hawaiian seabirds.

Upon completion of construction, there would be beneficial impacts to biological resources associated with the Proposed Action. The repairs to the land-based segment of the outfall and the underwater manholes would mitigate the risk of failure of the outfall that could result in a release of effluent in the nearshore waters and at the manhole locations that could have negative impacts to rare, threatened, or endangered species habitat.

(10)Have a substantial adverse effect on air and water quality or ambient noise levels.

Construction-related impacts would occur to air quality, water quality, and the existing noise environment, as discussed in **Sections 3.10.2**, **3.1.2,** and **3.11.2**, respectively. These impacts would be short-term and temporary. BMPs and other measures would be implemented to minimize these construction-related impacts.

Upon completion of construction, there would be beneficial impacts to the environment. The repairs to the land-based segment of the outfall and the underwater manholes would mitigate the risk of failure of the outfall that could result in a release of effluent in the nearshore waters and at the manhole locations that could impact water quality.

(11)Have a substantial adverse effect on or be likely to suffer damage by being located in an environmentally sensitive area such as a flood plain, tsunami zone, sea level rise exposure area, beach, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal waters.

The Proposed Action has been designed to withstand the level of forces necessary to minimize the likelihood that an extreme event would damage the structures. The Proposed Action does not involve habitable uses, nor would it encourage such uses. Therefore, there are no anticipated adverse impacts associated with natural hazards. The Proposed Action would have beneficial impacts by protecting the landfall section of the outfall pipe from potential damage and/or failure, as well as the manholes from potentially leaking effluent into nearshore and offshore waters.

(12) Have a substantial adverse effect on scenic vistas and viewplanes, during day or night, identified in county or state plans or studies.

The Proposed Action is not anticipated to affect the aesthetic and visual character of the surrounding area. Although it would present a new, visible structure at the shoreline, it would not be significantly different from the exposed pipe already present at the shoreline. The Proposed Action would not include structures that would block viewplanes or be incongruous with existing conditions of the site. Therefore, the Proposed Action would not have significant impacts to visual resources.

(13) Requires substantial energy consumption or emit substantial greenhouse gases.

Other than the energy expended during construction, the Proposed Action would require no additional energy consumption.

5.2 Anticipated Finding of No Significant Impact

Based on the significance criteria set forth in HAR Chapter 11-200.1 and discussed in **Section 5.1**, it is anticipated that the Proposed Action would not have a significant effect on the environment and that a Finding of No Significant Impact (FONSI) would be filed with the State of Hawaii Office of Environmental Quality Control following the public comment period.

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6.0 Agencies and Elected Officials Consulted

Table 9 identifies the Federal, State, and local agencies and elected officials consulted prior to the preparation of the Draft Environmental Assessment, as well as whether a comment was received. All comments received and responses are included in **Appendix G**.

Table 9. Agencies and Elected Officials Consulted

Agency	Pre-Assessment Consultation Comment Received
FEDERAL AGENCIES	
U.S. Army Corps of Engineers	X
U.S. Fish and Wildlife Service	
National Marine Fisheries Service	
STATE OF HAWAII AGENCIES	
Department of Business, Economic Development & Tourism	
Office of Hawaiian Affairs	
Department of Hawaiian Home Lands, Planning Office	X
Department of Health, Clean Water Branch	
Department of Health, Clean Air Branch	
Department of Health, Indoor and Radiological Health Branch	X
Department of Accounting and General Services	X
Department of Land and Natural Resources	X
Department of Transportation, Highways Division	
CITY & COUNTY OF HONOLULU AGENCIES	
Department of Parks and Recreation	
Department of Planning and Permitting	X
Department of Design and Construction	X
Department of Transportation Services	X
Honolulu Fire Department	X
Honolulu Police Department	X
ELECTED OFFICIALS	
Councilmember Andria Tupola, District 1	
Chair Sharlotte Poe, Waianae Coast Neighborhood Board No. 24	

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7.0 References

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Appendix A

Waianae Wastewater Treatment Plant (WWTP) Outfall Improvements and Rehabilitation: Comprehensive Summary of Condition Assessment Activities, Final Report

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WAIANAE WASTEWATER TREATMENT PLANT (WWTP) OUTFALL IMPROVEMENTS AND REHABILITATION: COMPREHENSIVE SUMMARY OF CONDITION ASSESSMENT ACTIVITIES, FINAL REPORT

Waianae, Oahu, Hawaii

Prepared for:

City & County of Honolulu
and SSFM

October 2019

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EXECUTIVE SUMMARY

The central focus of this document is the approximately 6,800 linear feet of ocean outfall sewer pipe, extending from the shoreline fronting Waianae Waste Water Treatment Plant (Waianae, Island of Oahu, State of Hawaii) to the terminus of the ocean outfall directly offshore. The outfall consists of 3,450 linear feet of 36-inch reinforced concrete pipe and extended with 3,350 feet of 42-inch pipe. Treated effluent is conveyed by gravity via the outfall to the 480-foot-long diffuser section where it is then discharged by an array of diffuser ports at a depth of approximately 110 feet. The original 36-inch outfall was completed in 1965, making it 54 years old at the time of this report; the 42-inch extension was completed in 1986, making the addition 33 years old at this time.

Funded by the City and County of Honolulu, managed by SSFM, and developed and executed by Sea Engineering, Inc. (SEI), the project included a condition assessment and evaluation of improvements determined to be necessary for the Waianae Waste Water Treatment Plant's ocean outfall. The goal of this multifaceted effort was to conduct inspection and analysis activities leading to an overall condition assessment that would later feed into planning and design efforts to improve or rehabilitate the Waianae ocean outfall if and where necessary. The ocean outfall is considered to be a critical component of the sewer system, and as such, has been identified by the City to warrant a periodic condition assessment.

The initial assignment, completed prior to mobilization for any work in the field, was the development of a comprehensive work plan, which in consultation with the City and SSFM, was developed by SEI to include several tasks that were specifically designed for Waianae's outfall, including: (1) a high-resolution multibeam hydrographic survey of the outfall corridor; (2) an underwater visual inspection of all external components of the outfall and disposition of adjacent seafloor, including a cathodic protection analysis of exposed metallic hardware and a brief shoreline assessment; (3) a stability analysis of the outfall based on extreme hurricane scenario events; and, (4) a comprehensive summary aggregating all results, conclusions, and recommendations into a single standalone document (e.g., this document).

The multibeam hydrographic survey was completed 10 August 2017, using SEI's inhouse survey vessel and advanced SBG Ekinox-E inertial navigation system, along with a leased high-resolution R2Sonic 2024 multibeam system. Results from the 256-beam swath sonar provided a very clear picture of the exposed outfall structure and surrounding seafloor, made visible in the form of a high-resolution digital terrain model of the outfall corridor. Accuracy and density of the swath soundings were of a quality such that individual ballast rock units were clearly distinguishable within the ballasted sections, as well as the dredge cut of the outfall trench for much of its trenched length. Spur and groove reef formations along the adjacent outfall corridor were equally well resolved. Review and analysis of the multibeam data indicated that the outfall was resting entirely on hard substrate and was completely trenched or ballasted for all of its length, with no portion of the reinforced concrete pipeline joints being exposed. The surrounding seafloor appeared stable throughout the outfall corridor, with no identifiable threats to the pipeline due to seafloor erosion, scour, or other large scale movements or processes. This initial survey will additionally serve as the baseline dataset, to which all future surveys may be compared for a measure of ballast attrition, trench erosion, or other seafloor changes that may threaten outfall stability.

An underwater visual inspection of all exposed external components of the outfall was conducted on 08 and 09 February, 2018. Inspection activities were performed by Sea Engineering PE divers, using advanced acoustic tracking technology for precise real-time diver positioning and track recording. The tracking system, known as an *ultra-short base line* (USBL) acoustic tracking system, combined with the surface vessel's differential GPS positioning, provided the divers with accurate positioning for attribution to observations and conditions found along the outfall. High-powered underwater scooters were employed for efficient diver movement along the 1.2-mile outfall. Results from the inspection revealed that the diffuser section was in good operating condition, with all open diffuser ports flowing, and all closed ports well sealed and not leaking. The concrete cap and jacket covering the new 42-inch pipe was primarily buried for most of its length, however, where it was exposed—such as in the diffuser section and in the vicinity of all manhole risers—it appeared generally in good condition, with no significant damage. Inshore of the 42-inch extension, the original 36-inch pipe joints were not exposed anywhere along its length, however, the concrete cap, trench rim, or ballast pile were visible in various areas. The concrete cap and jacket appeared to be in good condition where visible, and the ballast pile sections appeared stable with no significant attrition or movement. No leakage of effluent was observed anywhere along the outfall outside of the diffuser section. Comparison of the repaired ballast pile cross sections provided in the 1986 as-built plans with equivalent cross sections cut from the multibeam survey data showed relatively good agreement, indicating stability of the ballasted sections of outfall. The concrete and stainless steel manholes on the 42-inch extension appeared to be in good condition, with minimal corrosion or other degradation, and no leakage. And the cast iron manholes on the original 36-inch line, although not leaking, were found in an advanced state of corrosion and will require repair in the near future. The special wye structure, which forms the junction between the original 36-inch line and the newer 42-inch extension, was found in good condition with minimal corrosion and no leakage from either of the stainless steel slot covers.

A brief inspection of the shoreline landing site, where the outfall pipeline emerges from the ocean, identified areas of undercutting that resulted in an unsupported span of pipeline approximately 20 feet in length, located near the waterline. Analysis of historic aerial imagery confirmed that a portion of this area of shoreline has eroded significantly in the decades following construction. An emergency repair was designed and constructed by SEI in mid-2018 to temporarily stabilize the pipeline at this location, until a permanent repair solution can be implemented.

Global warming and climate change have combined in recent years to produce larger and more severe storms around the world. This has resulted in stronger hurricanes in the Central Pacific that have increasingly threatened the Hawaiian Islands. Because of the enormous waves and strong currents associated with hurricanes, these storms are considered to be a leading factor in terms of future threats to the Waianae Ocean Outfall. In response, a numerical modeling analysis was developed and conducted to quantify the effects of a direct, or near-direct strike of a major hurricane to the Waianae Coastline. Several hurricane scenarios, with tracks and intensities developed by NOAA, were used to generate a series of nested and interconnected wave models, incrementally increasing in resolution from a global scale down to eventually a shoreline scale, revealing the spatial distribution of wave heights and current patterns in the vicinity of the outfall for each of the scenarios. Wave and current data were extracted from the nearshore models in the vicinity the deepest ballast pile section—the most vulnerable location on the outfall—and used to drive a high-resolution computational fluid dynamics (CFD) model. For the highly immobilized and secured areas of pipeline, where the outfall is trenched and capped with a concrete jacket, the structure profile does not significantly project above the level of the surrounding seafloor, and the outfall is considered inherently safe due to this construction method, and is not analytically considered in this stability analysis.

The CFD model was used to calculate the transient lift and drag forces on several idealized ballast units (embedded halfway within the peak of the ballast pile) due to the passage of hurricane waves and in combination with decoupled steady-state wave-driven currents. CFD results indicated that all ballast units, ranging from 2 to 3.5 ft in diameter, developed lift forces that exceeded their submerged weight for at least a few seconds during wave crest passage. However, two empirical methods used to assess stone stability in river projects indicated that all stone sizes were stable for all scenarios, except for the 2-ft stone using the Grace (1979) method for two of the four scenarios. Return period wave heights calculated for the Waianae area, in conjunction with the range of stone sizes found during inspection, suggest that the outfall ballast sections may potentially have been designed to a nominal 50-yr wave height, and will likely remain stable for seasonably high surf episodes with wave heights equivalent to or less than that. Finally, the intentional placement of the investigatory ballast units embedded only halfway into the peak (with the remaining half fully exposed to flow) yielded conservative model results, however it also suggests that some damage to some ballasted sections of the outfall may result from the direct strike of a hurricane.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1 Preface

The Waianae Wastewater Treatment Plant serves as the primary sewage reception, treatment and disposal facility for a large portion of West Oahu. The facility utilizes a reinforced concrete pipe (RCP) ocean outfall structure for conveying treated effluent from the treatment plant to offshore waters for disposal. The project location is illustrated in Figure 1-1.

Since construction of the Waianae Wastewater Treatment Plant (WWTP) and its original ocean outfall in the mid-1960's, two powerful hurricanes, *Iwa* (1982) and *Iniki* (1992), have impacted Oahu. In recent years, several close approaches including Category 3 Hector (2018) which pounded south and west shores of Oahu with dangerously large surf, and Category 5 Lane (2018) which was forecasted to potentially make landfall on Oahu but weakened unexpectedly and veered off to open ocean just hours before a predicted landfall.

Storm waves produced by Hurricane Iwa were found to have caused significant damage to the submerged oil pipelines from the Single Point Mooring (SPH) at Barbers Point, where a concrete-jacketed 30-inch steel pipeline was laterally displaced up to 140 ft (43 m) in water depths of 45 to 60 ft (14 – 18 m) by wave and current forces. The damage sustained by Hurricane Iwa, and the occurrence of Hurricane Iniki a decade later, highlighted the potential risk to submerged pipelines and other seafloor infrastructure from extreme wave events such as those caused by hurricanes.

For as long as official records have been kept, tropical storms and hurricanes have historically had a relatively low probability of occurrence in the vicinity of the Hawaiian Islands; yet the potential for damage to Hawaii's offshore and nearshore coastal infrastructure is substantial and likely increasing due to rising ocean temperatures driven by global warming. Using revised hurricane design criteria, a 1998 study by Sea Engineering, Inc., (SEI) found that the existing condition of the Honouliuli ocean outfall was not stable, and resulted in additional ballast rock being placed along some sections of the pipe. A similar study completed in 2014 by SEI for the Sand Island WWTP's ocean outfall in Mamala Bay found that the outfall structure was estimated to remain generally stable in scenario hurricane conditions due to its location partially in deep water, ample reserves of stone where ballasted, and the trench and grout configuration used in shallower water.

1.2 Background

The Waianae Waste Water Treatment Plant (WWTP) is located approximately 1.5 miles south of Waianae Small Boat Harbor, on the western shoreline of the island of Oahu, in the State of Hawaii. The facility's relative location is illustrated in Figure 1-1. The treatment plant utilizes an ocean outfall structure for conveying treated effluent from the facility to offshore waters for disposal, where it is released at a water depth of 105 feet by an array of diffusers for dilution and dispersal in the water column by natural oceanographic processes.

The Waianae WWTP's ocean outfall was initially constructed in 1965 with a 3,133 ft (955 m) length of entrenched reinforced concrete pipe (RCP) with a diameter of 36 inches (914 mm), and terminated with a 230 ft (70 m) long, southward angled diffuser leg at a depth of approximately 24 ft (7 m). The diffuser leg was equipped with one 6-inch (152 mm) diameter diffuser and seven 8-inch (203 mm) diameter

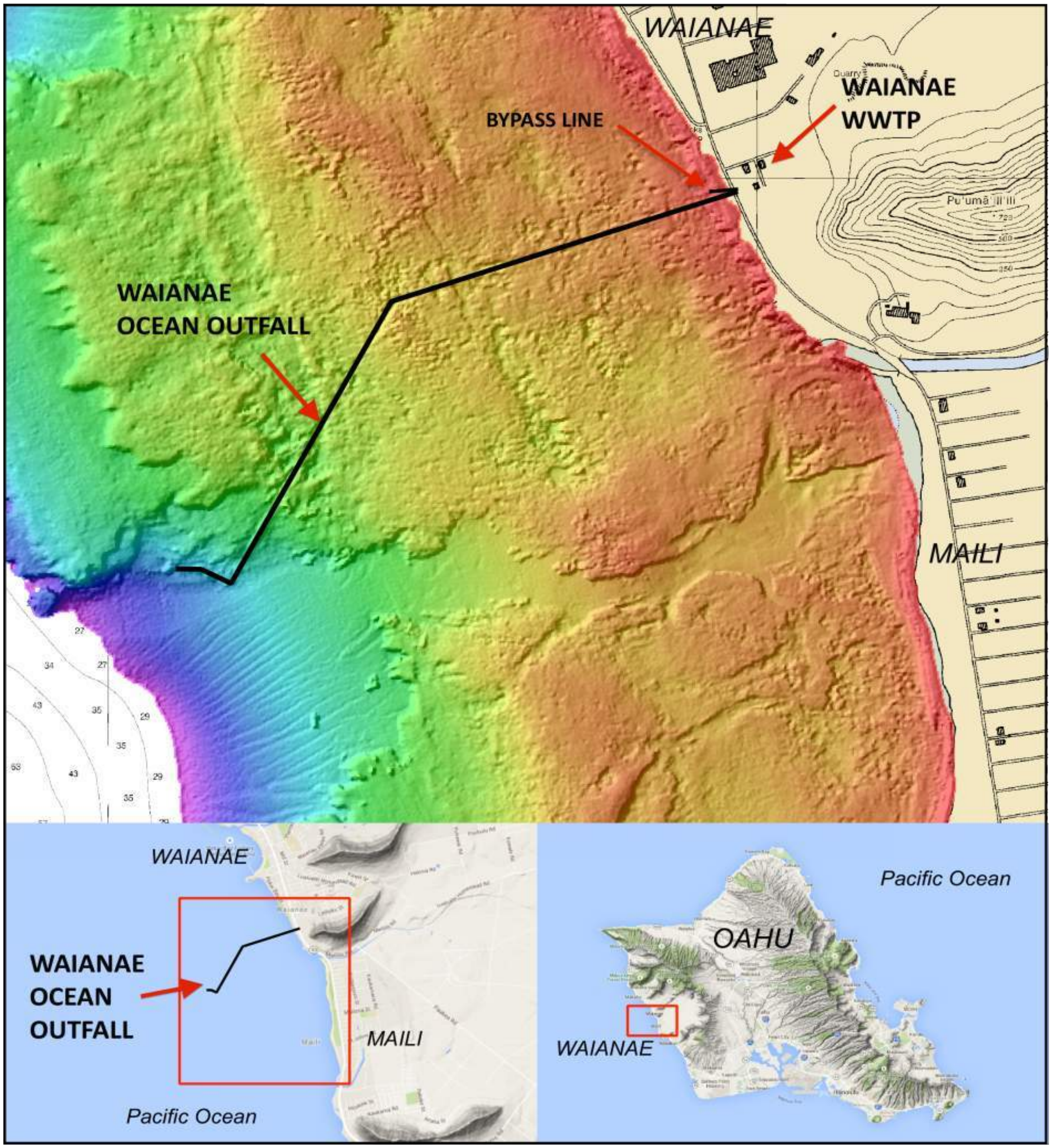

Figure 1-1. Project location map

diffusers mounted along the top of the pipe at 18 ft (5.5 m) spacing. During construction of the original outfall, a 24-inch (610 mm) diameter RCP by-pass line was also installed, which runs roughly parallel to the main line for a length of approximately 265 ft (81 m) starting from just landward of the shoreline. The by-pass line is normally closed and accessed through a wye structure located near station 00+00 of the main outfall, where it is controlled with a plug valve located in a valve box located above the high water mark. The by-pass line terminates just seaward of the reef line near sea level, north of the primary outfall.

Approximately two decades after initial construction, an extension was added to the original outfall by connecting to the originally installed junction box, also referred to as the *special wye structure* in the as-built plans. The extension project, which began in late 1982 and was completed in 1986, shifted the diffuser field out to an approximate depth of 105 ft (32 m). The 42-inch (1,067 mm) diameter extension consisted of an additional 3,051 ft (930 m) of pipe, for a total length of 6,184 ft (1,884 m), terminating with a 530 ft (162 m) long diffuser section. RCP (pipe) joints for the original outfall and extension were laid over a prepared gravel bed within a trench excavated from the reef, then backfilled with stone or crushed coral, and capped with tremie concrete, or ballasted with armor stone (original outfall only).

The new diffuser leg consists of 42 top-mounted diffuser ports equipped with 3-inch (122 mm) diameter elbow risers with a riser height of approximately 1 ft (0.3 m) and spaced at a 12 ft (3.7 m) on-center interval. The diffuser leg ends with a concrete stopgate structure, which serves as the outfall terminus. According to as-built construction plans, 21 of the diffuser ports were installed with blanking plates, meaning they were effectively closed. The remaining 21 ports were installed in an 'open' configuration, allowing flow.

For reference, a plan overview of the 42-inch extension project is presented in Figure 1-2, which was extracted from the 1986 as-built plans.

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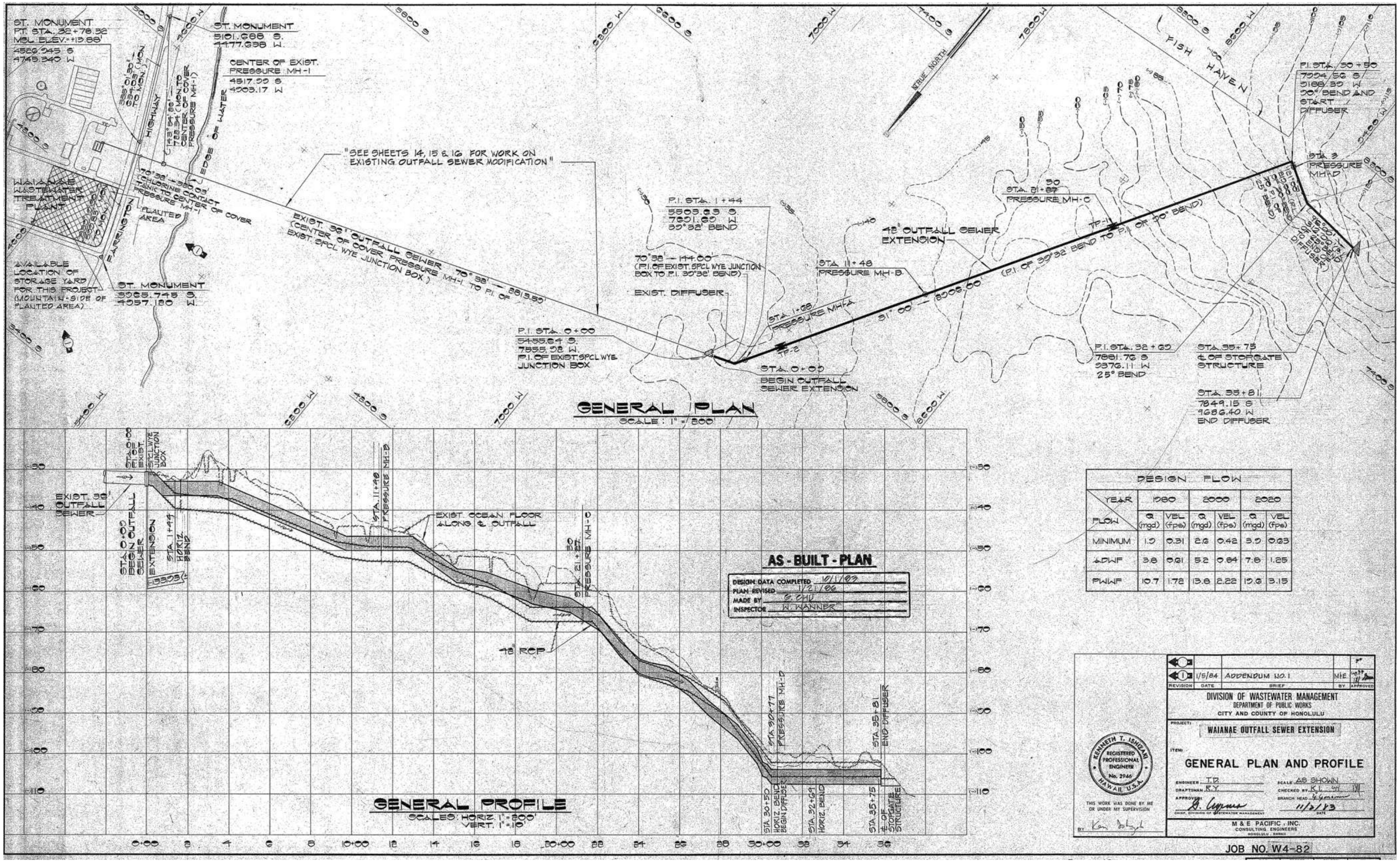

Figure 1-2. Page from as-built plans for outfall extension

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2. WORK PLAN

SSFM International, Inc. was contracted by the City and County of Honolulu to provide planning and design services for the Waianae Wastewater Treatment Plant (WWTP) Outfall Improvements and Rehabilitation Project. Sea Engineering, Inc. was subsequently selected by SSFM to assist with the inspection and condition assessment of the ocean outfall. Working together, SSFM and SEI developed a site-specific work plan, detailing numerous tasks necessary to inspect and assess the condition of the outfall. Following receipt of the City's approval of the work plan, SEI commenced planning and execution of the underwater inspection and condition assessment activities within the approved work plan for the submerged portions of outfall.

This work plan was developed to provide a comprehensive engineering inspection methodology for assessment of the existing condition of the outfall structure and adjacent seafloor corridor. Due to a lack of previously documented annual, regular, or any other type of physical or engineering inspections having been conducted of the outfall since it's construction, this work plan has been structured to present a wide array of inspection components and techniques in order to aid in evaluating the pipe's current condition, and to make informed estimates of its remaining service life. See Appendix A for the original approved work plan.

2.1 Primary Inspection Tasks

Recommended inspection tasks contained in this work plan included the following:

A1 – High resolution multibeam bathymetric survey of the pipeline and surrounding seafloor: The survey will provide an accurate map of the outfall's existing configuration, will provide an insight to its current condition, will be used to target areas of interest for visual inspection work, and will be used to construct a detailed digital terrain model of the outfall pipeline and surrounding seafloor.

B1 – External visual inspection of the entire outfall including diffuser port maintenance: The diving inspection will include the pipe barrel, trench, grout capping, ballast pile, and adjacent seafloor. Particular attention will be given to the 36-inch wye junction box which forms the beginning of the 42-inch outfall extension. All exposed metallic hardware will be checked for corrosion. Open diffuser ports will be inspected for blockages and closed (blanked) diffuser ports will be checked for leakages.

B3 – Dye injection leak testing: Dye testing will determine if there is any significant problems in the pipe, particularly in segments that are buried or covered with loose material such as ballast or unconsolidated sediments. The tracer dye will be injected at the plant, and divers and surface support vessels will be used to identify locations of leaks along the pipe.

C1 – Cathodic protection and corrosion assessment: An underwater potentiometer with a silver/silver-chloride (Ag/AgCl) reference electrode will be used to measure *in situ* voltage potentials of all exposed metallic hardware along the outfall. The voltage value of the potential measurements will indicate the current state of the metal surface (actively corroding, close to corrosion, or inert).

C2 – Concrete core extraction and testing: Pipe coring will be taken at selected locations where the reinforced concrete pipeline is exposed and will undergo destructive testing in a laboratory. Testing will yield compressive strength, chloride penetration relating to corrosion risk, and extent of chemical attack on the concrete; and will provide data for remaining service life modeling.

<u>**D1** – Stability analysis modeling:</u> Multiple scenario hurricanes with a direct approach to the island of Oahu will be used to generate extreme wave conditions at the ocean outfall. Numerical modeling of complicated wave transformations (including the effects of shoaling, refraction, and breaking) and wave generated currents will be used to predict circulation patterns and water velocities along the outfall corridor during the extreme events.

<u>**D2** – Service life modeling:</u> Using the results of the core testing analysis, past chloride exposure conditions will be determined, future chloride penetration using a numerical model will be predicted, and estimates of time-to-corrosion will be developed.

2.2 Optional Inspection Tasks

Optional inspection elements were those tasks which were thought to be potentially required at a later time, dependent upon the findings gathered during the initial inspection work, including:

A2 – Side scan sonar survey of the outfall corridor;

A3 – Laser scanning point cloud survey of specific damage areas; and,

B2 – Internal inspection of the pipe barrel.

None of the optional tasks were found to be necessary during the course of the recommended inspection activities.

2.3 Omitted Tasks

The approved work plan was later modified to remove a number of tasks deemed unnecessary, based on new information provided in preliminary findings obtained during the initial inspection, as follows:

<u>**C2** – Concrete core extraction and testing</u> and <u>**D2** – Service life modeling</u>

During external visual inspection of the outfall, the outfall pipeline was observed to be either entrenched below the grade of the seafloor or ballasted with armor rock. In either case, no part of the pipeline's concrete joints was visible or readily accessible over the outfall's entire length. Excavation to extract concrete cores was not recommended due to the risk to causing damage to the pipe during excavation. For these reasons, concrete core extraction, and therefore testing and service life modeling were not considered feasible, and were eliminated from the schedule of inspection tasks to be completed.

<u>**B3** – Dye injection leak testing</u>

The dye injection leak testing was omitted from the work plan in light of preliminary visual inspection results. The dye testing effort was considered unlikely to provide any additional useful information on the condition of the outfall that hasn't already been learned from the visual inspection work. This is because dye testing is used for the special conditions where surrounding water visibility is poor and a tracer is necessary to highlight the presence of any leaks, or to verify where a suspected leak is located based on other known reasons. In the case of Waianae however (and any other locations with clear saltwater conditions), the density differences between fresh and salt water plus the discoloration of the effluent make the effluent stream, even if small, very apparent to an observer (particularly a trained observer). Since none of the above special conditions were true for Waianae and the entire pipeline corridor was also found to be trenched with pipe joints all buried under feet of gravel and grout, a hidden leak is unlikely and we have no reason or evidence to suspect one.

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3. HIGH RESOLUTION BATHYMETRIC SURVEY OF OUTFALL CORRIDOR (TASK A1)

3.1 Introduction

As the first element of the Waianae Ocean Outfall inspection effort, a high resolution multibeam hydrographic survey was completed for the entire length of the outfall corridor. Multibeam systems are a variation of hydrographic sonars that utilize a swath of acoustic beams (256 in our case) from a single transducer that 'sweep' across the seafloor beneath the survey vessel. The swath of beams generates a high density of survey data, and results in a very detailed and precise bathymetric map of the seafloor.

This section summarizes the procedures, equipment, and results of the survey. The survey area is shown in Figure 1-1, where the survey coverage is a corridor approximately 500 ft wide, centered on the outfall alignment shown. Survey field work was completed on 10 August 2017.

3.2 Methodology

3.2.1 Project Geodesy

The project coordinate system for this survey is the Hawaii State Plane Coordinate System (SPCS), Zone 3, U.S. Survey Feet, using the North American Datum of 1983 (NAD83) as the horizontal datum. Project horizontal and vertical control are based on NGS benchmark "INU" (PID DL6319), and depths are expressed as feet below the mean lower low water (MLLW) local tidal datum.

3.2.2 Survey Vessel

The survey vessel for this project was Sea Engineering's *25-ft Whaler*, pictured in Figure 3-1. The *25-ft Whaler* is a military-grade rigid hull fiberglass and aluminum vessel, outfitted and configured to conduct hydrographic survey operations anywhere around the island of Oahu. The vessel is powered by twin 125-hp outboards that provide dependable steerage and maneuverability. A custom-designed aluminum cross beam assembly fastened across the vessel's cockpit provides rigid attachment points for the multibeam down-pole and sonar head, the inertial measurement unit (IMU) for the inertial navigation system (INS), as well as mounting points for the real time kinematic (RTK) global positioning system (GPS) and heading antennas. The customized mounting assembly allows for swinging the sonar head clear of the water for transit, while also providing positive and accurate relocation of the sonar in the down position for resuming survey operations.

3.2.3 Multibeam Sonar System

The swath sonar system utilized for this project was the R2 Sonic 2024, which generates a swath of 256 beams, with a user variable swath width from 10° to 160°. The operating frequency is selectable from 200 to 400 kHz with a beam width of 0.5° x 1°. The sonar system was side-mounted to the survey vessel in an over-the-side vertical configuration, with the central (nadir) beam oriented straight down (0° angle from the vertical). The side-mount fixture system was securely attached to the ship's hull via rigid aluminum framework, which was in turn securely bolted directly to the vessel to prevent any independent displacements or rotations, of the sonar head or other sensors, following installation that could affect data quality.

Command and control of the sonar head is accomplished through a separate communications hub called the sonar interface module (SIM) box, which also allows inputs from external devices such as the sound velocity probe, positioning system, and vessel motions from the INS. The SIM box additionally serves as a router/hub for all data to and from the data acquisition system, with 10/100/1000Base-T Ethernet uplink/downlink speed.

Figure 3-1. SEI's survey boat *25-ft Whaler* – multibeam mount at center front, rotated up

3.2.4 Navigation and Positioning

Precise vessel positioning was accomplished through an embedded Trimble GNSS receiver, located in the split-box of the inertial navigation system, which is capable of providing centimetric RTK GPS positioning in both horizontal and vertical axes. RTK is a GPS positioning system in which GPS satellite signal corrections are transmitted in real time from a nearby reference receiver or base station at a known location, to one or more remote receivers (i.e., the survey vessel) referred to as rovers. The use of an RTK enabled GPS system will compensate for atmospheric delay, orbital errors and other variables in GPS geometry, with the ability of improving positions to centimeter-level, and in some cases millimeter-level accuracy. The increased vertical accuracy that is provided by RTK-based GPS also allows recording of accurate water level elevations, and thus tidal heights, which are typically collected continuously while surveying. The RTK rover used for this survey was an embedded dual L1/L2 GNSS RTK GPS internal receiver, Trimble model BD982.

SEI's RTK system utilized corrections sent from a continuously operating base station owned and operated by Survey Supply Company, located in Mililani. A data link between base and rover was established via a cellular modem network link and signal repeater provided by a Bridge-X communications and telemetry hub, manufactured by Intuicom.

Technical specifications of the Trimble RTK system state a kinematic accuracy (rover mode) of 8 mm. Actual position accuracy of the receiver, like all RTK systems, is dependent upon various environmental factors including the number of satellites tracked, constellation geometry at time of survey, observation time, ephemeris accuracy, atmospheric conditions, and multipath errors. The given accuracies are presented as root mean square values, and are based on measurements processed by the manufacturer using acquisition software on real-time measurements.

3.2.5 Inertial Navigation System – Vessel Motions

The ocean, and the sea surface in particular, is a very dynamic environment with wind, waves and swell from multiple sources often occurring simultaneously at any given time. Nearshore survey activities are often planned around notoriously infrequent windows of predicted calm weather and seas, however, some reasonable threshold of conditions must be dealt with in order to meet the needs of industry. To this end, the inertial navigation system—with its highly accurate accelerometers and gyros embedded in the motion reference unit—is a critical component, necessary to record and later remove the effects of vessel motions in a dynamic sea surface environment. The INS supplies a multibeam system's data acquisition system (DAS) with a stream of highly accurate real time attitude data, including the vessel's primary (Euler angle) motions such as pitch, roll, and yaw, as well as heave. The modern INS is so advanced, it is often likened to the inner workings of a cruise missile in terms of function and technology.

For the Waianae Outfall corridor survey, SEI utilized an INS manufactured by SBG Systems (Paris, France) which supplies a line of miniature and accurate IMUs, and GPS-enhanced Attitude and Heading Reference System (AHRS) based on MEMS sensors for aerospace, marine and subsea applications globally. The particular system utilized by SEI is based on the Ekinox-D inertial measurement unit, which is reported to achieve 0.05-degree pitch and roll accuracy, and 5 cm real time heave accuracy. The IMU combines high end gyroscopes and accelerometers, and runs an enhanced Extended Kalman Filter (EKF) to provide precise roll, pitch, heave, and heading when connected to an external GNSS receiver.

Also included in the system is a console-mounted communications hub called a *split-box*, which serves as a gateway for the INS system inputs and outputs (I/O), and all external aiding instruments. As discussed in the previous section, the split-box also functions as the RTK rover, with an embedded dual L1/L2 GNSS Trimble RTK GPS internal receiver, which provides robust and accurate true heading as well as RTK GPS positioning to aid the IMU.

3.2.6 Sound Velocity Measurements

Accurate acoustic (sonar) depth measurements obtained from the water column are dependent upon an accurate record of the speed of sound characteristics for that particular water column, which is primarily a function of salinity and temperature. Measurements of sound velocity as a function of depth of the water column were recorded on site using an Odom *Digibar Pro* sound velocity (SV) probe. SV casts were completed with the Digibar probe at the start and finish of surveying activities to define the sound velocity profile (SVP) for use during real-time multibeam data acquisition, as well as to generate sound velocity profiles (SVPs) for use in post-processing. The two SVPs were obtained, one before collecting survey data, and one after collection to verify water conditions had not changed throughout the course of the survey, and to capture local variations in water conditions. A plot of an example SV profile collected on site is presented in Figure 3-2.

In addition to the manually deployed SV profiler, the multibeam sonar head itself is equipped with an externally mounted and continuously operating sound velocity probe that instantaneously tracks the changing water characteristics in front of the sonar throughout the course of the survey. The integrated

SV probe used in this case was a Valeport model *miniSVS 50mm*, which was configured to stream the sound velocity data to the sonar's processing electronics, where it was utilized by the control system for real-time calculation of *beam forming* and *beam steering* parameters. Beam steering is an automated, computer-controlled process that provides continuous optimization of signal processing and sonar beam forming to adjust for changing water conditions, which assists in yielding the most accurate slant range measurements.

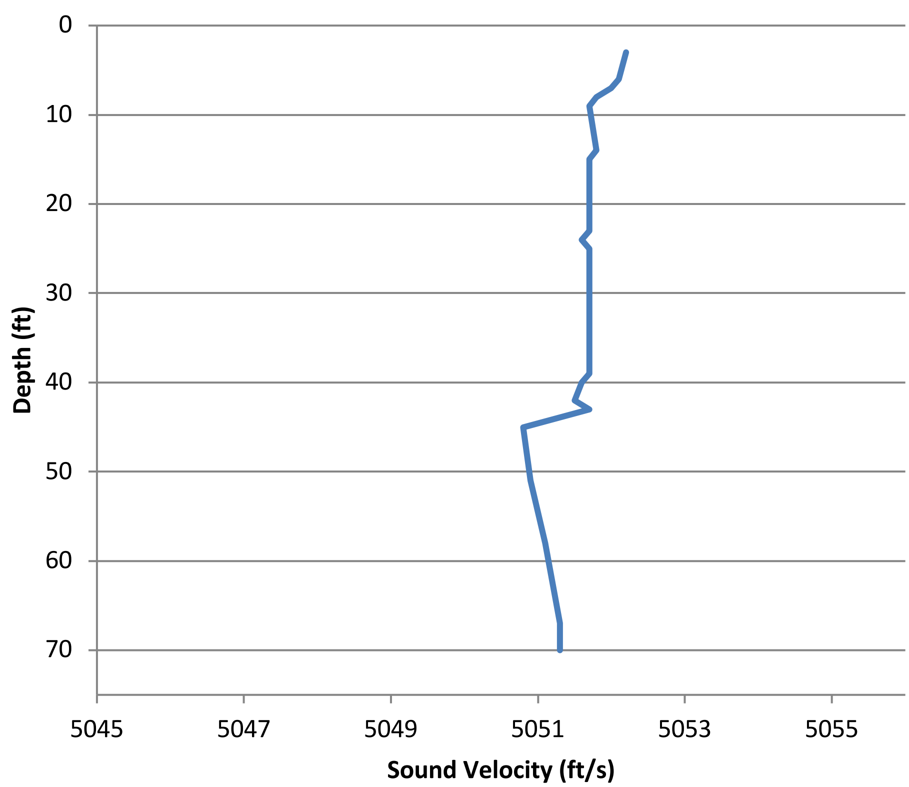

Figure 3-2. End of survey sound velocity profile

3.2.7 Data Acquisition System

The suite of data collection software and utilities used for this survey is known as *Hypack* and *Hysweep* (Hypack USA, Middletown, CT) and is the industry leading supplier of hydrographic software. Hypack was utilized for the acquisition of raw multibeam, positioning, and vessel motion data streams, along with RTK-based tide data. Additionally, Hypack/Hysweep performs the critical task of integrating all instrument and sensor data streams with extremely precise time stamping into a unified composite raw data record. The Hypack/Hysweep subroutine *MBMAX64* was used for cleaning, post-processing, and quality control of the raw data. A photograph of the operational multibeam data acquisition setup as installed on the *25-ft Whaler* for this survey is illustrated in Figure 3-3, which shows the multibeam SIM box at the bottom of the stack, with the INS split-box on top. A multitude of data I/O cables can be seen connecting the two boxes with various devices and sensors related to the multibeam system.

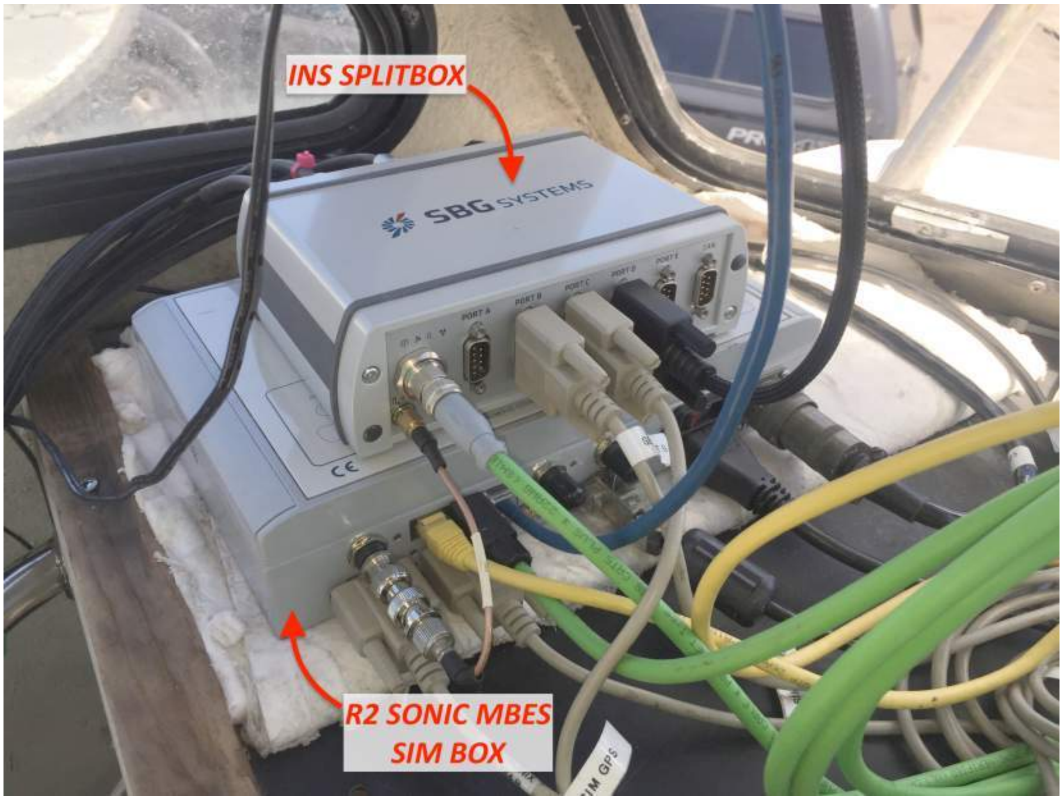

Figure 3-3. SIM and split-box, shown with necessary cable connections

A wider view of the vessel's wheelhouse, seen in Figure 3-4, reveals nearly the entire multibeam data acquisition system as used for this survey, which consists of the following primary elements:

- An inertial navigation system which is comprised of the IMU (not shown in Figure 3-4), rigidly installed near the vessel's center of gravity, and cabled directly to the INS split-box located in at the helm;
- Two RTK antennas (not shown) cabled directly to the INS split-box which provide positioning and heading, with the GPS receiver integrated into the INS split-box;
- R2Sonic 2024 multibeam sonar head and SV probe (not shown), side mounted and directly cabled to the R2Sonic sonar interface module (SIM) box at the helm;
- Bridge-X telemetry unit, employed to increase reception quality of the RTK cellular modem connection. Provides RTCM messages (GPS corrections) from the RTK base station on land to RTK rover on the vessel; and,
- Data acquisition computer (Getac B300 hardened field laptop), connected to both the INS split-box and the R2Sonic SIM box via network cable connections.

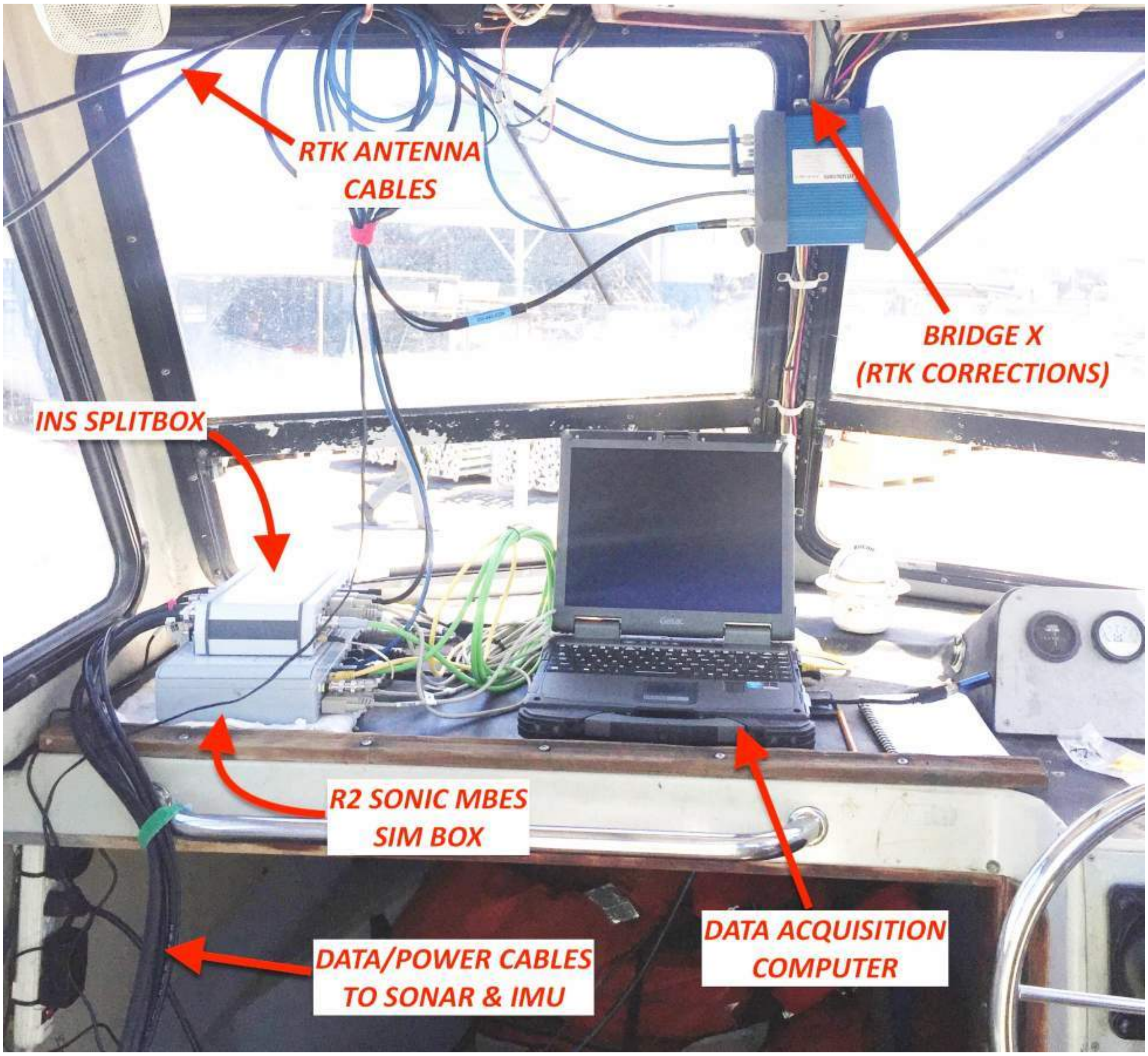

Figure 3-4. Survey electronics, as installed on *25ft-Whaler* during Waianae Outfall survey

3.2.8 Survey Control

Horizontal and vertical control for this effort was provided by the local land surveying firm Control Point Surveying, which shot in a temporary bench mark "TBM SE" on the pier edge at Waianae Small Boat Harbor. A secondary control was obtained from the NGS/USACE benchmark "INU" (PID DL6319). RTK antenna positions were checked at the beginning and end of every survey day at the primary project benchmark TBM SE, which was also the location of the tide staff and a water level logger. Benchmark coordinates used for this project are listed in Table 3-1. No significant differences in position were observed during the pre- and post-survey position checks.

Table 3-1. Project control, HSPCS, Zone 3, US Survey Feet, NAD83

BENCHMARK	NORTHING	EASTING	ELEV (MLLW)
INU	102722.03	1573472.76	5.7
TBM SE	102488.57	1573527.24	3.87

3.2.9 Tide Corrections

Due to the increased vertical accuracy that is provided by RTK-based GPS, it was possible to record very accurate instantaneous water level elevations while surveying, which included long period surge and tide components. These components were removed from the depth data during post-processing, producing tide-corrected depths for final use.

3.2.10 Estimated Vertical Accuracy

The potential error incorporated into depth measurements collected with swath sonar systems is estimated as a function of the inaccuracies due to residual systematic and system specific instrument measurement accuracies, such as the speed of sound in water, tide measurements, and vessel motions.

Combining these individual depth errors yields the total estimated uncertainty in vertical accuracy. There are two basic categories of error affecting the depths: *Bias errors* are constant errors such as draft offsets or errors in tidal benchmark elevation; *Random errors* are errors present in the measurement system, such as combined multibeam “black box” errors, GPS inaccuracies, and motion sensor inaccuracies. An estimate of the total survey accuracy is a root mean square (RMS) summation of both bias errors and random errors.

Bias errors were estimated as follows:

Position -- No offsets in position were found during occupation of benchmarks. The RTK elevation data acquired while occupying the project vertical control benchmark “INU” resulted in a standard deviation of 0.042 ft (0.5 in), and 4σ (4 x standard deviation) of 0.169 ft (2.0 in). For error estimation, the more conservative 4σ value will be used.

Draft -- Maximum error in draft measurement is estimated to be 0.16 ft.

Speed of Sound -- Maximum estimated error in the speed of sound measurements in seawater based on site sound velocity profile casts is an estimated 3.3 ft/s. At a range of 140 ft (maximum depth in data set) and two-way travel time, the maximum difference in depth measurement is estimated at 0.1 ft or 1.2 inches.

Random errors include total system errors (i.e., combined multibeam "black box" and GPS positioning) and tide measurements. These errors were estimated together by examining the cross lines within the survey area. The average depth differences for a cross line comparison were calculated for all beams where available, with an average departure of 0.01 ft from the base surface. No tidal offsets were present in the data set. A conservative estimate of total system RMS vertical accuracy is therefore:

$$Error_{RMS} = \sqrt{(X\ line\ error)^2 + (Position\ error)^2 + (Draft\ error)^2 + (SV\ error)^2}$$

$$Error_{RMS} = \sqrt{(0.01)^2 + (0.169)^2 + (0.16)^2 + (0.1)^2}$$

Error $_{RMS}$ = <u>0.27 ft</u> (3.2 in)

3.3 Data Processing

3.3.1 Patch Test (Calibration)

The *patch test* is a required procedure for multibeam surveys performed to calibrate the sonar system for any angular misalignments between the sonar head, heading sensor and the inertial measurement unit as installed on the vessel. Patch test data are used to correct for residual biases after the mobilization of the vessel, including pitch, roll and heading offsets. The patch test also calculates the latency of the GPS system which is the difference in time between the when positioning data was received and the when the computed position was logged by the acquisition system, however this quantity is typically negligible when using RTK-based GPS. Also related to timing, the inertial navigation and multibeam system both utilized a *1 pulse per second* (1PPS) timing signal that theoretically eliminates the issue of GPS latency, however the value was still verified in the patch test routine.

In general, the patch test procedure is a two part process, the first of which is conducted in the field and requires data to be collected under specific and tightly controlled conditions; the second stage is completed back in the office using a specialized routine of the *MBMAX64* data processing tool during the data cleaning and quality control procedure.

The patch test field operation consisted of data collection at specific speeds and directions along several coincident and parallel survey lines that were positioned over areas of local seafloor with flat bottom characteristics (for roll and latency) and with high relief such as a large rock outcrop, sunken vessel, or large debris (for pitch and yaw). Following survey field operations, the patch test results were then analyzed to calculate angular offsets, and finally calibrated by entering the calculated device offsets into the multibeam post-processing software. The patch test values calculated specifically for this survey are summarized in Table 3-2 below.

Table 3-2. Calculated multibeam patch test values

Component	Correction
Roll	2.05°
Pitch	3.00°
Yaw	1.00°
Latency	0.00 s

3.3.2 Data Cleaning

Post-processing of soundings (depth data) from the multibeam system was completed utilizing Hypack's MBMAX64 swath data editor, where the calculated patch test offsets for alignment corrections were then applied to the entire data set. The first pass in the editing process involved an assessment of the aiding instrumentation data quality. At this stage, the vessel's heading and attitude data were reviewed for tracking loss, heave drift or other loss in data integrity. GPS-based position quality sometimes degrades due to electromagnetic frequency (EMF) noise, poor satellite coverage, or poor reception of the base station corrections. To remove poor position data, quality filters were applied to the positioning in order to reject data with less than RTK-level accuracy. Tidal measurements recorded as RTK elevations of the water surface were reviewed and later used to correct all depth measurements to the mean lower low water (MLLW) tidal datum based on project vertical control. SV profile and probe data were reviewed and applied to the sonar data to correct slant range measurements and compensate for ray path bending.

The second stage of editing involved review of all sonar data for quality and accuracy. At this point, swath data from each file were individually reviewed line by line and processed for false returns such as from surface noise, bubbles or large particles in the water column, fish, and other less common forms of erroneous data. During this review, bad data were either flagged for closer inspection by the chief surveyor or removed from the dataset.

After swath editing, all data were reviewed through the Hypack/Hysweep cloud editing routine. The cloud editor opens multiple line files to create a unified point cloud representation, allowing the reviewer to ensure that the data set was internally consistent and that no outliers remained, and conversely, that no actual features that may have appeared as fliers line-by-line were mistakenly removed as outliers. Additionally, the cloud editor permits the data to be analyzed for swath-to-swath overlap comparisons. The survey lines were "tiled" to ensure that all sounding data were systematically edited and reviewed for completeness. The cloud editing procedure also provided confidence in vessel positioning and sonar calibration by observing features mapped at the same location.

3.3.3 Cross Line Analysis

Several survey lines were run perpendicular to the primary survey line direction (aligned with the axis of the outfall) to check for roll offsets, timing delays or offsets due to tidal fluctuations. Data from these cross lines were compared with the primary survey data using specialized subroutine within Hypack Hysweep's MBMAX64 processing utility. This processing utility called *Check Line Statistics* allows the user to statistically compare numerous lines or surfaces with separate cross lines, or even data from previous surveys, to check the quality and agreement of the data. Several locations spaced throughout the data set were used for comparison. The average departure or difference observed during cross line checks was 0.01 feet, and a standard deviation of 0.39 feet, suggesting very good agreement within the data set. Histogram output from the check line statistics test is presented in Figure 3-5, which illustrates the desirable bell-shaped curve of depth differences, centered on the mean difference of 0.01 feet. A bell curve distribution is indicative of good agreement, with the vast majority of soundings within the standard deviation of 0.39 ft.

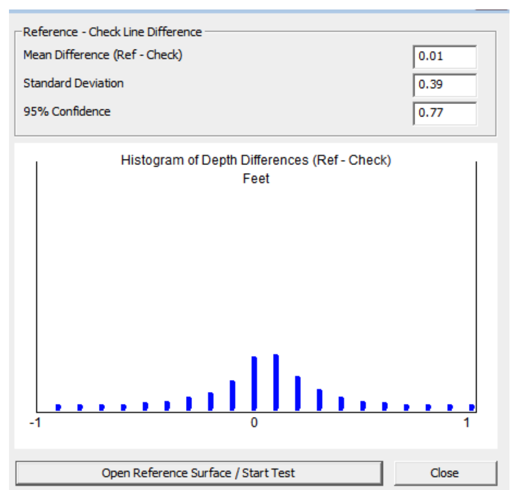

Figure 3-5. Cross line statistics results

3.3.4 Visualization

The accepted dataset was used to generate three-dimensional digital terrain models (DTMs). These models were used to identify residual biases and assisted in 3D visualization during the editing procedure. Areas of interest were identified through the DTMs and investigated further in the editing program.

Lastly, the finalized depth data were exported from the processing software as an ASCII text file of XYZ triplets of the entire accepted dataset, and then imported to the Geographic Resources Analysis Support System (GRASS) GIS for conversion into a high resolution surface grid for contouring and visualization. It was necessary that the outfall corridor was divided into smaller panels to accommodate the higher resolution. Sun-illuminated *hill-shade* rendering was performed on the bathymetry grid generated in GRASS to best illuminate and highlight the outfall and seafloor features.

3.4 Survey Results

In general, the multibeam results clearly resolve the outfall along much of the surveyed corridor, where the surrounding seafloor is characteristically irregular, hard bottom substrate, as illustrated in the overview bathymetric DTM presented in Figure 3-6 below. The deeper diffuser section is the exception, which appears to just intersect the sand channel created by Mailiili Stream (A), with the submerged expression of what is likely the stream's prehistoric alignment given by the sand channel clearly visible (B) at image lower center, which runs east-west bisecting Pokai Bay. The northern boundary of the sand channel appears to run just north of the diffuser section (C), suggesting that the diffuser leg may rest on at least partial sand bottom, or is partially covered by the northern fringe of this deposit.

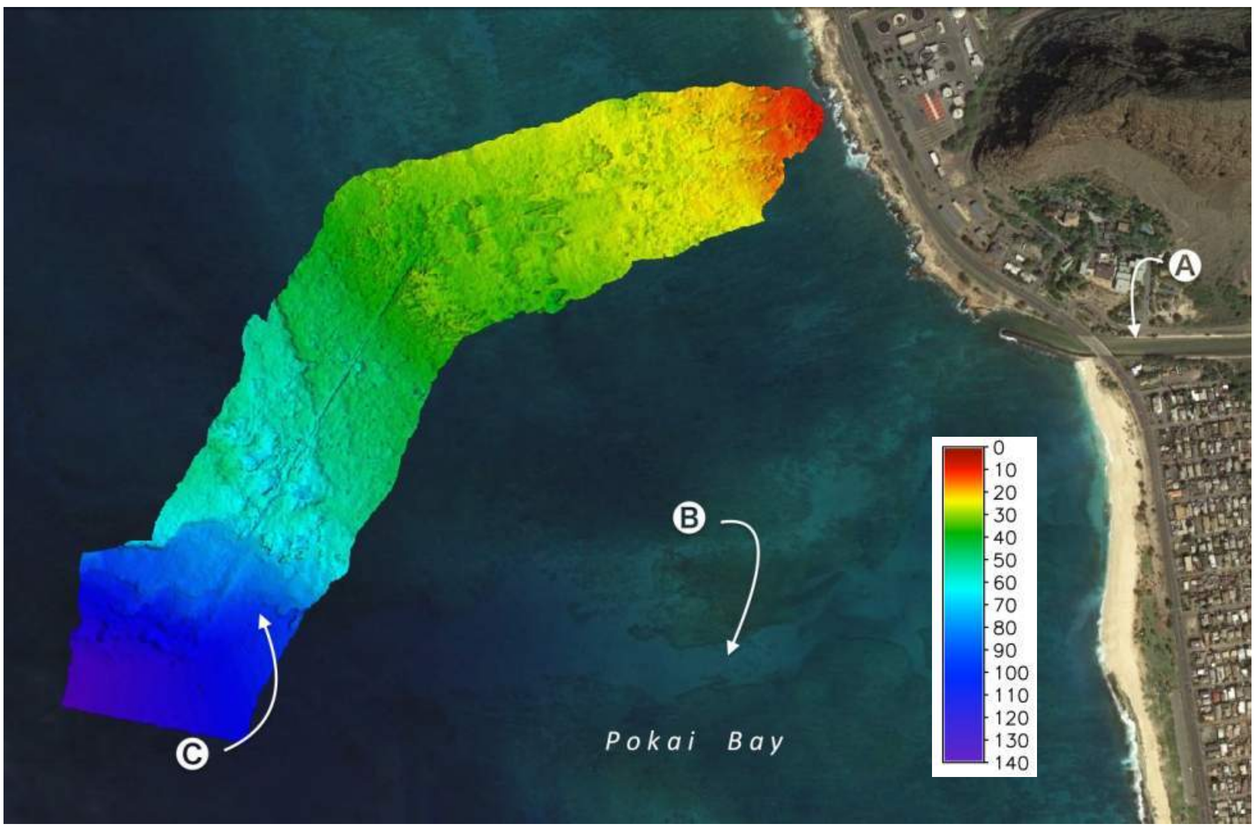

Figure 3-6. Overview of surveyed outfall corridor. Depth in feet above MLLW.

A closeup view of the nearshore section of outfall corridor, including landfall, between the shoreline valve-box and approximately 20-foot water depth (red to yellow shaded bathymetry in Figure 3-7, top panel) suggests that the seafloor is largely composed of spur-and-groove type coral/limestone formations, with the groove features apparently accumulating some limited sand veins and sand patches, as indicated in the corresponding aerial imagery in Figure 3-7 (bottom panel). Also in Figure 3-7, the outfall with concrete cap and jacketing (A) is clearly visible just offshore of the shoreline, as the cap protrudes above the surrounding reef. On land, the jacketed pipe is seen entering the water (C), just seaward of the valve-box (D), which also represents Station 0+00 of the original 36-inch ocean outfall alignment. A section of outfall trench (B) with buried pipe is visible further offshore.

Further out, approximately between the 20 and 30-foot depth contours (yellow to green shaded bathymetry), the seafloor is relatively flat and smooth, but marked with steep-walled potholes and other deep scarring, as shown in Figure 3-8. Continuing offshore, in roughly 30 to 40-foot water depths, the outfall trench is visible (A) at approximately Station 17+00. A ballasted (rocked) section of pipe (B) is seen between Stations 20+00 to 23+00, with individual ballast stones discernable along the ballast pile. A relatively large and apparently sand-filled pothole (C) lies to the north (aerial image, bottom panel). Pressure Manhole 3 (D) is almost perceptible along the ballast pile, suggested by the saddle shaped depression in the pile at this location.

In the vicinity of the offshore wye structure, Figure 3-9 reveals a section of ballasted pipe (A) that is clearly visible at approximately Station 25+00 to 26+00. The wye junction itself (B) is vaguely discernable at Station 28+00, where the abandoned original diffuser leg (C) is visible extending approximately 170 ft from the wye. The 42-inch extension begins at the wye, makes a 39° bend, and continues offshore in a trench (D). At this point, the general seafloor slope breaks and falls more steeply to a scarp line that runs basically north-south at approximately 50 to 60 ft depth (green to cyan shaded bathymetry). Between this scarp line and the Mailiili sand channel (C), the bottom is broken and irregular with pits and scars, likely filled with sand. The remaining corridor sloping down to 100 ft or greater appears to transition from hard bottom to sand or a combination of the two.

For a more thorough inspection of the results, a complete set of annotated sun-illuminated hill-shade renderings of corridor bathymetry are presented as a map set in Appendix B, along with a similar map set, with annotations overlaid, provided in Appendix C.

Coordinates for key features that were observable from the multibeam results are presented in Table 3-3 below, with northing and easting reported in feet using the Hawaii State Plane Coordinate System (HSPCS), Zone 3, referenced to the NAD83 horizontal datum. Corresponding geographic coordinates in degrees latitude and longitude using the WGS84 horizontal datum are also provided.

Table 3-3. Key features of outfall (HSPCS Zone 3, US Survey Feet, NAD83 and Lat/Long WGS84)

ID	FEATURE	EASTING	NORTHING	LAT	LONG
1	Onshore Valve Box	1577710.17	96796.60	21.433036°	-158.184370°
2	End of Original Outfall / Junction Box (Wye)	1575060.52	95854.11	21.430433°	-158.192157°
3	39° Bend	1574918.45	95803.80	21.430294°	-158.192574°
4	90° Bend	1573431.14	93316.15	21.423441°	-158.196938°
5	Start of Diffuser	1573428.52	93317.66	21.423445°	-158.196946°
6	25° Bend	1573234.57	93428.11	21.423749°	-158.197516°
7	End of Diffuser / End of Outfall	1572932.04	93458.39	21.423831°	-158.198406°

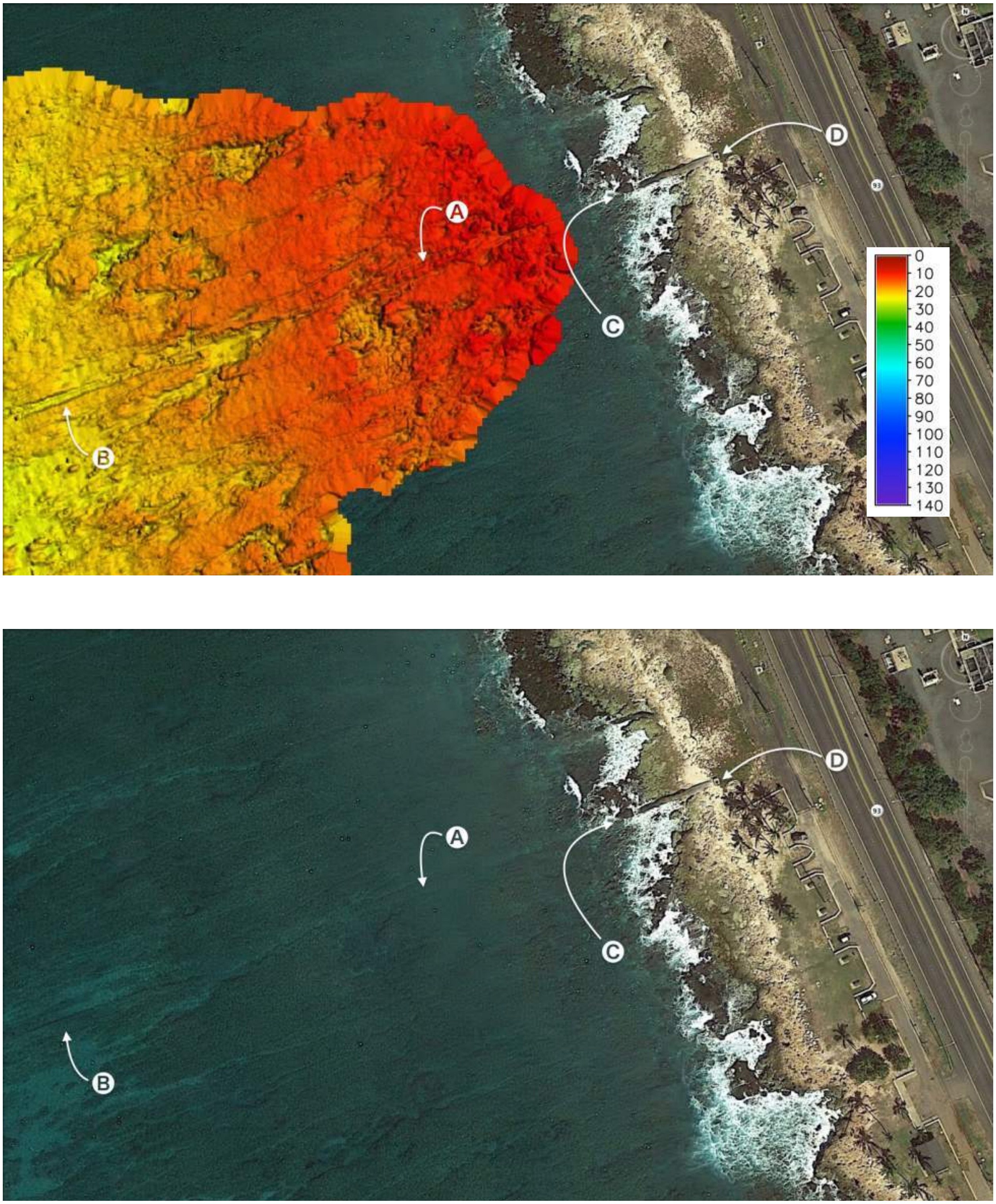

Figure 3-7. Outfall landing with DTM (*top*) and without DTM (*bottom*) over aerial image, dated 29 Jan 2013. *Image Source: Google Earth, 2017*

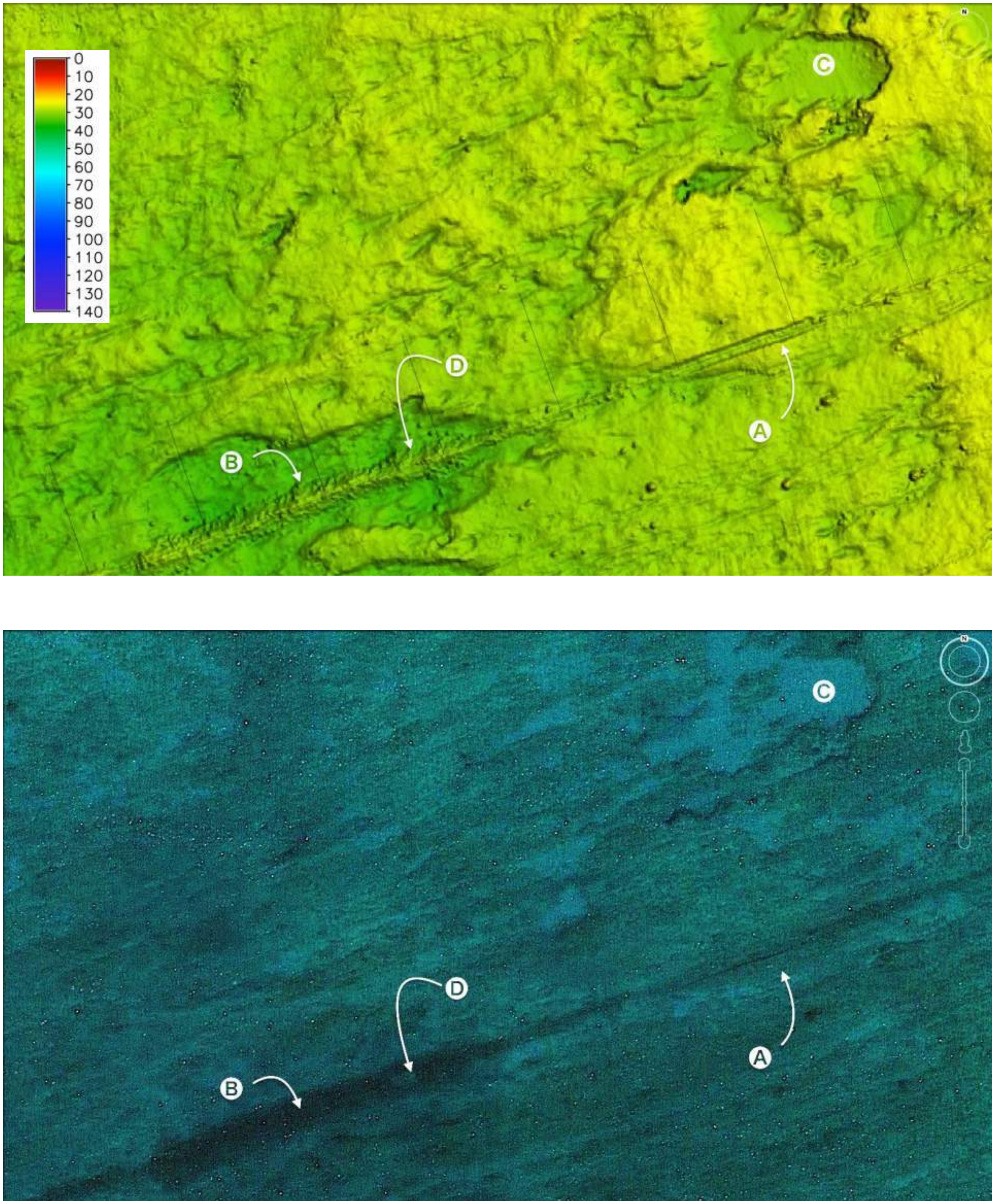

Figure 3-8. Shallow outfall corridor with DTM (*top*) and aerial image (*bottom*), dated 29 Jan 2013. *Image Source: Google Earth, 2017*

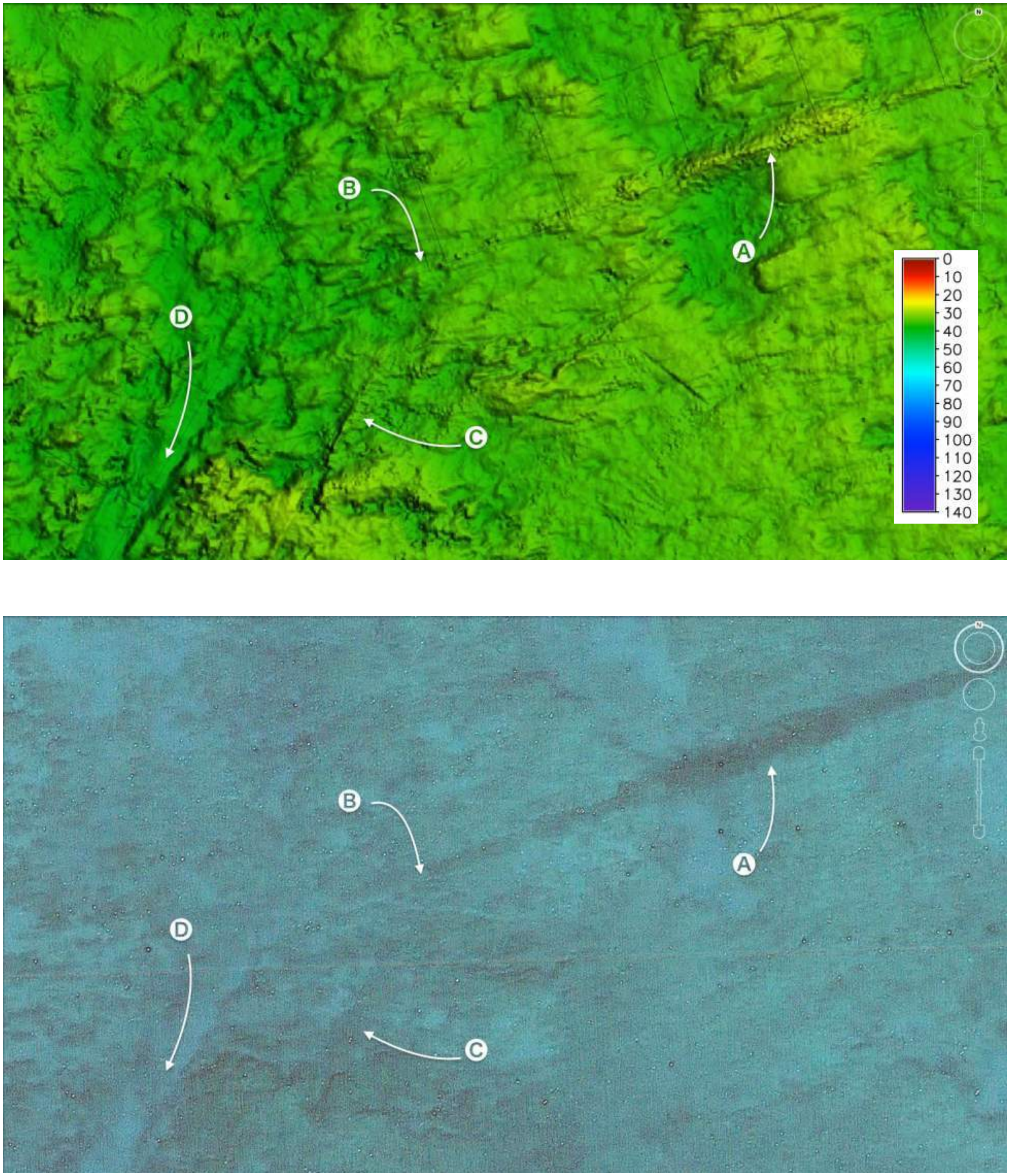

Figure 3-9. Wye junction structure with DTM (*top*) and aerial image (*bottom*), dated 29 Jan 2013. Image Source: Google Earth, 2017

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4. EXTERIOR INSPECTION (TASKS B1 & C1)

4.1 Introduction

The Waianae Waste Water Treatment Plant (WWTP) serves as the primary sewage reception, treatment and disposal facility for a large portion of West Oahu. The facility utilizes an ocean outfall structure for transferring treated effluent from the treatment plant to offshore waters for disposal. SEI was tasked with completing a visual inspection of the exterior portions of Waianae Ocean Outfall as part of the larger outfall condition assessment effort, as outlined in the work plan, *Waianae WWTP Ocean Outfall Inspection and Condition Assessment Program* (SEI, 2016). This section summarizes the procedures, equipment, and results of the underwater visual inspection, which was completed 08-09 February, 2018. The project site is illustrated in Figure 1-1, located in Section 1.

4.2 Outfall Configuration

The Waianae WWTP discharges secondarily treated effluent through a 36-inch diameter reinforced concrete ocean outfall, which was initially constructed in 1965 to a depth of 24 ft, and later extended with a 42-inch pipe to a depth of 105 ft in 1986. As-built drawings provided for the original pipeline and new extension reflect repeating station numbers between the two drawing sets. Therefore, in order to minimize confusion for the remainder this report, stationing along the original outfall will remain unaltered from that shown in the plans, while references to stationing along the outfall extension will be modified by appending the shown station numbers with an "E" to indicate extension. Figure 4-1 presents a detail of the transition location including the special wye structure (junction box) and decommissioned original diffuser leg, shown with digital terrain model created from the multibeam survey data, while Figure 4-2 illustrates the general outfall layout with described stationing change.

The entire pipeline including the original pipe, new extension, and new diffuser leg were installed within a trench excavated from the reef, laying on a crushed gravel bed at the base of the trench. Once installed in the trench, the reinforced concrete pipe (RCP) joints were typically capped with a tremie concrete jacket. In some limited locations along the original outfall, where the trench wall height was insufficient, the pipe was backfilled with small stone and then ballasted with larger armor stone. The original 36-inch outfall extends offshore from the shoreline to a junction box referred to on the plans as the *special wye structure,* located at station 28+13.59.

The special wye structure is an inline concrete junction with three ports that allow flow in a Y-shaped configuration as follows: (1) the inlet—the base of the Y-shape—is connected to the end of the original 36-inch trunk line; (2) the south branch of the wye was connected to a reducer section for flow to the original (now decommissioned) 30-inch diffuser leg, which angles off to the southwest from the wye at this location (where it is now partially abandoned in place); and lastly, (3) the north branch, which was originally plugged until construction of the extension, and now provides a 36-inch extension joint that proceeds on a straight alignment from the special wye structure, beginning with a pipe increaser section, to increase the diameter of the pipe from 36 to 42 inches, which then connects to the first joint of the main trunk of the new 42-inch extension line. The special wye structure is equipped with 1½-inch thick slots on each of the downstream branches of the wye, which accept fiberglass gates that slide into the slots to terminate flow of effluent. The wye branch leading to the decommissioned diffuser leg is gated at the slot, while the branch to the 42-inch line is ungated (open). The slots are sealed by stainless steel slot covers with rubber gaskets, bolted down to the top of the special wye structure.

Numbering restarts at this location, with station 28+13.59 of the original outfall being equivalent to 00+00 of the 1986 extension, as shown in Figure 4-1. The outfall extension continues offshore from the transition along the same alignment for approximately 150 ft where it then makes a 40° turn towards the southwest. The outfall continues along this new alignment to the southwest up to station 30+50 E where it makes a 90° turn toward a northwest alignment. The outfall continues to the northwest with the diffuser leg starting at 30+77 E up to 32+65 E, were it bends 25° in a more westerly direction. The diffuser section is similarly trenched into the reef and capped with a concrete jacket, with only the diffuser port risers and fiberglass diffuser elbows protruding from the cap. The diffusers continue in this manner every 12 ft along the pipe up to the stopgate structure at 35+75 E. The stopgate structure forms the termination of the outfall and the end of the pipe, and provides an additional diffuser formed by a 6" diameter monel pipe encased in a concrete gate that blocks off the end of the pipe.

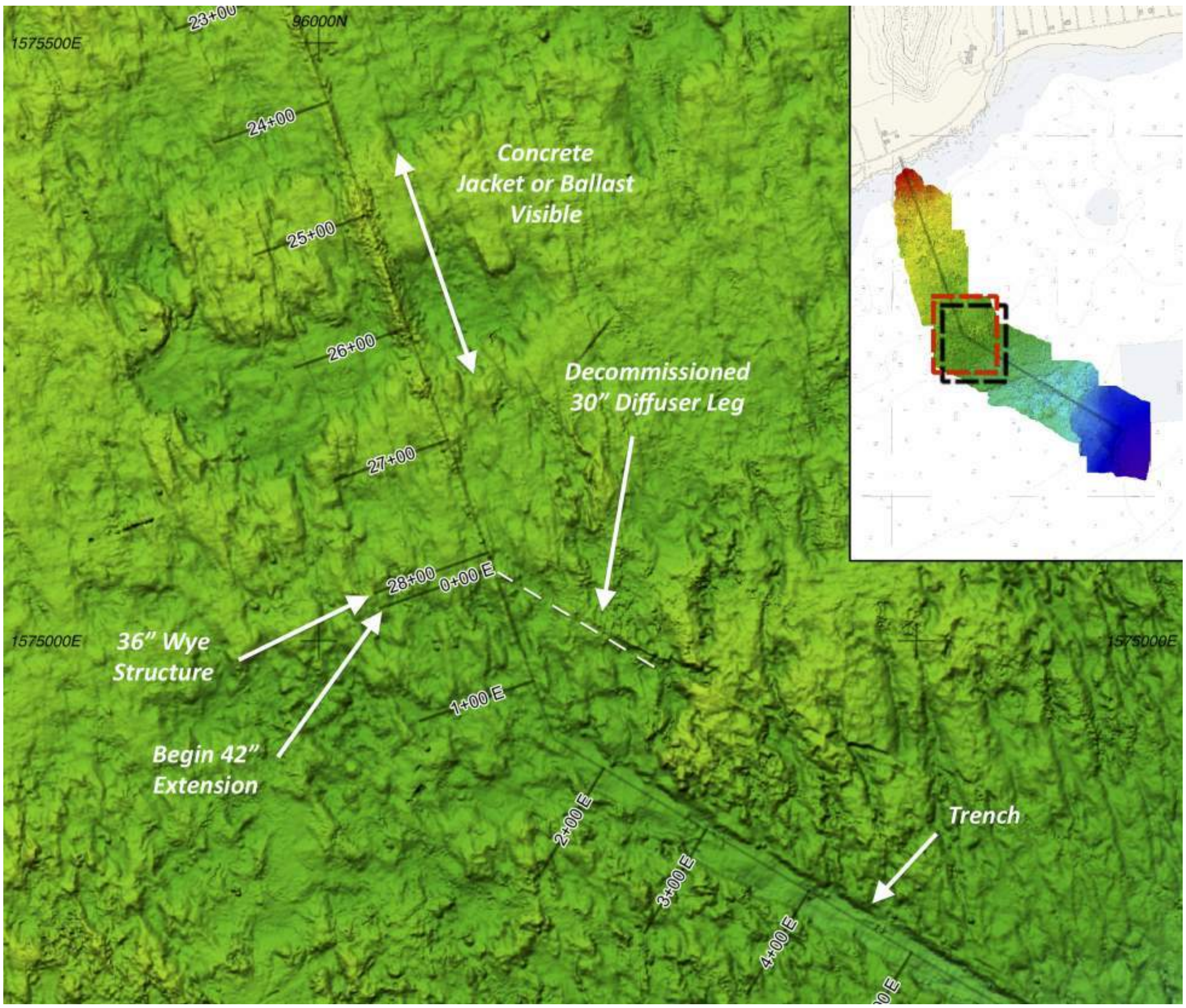


Figure 4-1. Vicinity of junction box (special wye structure) and start of outfall extension

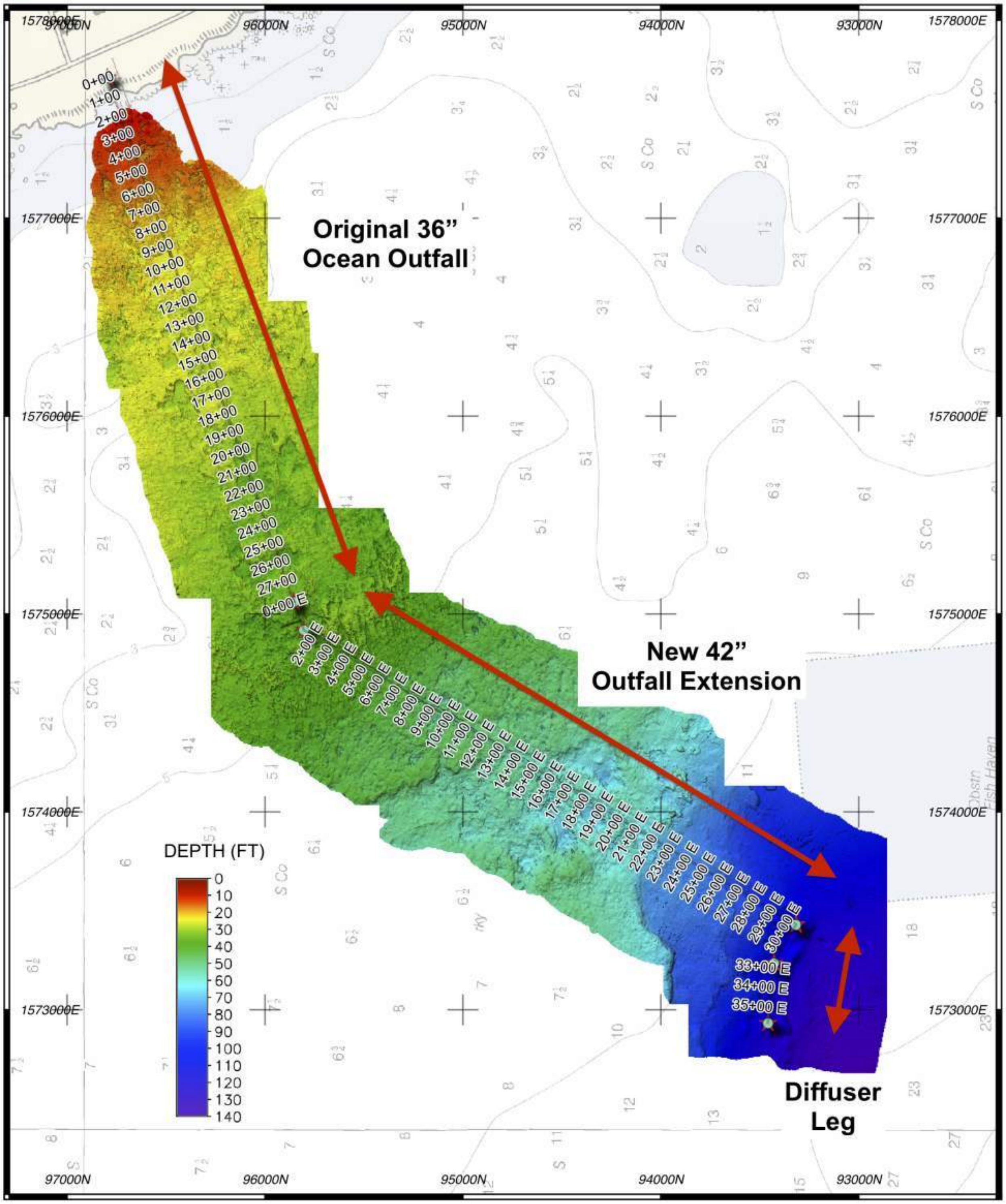


Figure 4-2. Outfall station numbering

4.3 Inspection Methodology

SEI's inspection team—comprised of three licensed professional engineering divers, and supported by SEI commercial divers—conducted an underwater visual inspection of the entire Waianae Ocean Outfall. The inspection activities were completed on 08-09 February, 2018.

Following the approved 2016 Work Plan, the scope of work required execution of multiple tasks, including: visual inspection of exposed portions of the outfall; inspection of exposed metallic hardware for corrosion and serviceability; inspection and clearing (if necessary) of diffuser ports; and, video documentation of existing conditions along the outfall corridor. A high-resolution underwater digital video system was employed by inspectors to document general site conditions, as well as to record potential deficiencies, damage, or any areas observed along the outfall deemed to be of interest by inspectors.

Visual inspection by engineering divers provides an excellent near-field look and general assessment of the outfall and associated structures, however it provides relatively sparse information about larger-scale macroscopic trends that may be affecting the adjacent seafloor upon which the structure rests. To fill this gap, underwater inspection work utilized the previously collected high resolution multibeam bathymetry data for dive planning, feature targeting, real-time navigation, assessment of large scale phenomena that may impact the outfall, and as a graphical aid for illustrations in writing this report. The complete set of high resolution bathymetric maps is provided for the reader in Appendices A and B. Detailed descriptions of hardware and instrumentation, system setup, software, execution and processing for the multibeam hydrographic survey are provided in Section 2 of this report.

4.3.1 General Inspection Criteria

The visual inspection is essentially an overview of the entire outfall, starting from the stopgate structure located at the outfall's deep-water terminus, and continuing up to the pipeline's shoreline landfall, with divers working from deep to shallow water in order to maximize bottom time. During inspection, the engineering divers' focus included, but was not limited to, the following primary elements:

1) Evidence of spalling or cracks of exposed concrete surfaces;
2) Condition of the grout cap and trench system;
3) Leaks or evidence of degradation;
4) Manhole condition;
5) Diffuser port condition and flow status;
6) Bio-fouling, clogging or blockage of diffusers;
7) Attrition or loss of efficiency of ballast or armor stone material, where used;
8) Scour of underlying or adjacent unconsolidated marine sediments (e.g., loss of supportive gravel, coral rubble, or sand);
9) Manmade debris; and,
10) Corrosion of the outfall's metallic components

4.3.2 Ocean Forces and Processes Affecting Outfall stability

A number of naturally occurring phenomena within the dynamic ocean environment are capable of exerting significant influence on outfalls and their protective ballast material. These processes include hydrodynamic forces due to waves, currents driven by tides or wave setup, and sediment transport resulting from the currents. The arrival of large waves from local or distant storms increases near-bottom water velocities, amplifies the typical effects of these processes and is capable of damaging the outfall. During the inspection, engineers carefully looked for evidence of activity from these processes, each of which is discussed below in general terms of how they might affect the Waianae Ocean Outfall.

4.3.2.1 Waves and Currents

In the velocity field that propagates through the water column beneath deep-water waves, water particles move in a circular orbit. Instantaneous water particle velocity decreases exponentially as a function of depth, where the maximum depth of wave-induced particle motion is a function of wave height and period. The larger the wave and longer the period, the deeper the effects of the wave are felt in the water column. As a wave advances towards shore and encounters shallow water, it's underlying velocity field begins to experience the effects of resistance on the seafloor. The frictional and momentum forces of waves interacting with the seafloor modifies the wave-form, causing the wave height and face steepness to increase, the wavelength to shorten, and the circular orbit of the particles to become increasingly elliptical and flattened. As the wave propagates into progressively more shallow water, it eventually reaches a critical steepness where the wave will "break", which typically occurs in a depth of water approximately 1.3 times the height of the wave. The highest energy release occurs where waves are breaking, due to the violent and dynamic nature of the phenomenon. It is in this high-energy *surf zone* area that a pipeline is thought most likely to be damaged during a storm or large swell event.

Figure 4-3. Breakers in the vicinity of the Waianae Ocean Outfall shoreline landfall (25 August 2015)

In addition to the wave-induced oscillatory particle motion, waves approaching a straight coastline at an angle can generate a steady *longshore current*. These longshore currents are responsible for much of the longshore transport of sediment and nearshore erosion for shorelines comprised of long sandy beaches. The impact of this current and the sediment load carried by it (known as littoral transport) directly affects, and is effected by, any structures which may interrupt the flow such as a groin or breakwater. In the vicinity of Waianae Ocean Outfall however, the lack of substantial sand or other unconsolidated sediment fields underlying or adjacent to the pipe, along with the fact that it is trenched into hard reef substrate, minimize the threat of negative effects from littoral transport.

4.3.2.2 Hydrodynamic Forces

The dynamic forces acting on a submerged object due to moving water are comprised of viscous forces and pressure forces generated by varied fluid velocities over and around the object. At higher *Reynolds Numbers*[†], such as our case, pressure forces such as lift and drag become dominant and the viscous forces become negligible. The velocity field that propagates beneath a wave crest depends on the wave height, wavelength, and water depth, and is capable of generating high local velocities near the surface. As the wave shoals and nears breaking in shallow water, these high velocities may also impact the seafloor. Additionally, the currents generated by waves can cause movement of the entire water column. The impact of this mass of water on the outfall can cause forces on the pipe or ballast just as if they were in a flowing river. Extreme flow over the top of the pipe or ballast pile can cause lift forces to develop that may act to reduce stability by effectively reducing the weight of the pipe or ballast, or even briefly suspend the structure or ballast unit. Once isolated from the main structure and/or exposed on the seafloor, the horizontal drag force on the pipe or ballast will act to push in the direction of the current flow. These lift and drag forces caused by steady currents and oscillating velocities from waves, can cause large objects (like an unprotected RCP pipe joint or ballast rock) to "jump" or move as a large wave crest passes overhead. However, hydrodynamic forces on the Waianae Ocean Outfall were minimized by design by trenching and capping of the RCP joints into the hard reef substrate. Still, in some limited locations of the outfall there are sections where ballast stone was required to be used, and the finished ballast pile does extend sufficiently above the seafloor to be subject to and threatened by these forces.

4.3.2.3 Liquefaction

The vibratory action of shock waves propagating through the seafloor imparted by large surf, or more significantly, seismic events, can cause unconsolidated water-saturated sediments to go into suspension. This process is known as liquefaction and results in sediment layers losing their shear strength, and therefore their ability to support higher density objects resting upon them. Liquefaction allows dense objects (such as ballast rock or RCP joints) previously resting soundly on the sediment layer, to sink or settle downward into the liquefied sediment, and thereby displace any structure or material located above. Liquefaction is not expected to be a significant factor at the Waianae Ocean Outfall due to its construction on primarily hard bottom (reef/limestone), however, some limited areas where the pipe is ballasted and supported on the flank by crushed gravel or coral rubble may still be at risk from this phenomenon.

[†] Reynolds Number (Re) is a ratio that relates a fluid's density and velocity to the size of the object within that flow, and is represented by $Re = \frac{UD}{\nu}$, where U = velocity; D = diameter or width of object; and, ν is kinematic viscosity.

4.3.2.4 Sediment Transport and Scour

Sediment (littoral) transport and seasonal beach migration (inshore/offshore) are driven when water velocities are great enough to suspend the sediment particles and transport them in the water column as suspended-load and bed-load, the rate of which is a function of particle size (diameter) and water velocity. In general, the greater the water velocity, the larger a grain size that can be transported. The suspension and movement of unconsolidated sediments (which in extreme cases can include gravel and coral rubble) in the water column may result in erosion and scour—lowering the bottom elevation in the affected area. Eroded material may or may not be redeposited at the same location depending on the dominant current patterns and the up-current sediment supply.

A more localized type of erosion that typically occurs adjacent to a structure is referred to as scour. Localized depletion of sediment to some degree is typically observed around most offshore structures that have transportable sediment near their foundations or perimeters. Manmade structures installed in offshore waters often create an obstruction to the flow of existing currents, causing increased flow velocities and turbulence around the edges of the obstruction. The velocity of the water increases as it flows around the outer edge of the obstruction causing a localized increase in the energy proportional to the square of the velocity. This increased energy in the form of turbulence formed along the downstream side of an obstruction allows the water column to mobilize greater volumes of sediment, as well as larger grain sizes within the sediment, than would be the case if the structure were absent.

Scour around an outfall is often observed as a differential in bottom elevation of the near-field (adjacent) sediment distribution around a pipe and ballast pile. Sand and other sedimentary material tend to be deposited on the up-current side of an outfall as bottom water velocities stagnate in the vicinity of the structure's approach. As bottom currents flow up and over the pipe or ballast pile, flow increases in velocity due to Bernoulli's principle, and often shed turbulent vortices from the peak into the downstream wake, as illustrated in Figure 4-4. The higher velocities in this downstream turbulent zone have an elevated ability to suspend sediments and locally enhance the sediment transport process. For outfalls constructed on sandy substrate, or in the vicinity of large sand deposits, particularly in shallower water, the end result is a buildup of sand/sediment on the upstream side, and a scour hole or depression along the downstream side. This is a significant issue for outfalls built on primarily on sandy or other unconsolidated sedimentary seafloor layers, and if allowed to progress unchecked has the potential to destabilize and displace the structure, resulting in possible failure or even rupture of the pipeline.

Scour is not expected to be a major concern for the majority of Waianae Ocean Outfall because of its location on primarily hard reef substrate. However, there are a number of areas along the outfall corridor where the flank of the outfall trench is low, and the pipe is protected by ballast, and sand or gravel may in some locations may support the toe of the ballast pile. These are the very limited areas where scour may potentially pose a threat to outfall stability, and are summarized by station number in Table 4-1.

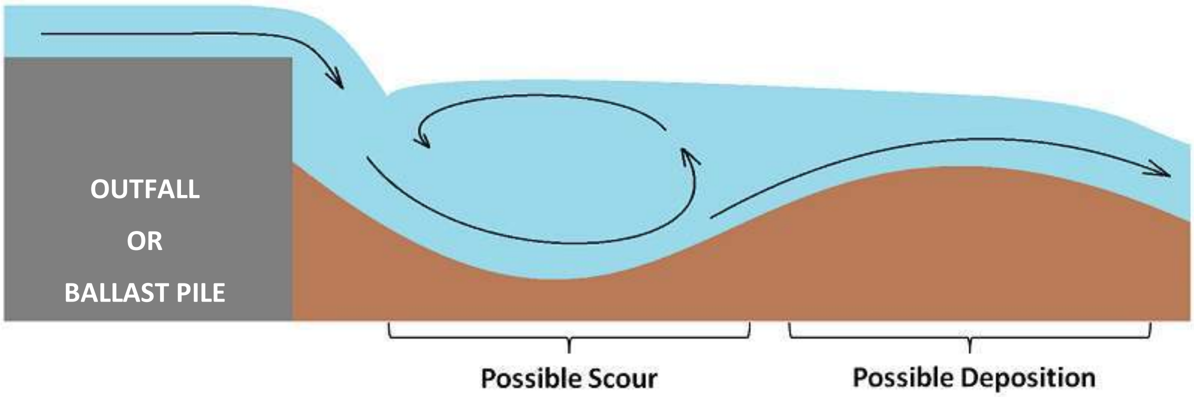


Figure 4-4. Conceptual illustration of downstream scour adjacent to outfall

Table 4-1. Ballasted sections of Waianae Ocean Outfall

ID	Depth ft	Start station	End station	Length ft
1	17	06+60	07+00	40
2	19.5	08+40	08+65	25
3	21	09+75	10+82	107
4	23	14+60	15+05	45
5	25	16+50	16+80	30
6	29	20+50	22+90	240
7	29.5	23+90	24+60	70
8	30	25+45	26+30	85
9	31	27+70	28+00	30
Total length of ballasted pipe				**672**

4.3.3 Video and Photo Documentation

High resolution digital video imagery was utilized to record outfall conditions along the entire submerged length of the outfall and adjacent seafloor. A complete, annotated video record of the underwater inspection is provided on digital media as a separate attachment.

4.3.4 Diver Positioning Along Outfall

As inspectors travel along the outfall making measurements and observations of its condition, the need for precise location awareness to attribute those observations becomes clear. For accurate positioning of divers during the underwater inspection, an Applied Acoustics Ultra-Short Baseline (USBL) system was used for this inspection to track and record divers in real time. A USBL system is an underwater acoustic positioning system that consists of a transceiver mounted on the mother vessel, which transmits an acoustic pulse that is detected and returned by a roving transponder, which may be attached to a diver, remotely operated vehicle (ROV), towfish, or on the seafloor, as illustrated by the conceptual diagram in Figure 4-5. The transponder's reply is detected by the ship mounted transceiver and processed in real-time, and positioning of the transponder is computed from range, azimuth, and declination data of the acoustic signal, and combined with differential GPS (DGPS) survey grade positioning of the mother ship, resulting in an accurately calculated position for the remote vehicle or diver to which it is attached. SEI used Applied Acoustics' model Easytrak Nexus Lite™ 2695 USBL for the inspection at Waianae. Technical specifications and detailed requirements for the USBL system operation are provided for the reader in Appendix B.

The lead diver of each team was equipped with a transponder (shown in Figure 4-6) to relay their underwater position in real time for positioning all video operations, allowing videos to be associated with a mobile position display that changes as the diver traverses the outfall. Due to the length and depth of the outfall, underwater scooters were utilized to assist the divers in efficiently covering the entire length of the structure while minimizing bottom time for safety as well as avoiding timely decompression stops and surface intervals. Figure 4-7 shows photographs of SEI engineering divers during the inspection at Waianae, equipped with the high-powered underwater scooters and the USBL transponder for positioning.

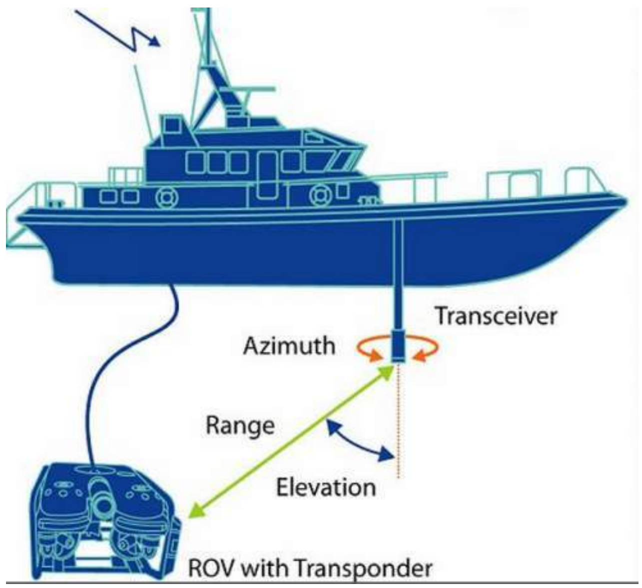


Figure 4-5. Conceptual illustration of USBL system operation

Figure 4-6. Applied Acoustics' Easytrak Nexus Lite™ USBL transponder model used at Waianae

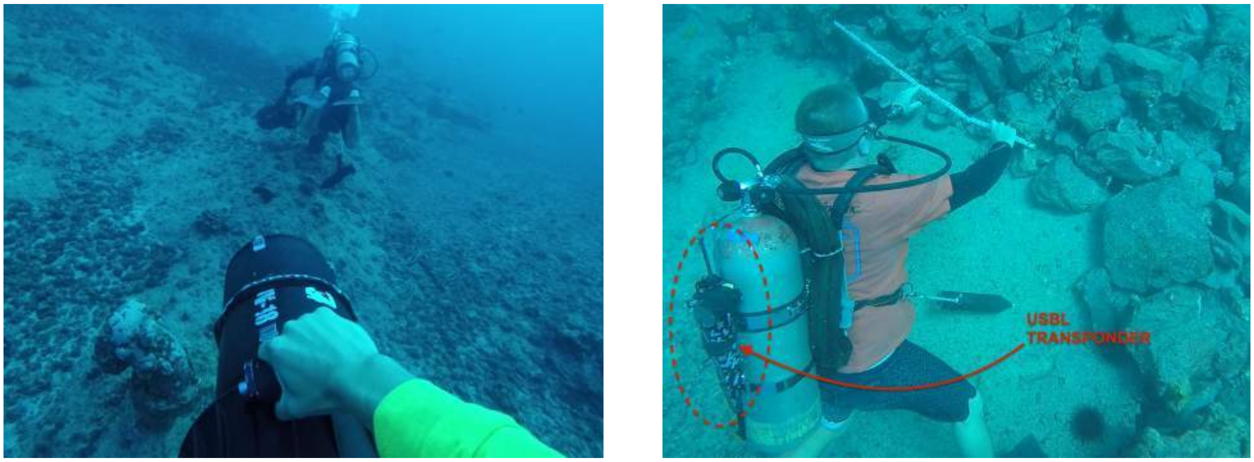


Figure 4-7. Lead diver with transponder in front on scooter (*left*), and transponder location on diver (*right*)

4.3.5 Outfall Hardware Inspection

4.3.5.1 Corrosion of Metallic Hardware In Seawater

The galvanic process commonly referred to as corrosion arises when two dissimilar metallic alloys, or different regions of the same metal are immersed in an electrolyte (e.g., generally a liquid capable of conducting electricity such as seawater), are connected through a metallic pathway and exhibit a sufficient voltage potential difference to initiate an oxidation reaction. The location where this reaction occurs is known as the *anode* and is characterized by a negative charge. The basic chemical reaction that occurs when ferric metals (e.g., steel) corrode is the following:

$$\text{Oxidation: } Fe \rightarrow Fe^{++} + 2e^{-}$$

Once liberated via oxidation, the free electrons flow as current through the conductive metallic pathway to a more positively charged region within the metal's surface and produce a reductive reaction at this opposite area known as the *cathode*. This reaction is illustrated in the following equation:

$$\text{Reduction: } O_2 \text{ (dissolved)} + 2H_2O + 4e^{-} \rightarrow 4(OH^{-})$$

Ferric metals (including steel alloys) in particular are susceptible to corrosion due to galvanic action when immersed in seawater. Seawater is an excellent electrolyte because it contains a significant percentage of chlorine ions found in solution as [Cl^-]. In fact, there are approximately 35 grams of dissolved salt per kilogram of seawater. Sites on the surface of the metal where oxidation (electron loss) is occurring are the anodes, releasing metal ions into the water column, and free electrons that are conducted through the metal itself. The free electrons travel through the metallic pathway to cathodic regions where a reduction reaction (electron gain) is occurring. Metal ions can go into solution within the seawater, or react at the surface to form corrosion products such as ferric oxides on the outer surface of the metal, forming the ubiquitous reddish-brown appearance commonly known as rust.

Together, the two reactions form a circuit or cell, similar to a battery, and is often referred to as a galvanic cell. The major point of interest is that the rate at which these reactions occur is governed in large part by the rate at which oxygen can be consumed by the reduction reaction at the cathode. In basic terms, this means that the reduction rate and thus the rate of corrosion is controlled by the amount of dissolved oxygen available in the water column at the reduction site. In general, this explains why ferric metals corrode much more rapidly in the intertidal splash zone or near the water's well-oxygenated surface layer, in contrast to the typically lower rates experienced at greater depths.

The *galvanic series* is a table of commonly used metals that determines the nobility (corrosion resistance) of metals, as shown in Figure 4-8. When two dissimilar metals are submerged in an electrolytic liquid like seawater, and are electrically connected by direct contact or other electrical conductor, the less noble metal (or region of the same metal) will experience galvanic corrosion. The potential to corrode can be measured as a difference in voltage potential with respect to a reference electrode such as silver-silver chloride (Ag/AgCl), where the less noble (more active) metal is the one with a lower (more negative) electrode potential than the nobler (less active) one, and will function as the anode within the galvanic cell.

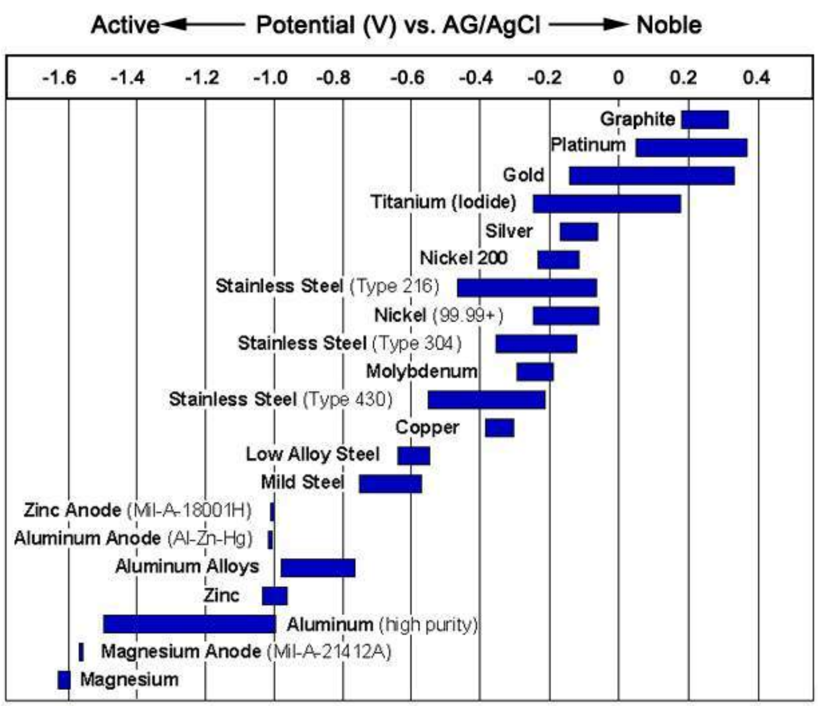


Figure 4-8. Galvanic series of common metals, with respect to Ag/AgCl reference electrode

All exposed ferric metal fixtures on the outfall are susceptible to corrosive attack, the rate of which will vary depending on the type of metal, the type of protection, and the localized environment of the hardware. For ferric metals in general, the rate of loss of material due to corrosion can be significantly reduced by attachment of sacrificial zinc alloy anodes, or by using an impressed current system.

4.3.5.2 Inspection of Outfall Hardware

SEI engineering divers examined all visible and accessible metallic hardware along the Waianae Ocean Outfall for evidence of corrosion or degradation. In addition to visual assessment, inspectors obtained *in situ* voltage potential measurements of ferric (iron alloy) metals, which included stainless steel and cast iron hardware, due to their susceptibility to galvanic attack in seawater. These galvanic potential measurements provide the best quantitative measure of a metal's state, in terms of whether it is actively corroding or otherwise inert or galvanically protected.

To obtain these measurements, inspectors utilized a POLATRAX™ Cathodic Protection (CP) probe (referred to as a CP-Gun due to its shape), which uses a silver/silver-chloride (Ag/AgCl) reference electrode for the measurements (refer to the galvanic series in Figure 4-8). The value of the galvanic voltage potential with respect to the reference electrode is indicative of the current state of the metal surface—in other words, an indication of whether the metal is close to corrosion, actively corroding or inert/protected. The voltage potential measurements require contact with a shiny bare-metal surface to obtain proper readings, requiring divers to clean small sections of the metal surface for each feature with scraping tools and wire brushes to obtain direct electrical contact. General locations where voltage potential readings were taken are summarized in Table 4-2 below, indicating metal feature type, metallic alloy, and approximate station number of feature location on the outfall. Photographs of diving inspectors shown in Figure 4-9 illustrate the process of obtaining voltage potential measurements using the CP-gun at: the active diffuser section (left image); and, an original cast iron manhole cover at MH 3 (right image).

Table 4-2. Locations of metallic hardware on Waianae Ocean Outfall

station Number (ft)	Feature Description	Metal / Alloy	Approx. Depth (ft)
10+45	Manhole cover, MH 2	Cast iron	20
20+23.5	Manhole cover, MH 3	Cast iron	27
26+15.5	Manhole cover, MH 4	Cast iron	30
28+13.59	Slot covers, Special wye structure	stainless steel	31
01+68 E	Manhole cover, MH A	stainless steel	33
11+48 E	Manhole cover, MH B	stainless steel	46
21+30 E	Manhole cover, MH C	stainless steel	64
30+77 E	Manhole cover, MH D	stainless steel	100
30+77 E –> 35+75 E	Diffuser bolts	Monel	100
35+75 E	Lifting handles, Stopgate	Monel	100

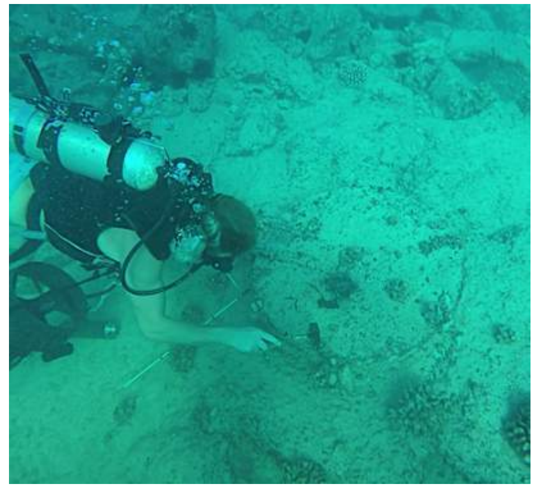


Figure 4-9. CP-gun measurements on monel diffuser bolts (*left*); surface cleaning, cast iron cover, MH3 (*right*)

4.4 Results and Discussion

4.4.1 General Inspection

The Waianae Ocean Outfall original 36-inch pipeline and newer 42-inch extension were installed within a trench excavated from the reef and backfilled with stone and capped with tremie concrete. In areas where the trenching was not sufficiently deep enough to fully support the pipe with stone and concrete, the pipe was ballasted with rock. For this reason, the RCP joints were not visible to inspectors at any point of the inspection, and in many cases, even the concrete cap was not visible where it was covered with natural seafloor sediment and coral rubble. Engineering divers inspected the exposed portions of concrete jacket and cap for cracks, undermining or other physical deficiencies where it was visible, and inspected the ballast pile where stone was used to stabilize the pipe (refer to Table 4-1 for locations of ballasted segments). Inspectors attempted to peer through larger void spaces between individual ballast stones in an effort to view the actual RCP joints, but were unable to find any such areas of exposure. In addition to noting the general condition of the ballast pile, representative measurements of stone size were taken in several places to serve as a basis for sizing. For an understanding of the general locations of the features discussed in this report, the reader is referred to the annotated multibeam survey maps provided in Appendix A.

4.4.2 Visual Overview

The visual overview inspection revealed the following observations:

- At no point during the inspection were the actual 36-inch or 42-inch RCP joints visible. This is a good indication, as it is consistent with design and implies stability.
- The stopgate structure, special wye structure, and manhole risers visibly appeared to be in good operating condition, with no significant cracks or spalls evident to inspectors. A majority of the mass of most structures were embedded in the ocean floor and appeared well supported with no significant evidence of scour or failure of supporting trench walls. Representative photographs of the stopgate structure and special wye structure are provided in Figure 4-10 and Figure 4-11, respectively.

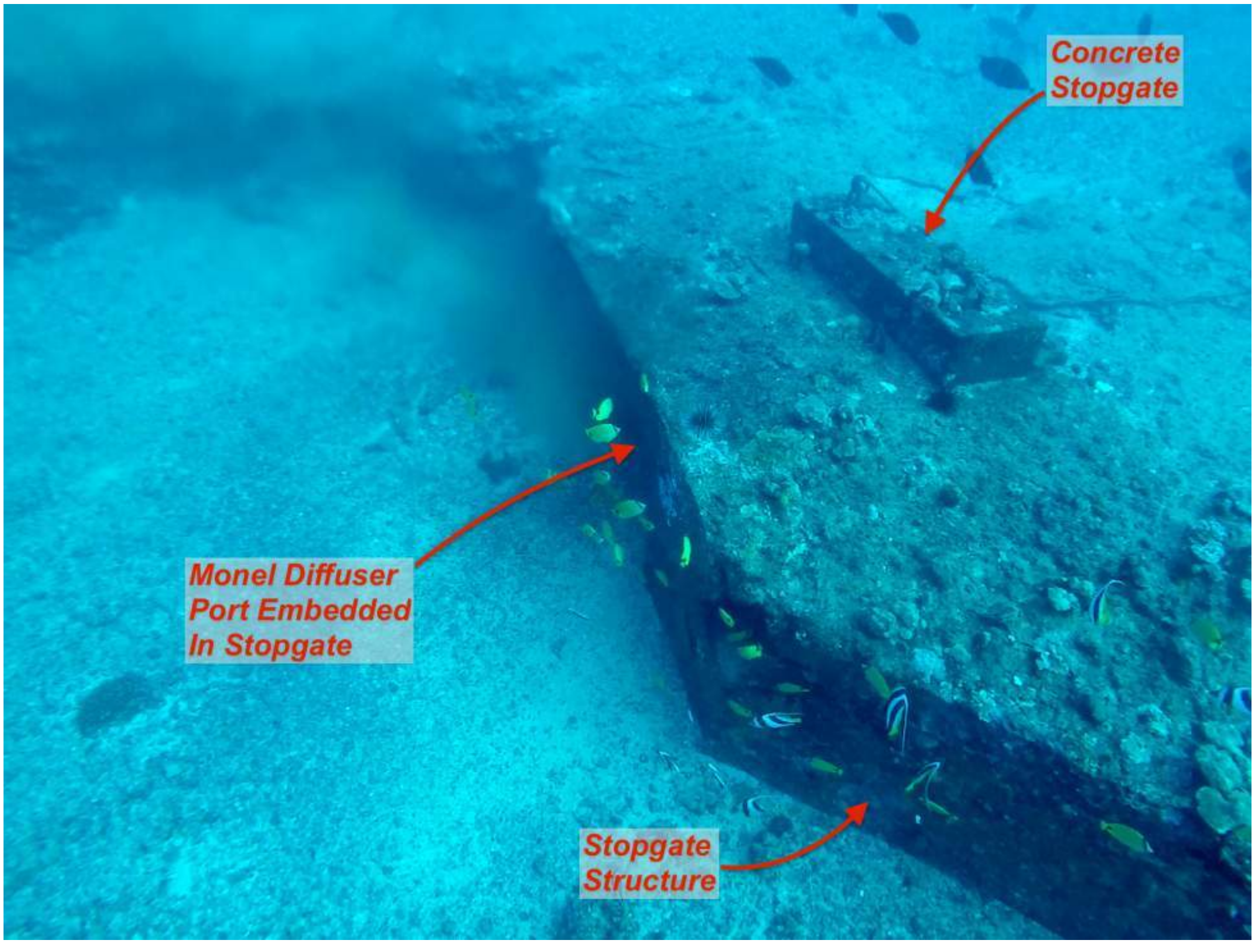


Figure 4-10. Stopgate structure, located at end of diffuser leg, which is also the outfall terminus.

- All 42 fiberglass diffuser ports, including the exposed end of the riser, the 90° elbow section, and connecting hardware, appeared to be in good operating condition with no blockage or restrictions of any of the 21 open diffuser ports, and no visible leaks from the 21 closed diffusers, which were blanked with fiberglass blind flange plates. A summary of diffuser port conditions is presented in Table 4-3, located at the end of this section, which provides the existing status of each diffuser port by number. Port numbering begins at the upstream start of the diffuser leg (approximately station 30+70), just before Manhole D, and increases towards the outfall terminus. Regular flow was also observed from the monel pipe diffuser seated in the stopgate. Figure 4-12 illustrates typical conditions along the diffuser leg, while Figure 4-13 pictures effluent flowing from the final diffuser of the outfall, which is simply a monel pipe embedded in the stopgate.
- No indications of significant scour were observed along the outfall, which was as expected since the outfall is buried and trenched into hard material over the vast majority of its length. The outfall was so well buried in fact, that in some locations it was indiscernible from the natural seafloor, such as the area shown in Figure 4-14 between stations 23+00 E and 26+00 E.

- During earlier visual inspections of the shoreline landing and above-water portions of the outfall conducted in August 2015 and July 2017, an area of partial erosion and scour of the shoreline limestone, sandy sediments and sedimentary rock was noted. The erosion resulted in a collapse of approximately 50 to 75 ft of the south trench wall seaward of the valve box, in the intertidal zone. Loss of the section of supporting south trench wall resulted in undermining of the pipe and development of a void space below the pipe. An unsupported span of approximately 20 ft currently affects the pipe. This condition was previously noted in an SEI memorandum, dated 26 June 2017. Emergency repair of this area by injecting tremie concrete under the pipe has been scheduled. Several locations along the outfall were noted where the concrete jacket or cap formed a mushroom-shaped profile or "muffin top" that appeared to have a slight undercut along the edge of the pour. This appeared to be the result of construction methodology and concrete form over-pour, and did not appear to be a sign of active erosion, undermining or instability. An example of this condition can be seen in Figure 4-15.
- Near station 02+50 E, the concrete cap was found broken into several large masses with large visible voids underneath the edges of the breaks. No underlying gravel, stone or RCP joint was visible at this location, and it appears the damage was limited to the concrete cap. A photograph of this location is presented in Figure 4-16.

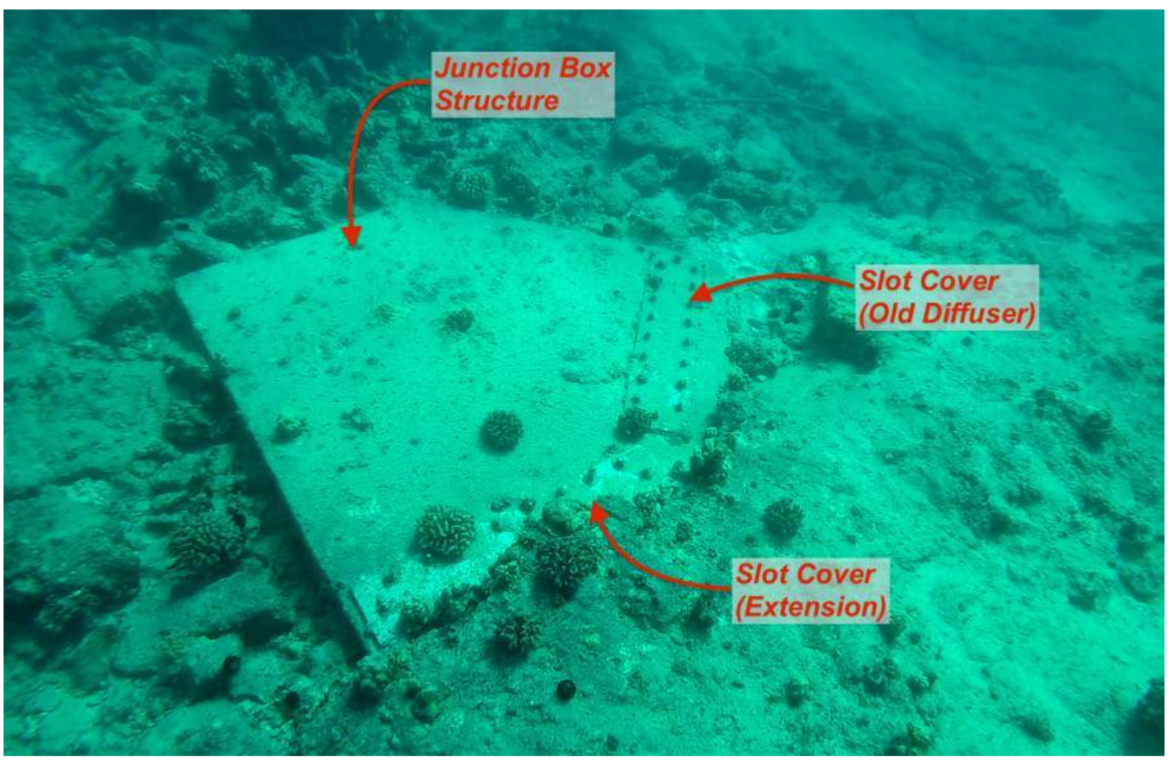


Figure 4-11. Special wye structure, looking NE, with stainless steel slot covers visible at lower right edge.

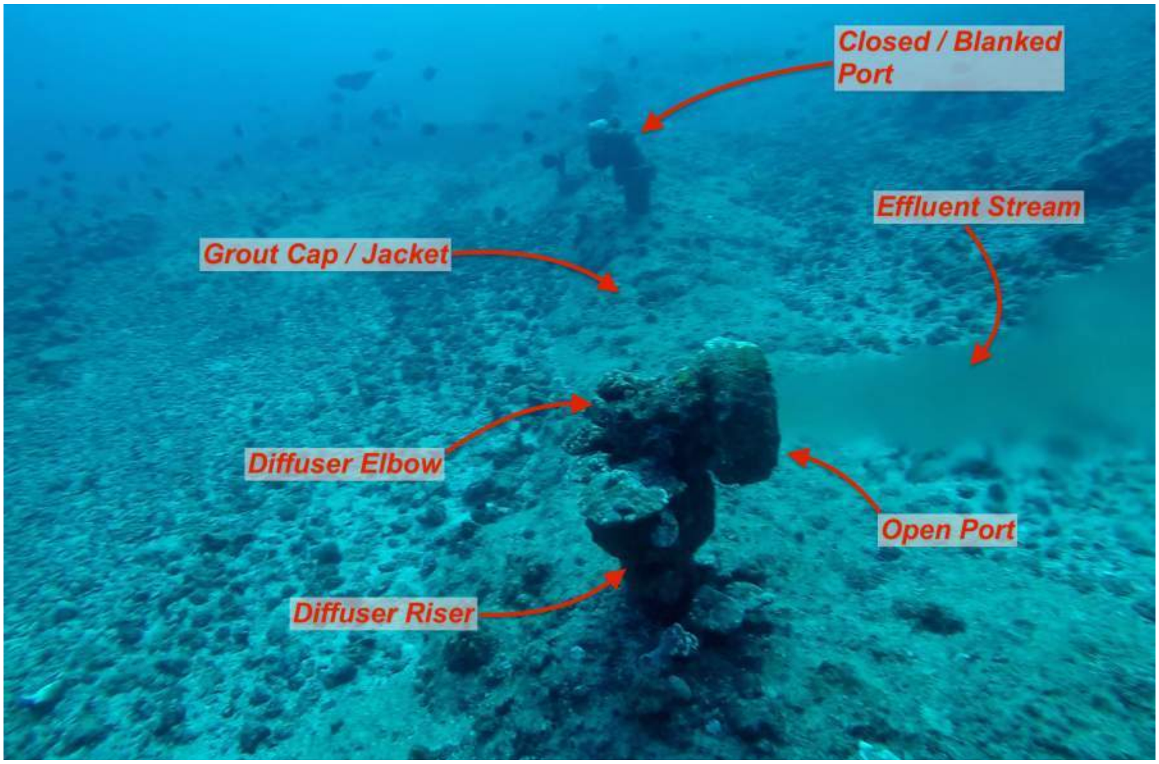


Figure 4-12. Looking northward along the diffuser leg, with open diffuser in foreground, blanked diffuser behind.

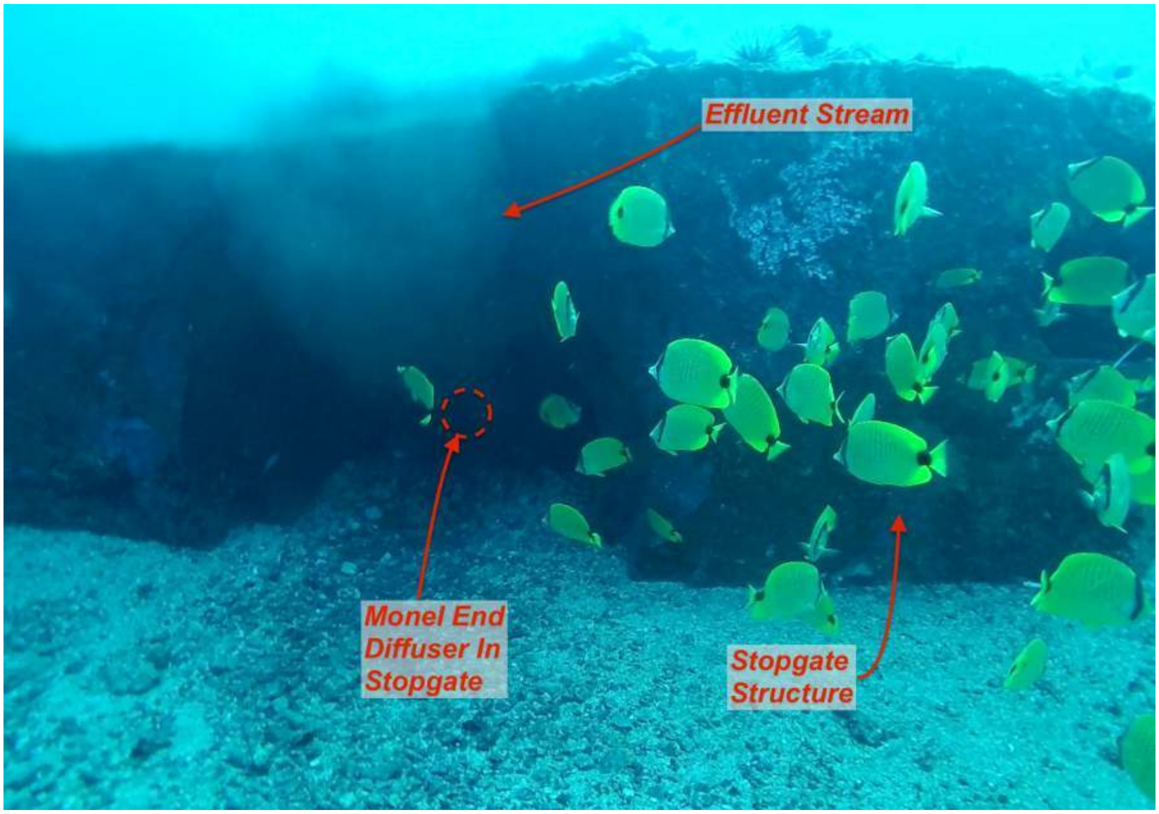


Figure 4-13. Stopgate structure, with single monel diffuser port

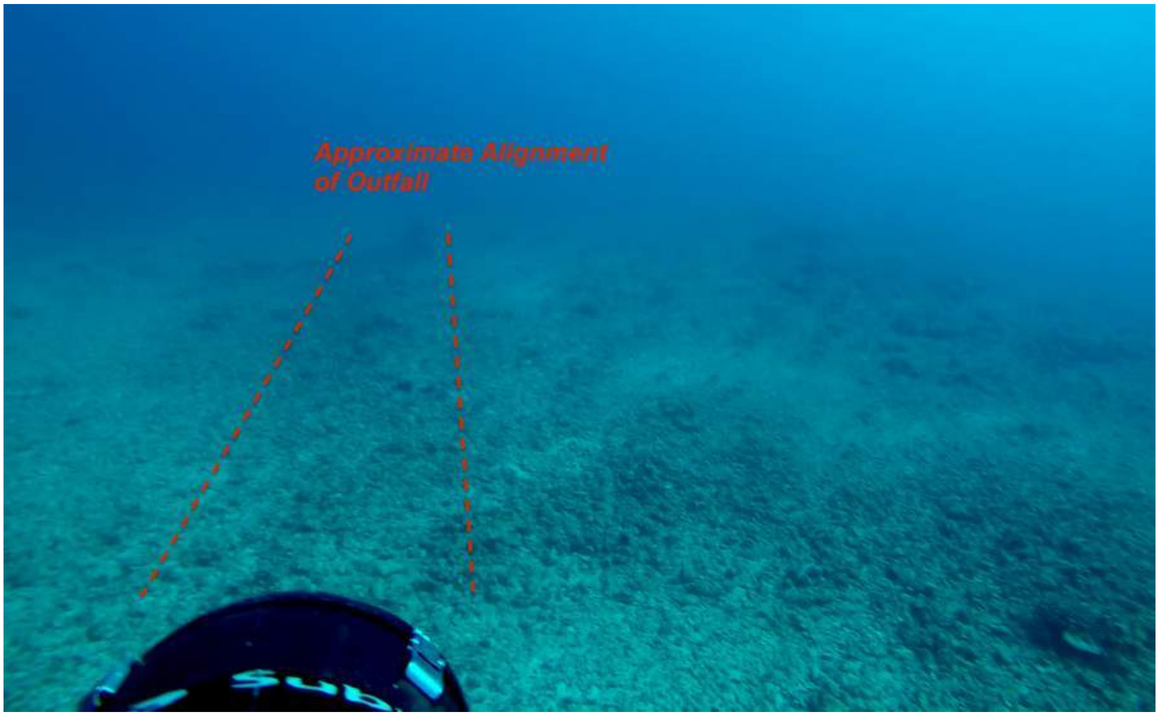


Figure 4-14. Outfall completely hidden, approximately between station 23+00 E and 26+00 E

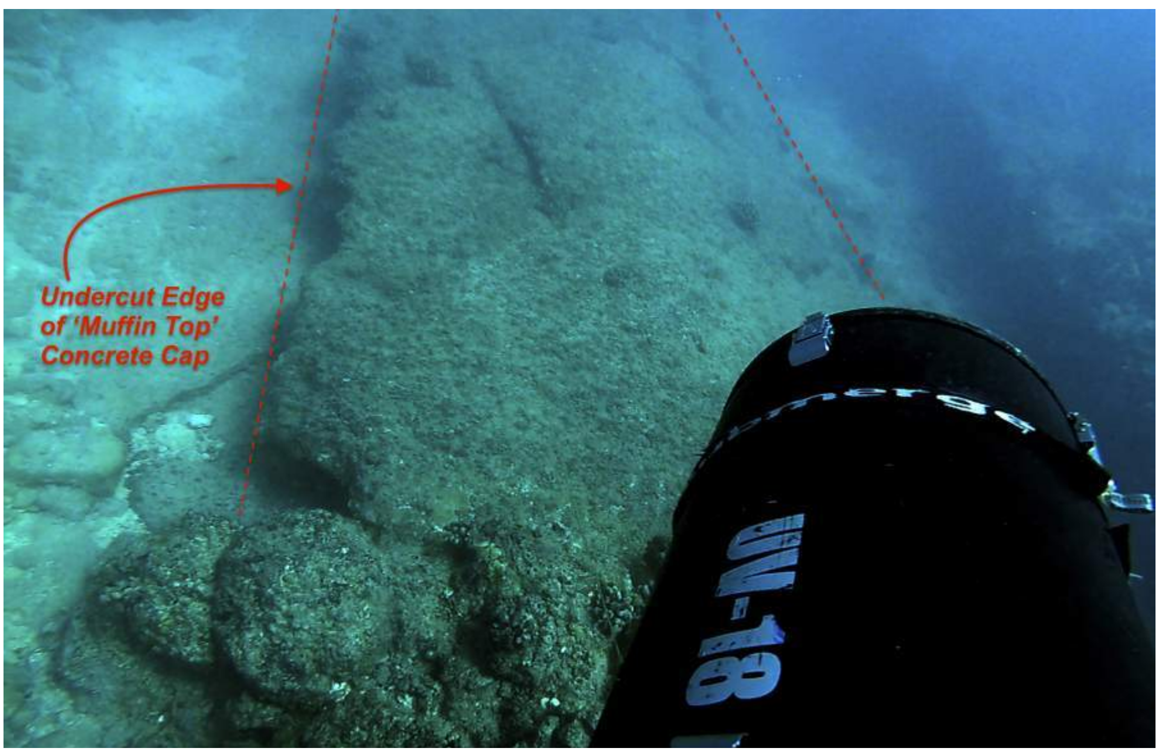


Figure 4-15. Concrete jacket/cap with edge voids creating a “muffin top” profile

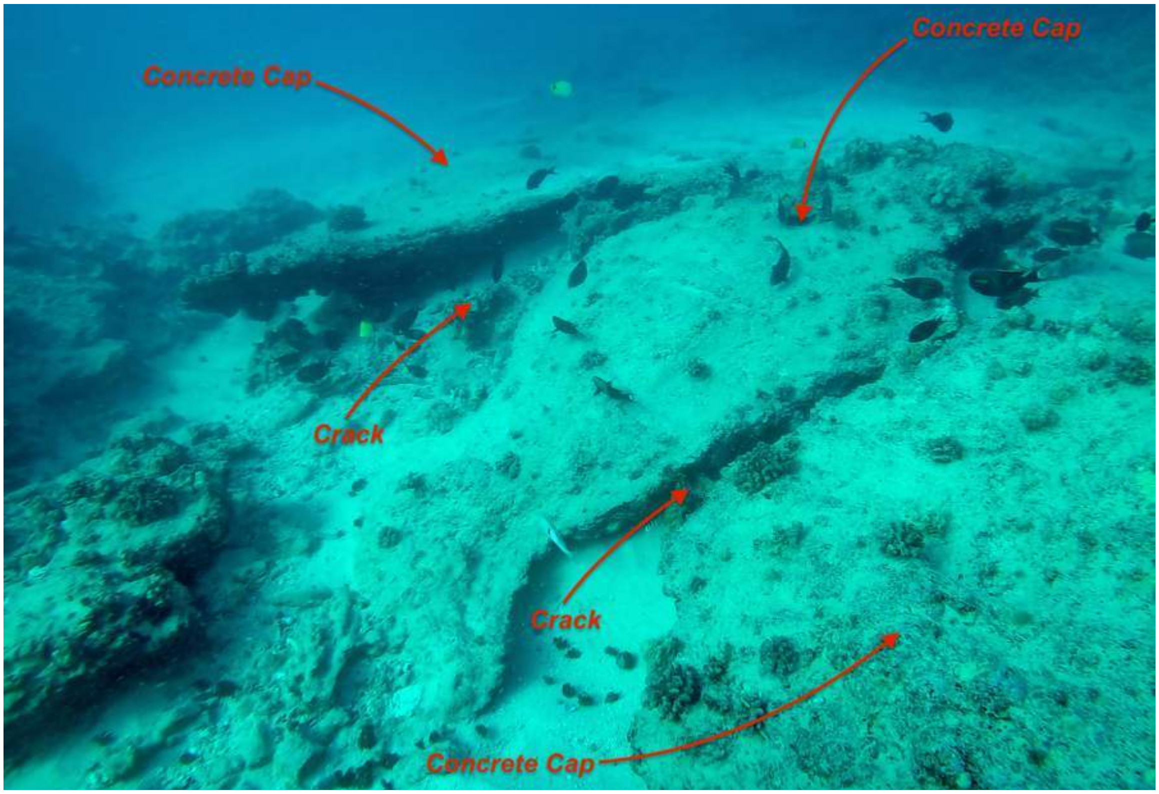


Figure 4-16. Concrete jacket/cap broken into three massive pieces

- The concrete structure which forms the special wye structure at the end of the original outfall had been repaired for leakage in March 1996. The slot covers at the special wye structure showed no signs of degradation and appeared to be in good condition, as shown in Figure 4-11. No leaks were observed during this inspection, indicating the 1996 repairs are effective.
- In general, the sections of the outfall that were covered with ballast stone appeared to be in stable condition, and able to provide the pipe with ample protection. No evidence of significant armor stone movement or depletion was observed and the extensive growth of coral the majority of the ballast pile sections suggests stability.
- All seven of the underwater manholes were located (Manhole 1 is located on the valve box at station 00+00, which is onshore), and showed no visible signs of leakage or significant damage to the manhole riser, gasket, or cover. Manhole 2, the shallowest manhole on the outfall, was found nearly completely buried within the sand and seafloor sediments, and required partial excavation for inspection. Conditions of the metallic manhole covers varied depending on the type of metal used, and is discussed in more detail in the hardware section. Photographs of each manhole are illustrated in Figure 4-17 through Figure 4-23, where they are presented in sequential order starting from the shallowest (inshore) manhole and proceeding in the offshore direction to the deepest.

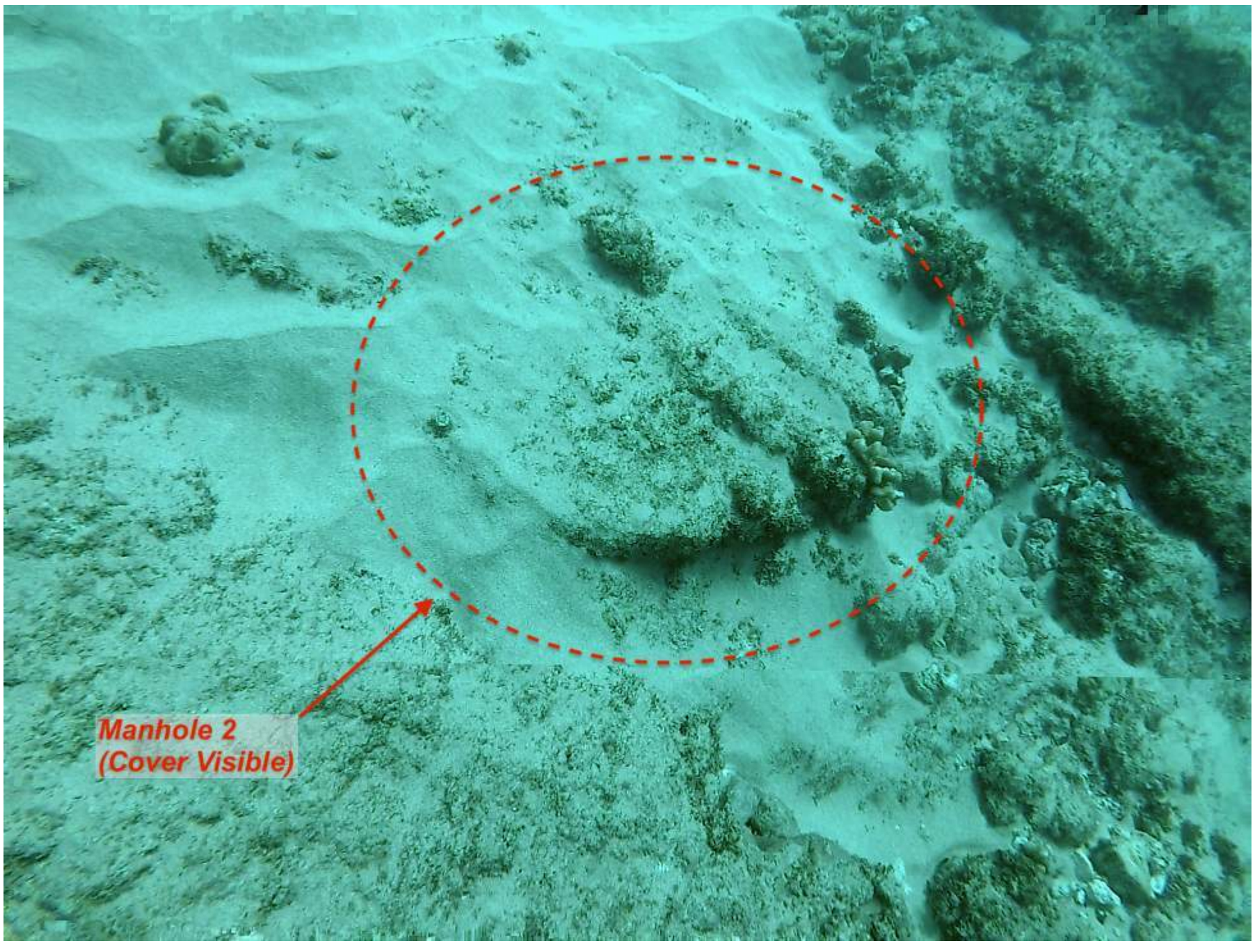


Figure 4-17. Manhole 2, first underwater manhole on the original 36-inch pipeline

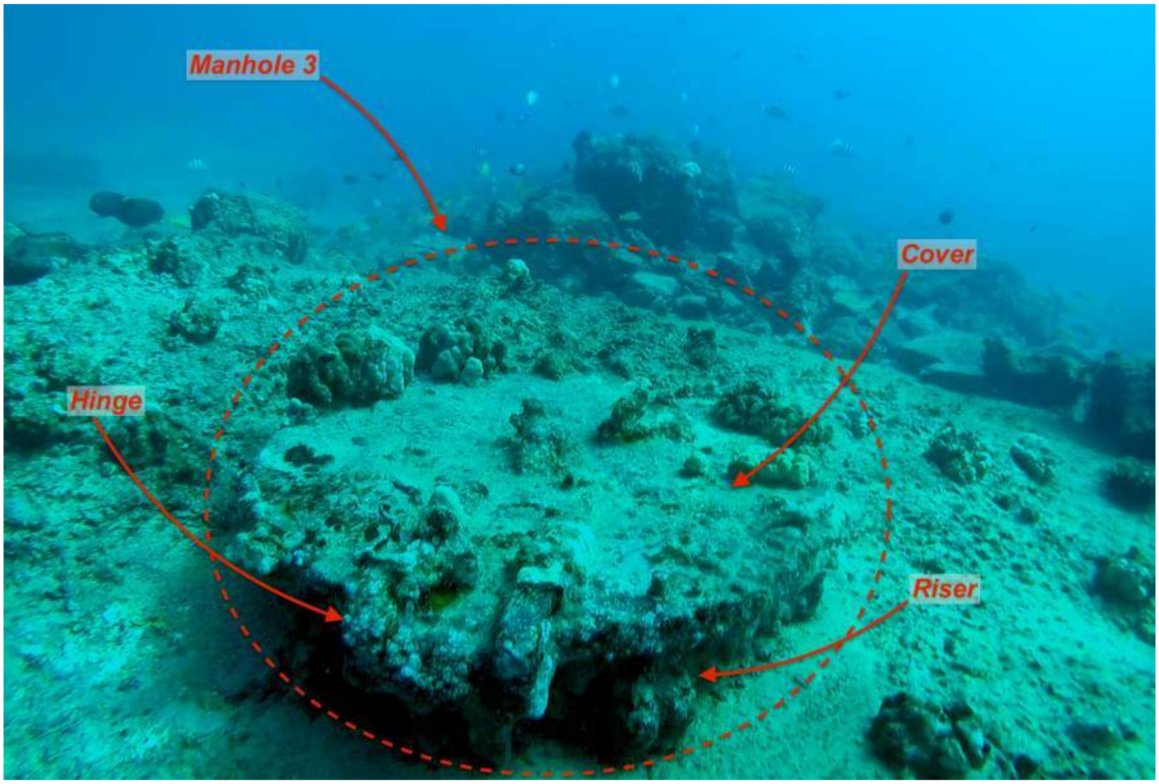


Figure 4-18. Manhole 3, on the original 36-inch pipeline

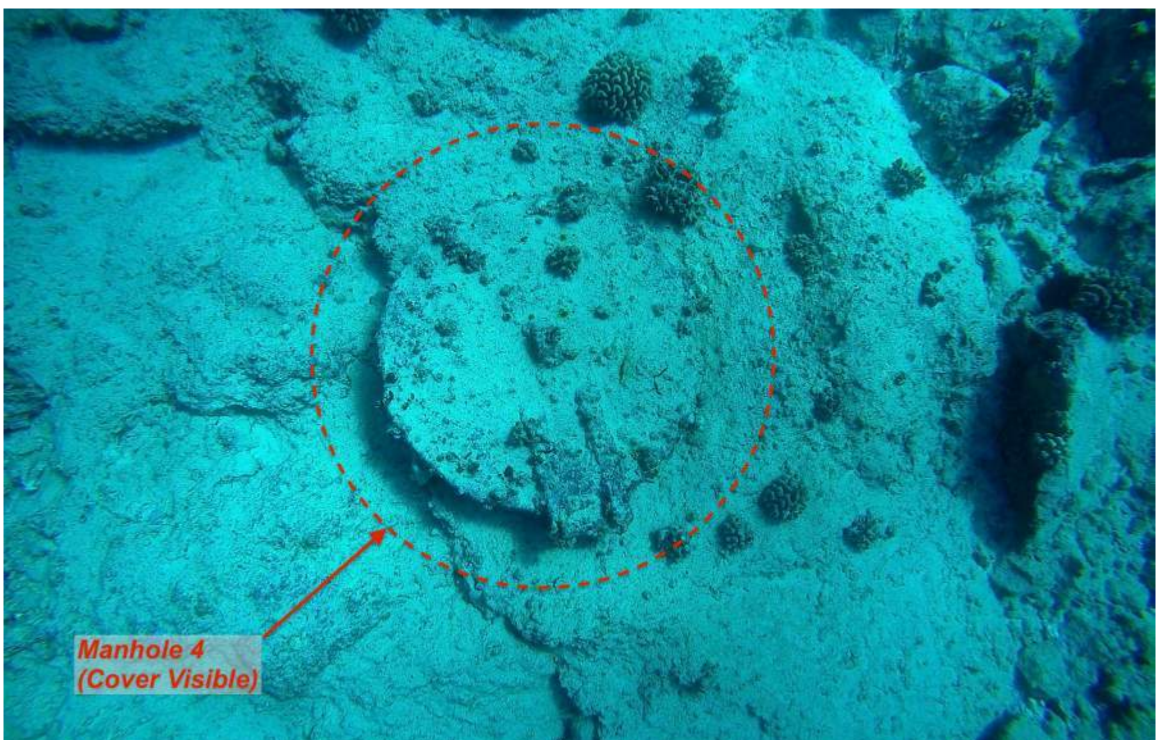


Figure 4-19. Manhole 4, deepest manhole on the original 36-inch pipeline

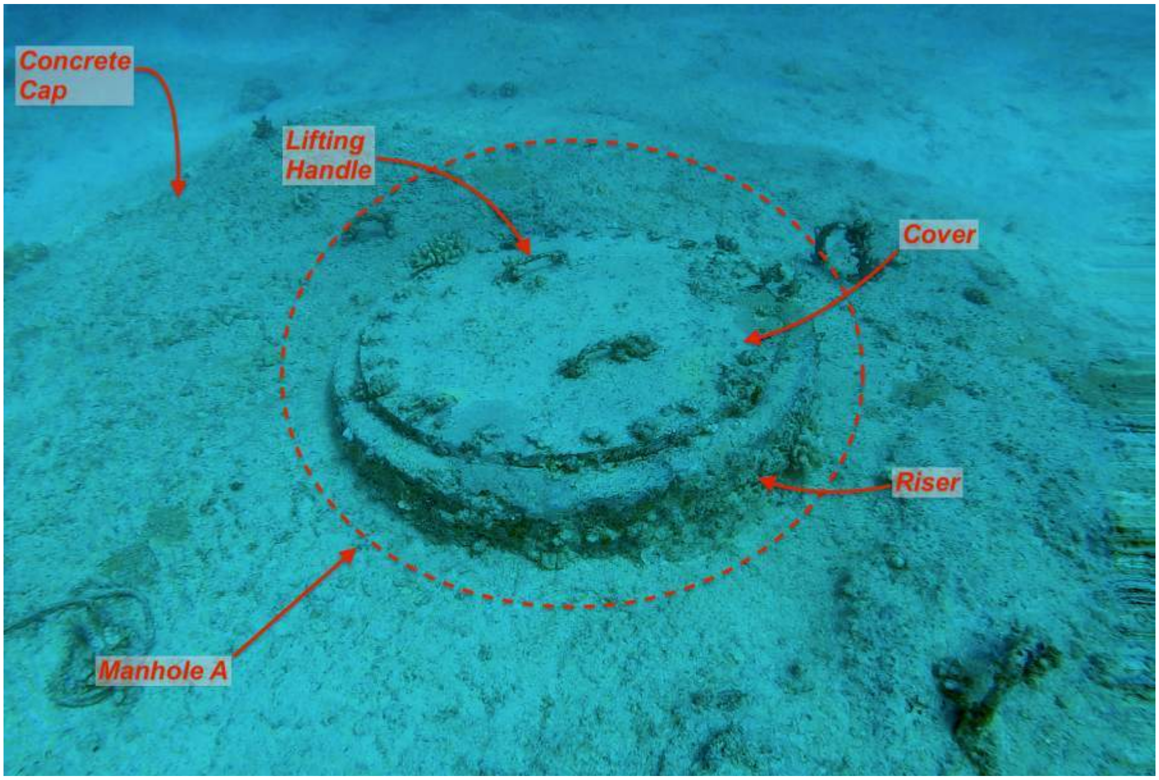


Figure 4-20. Manhole A, shallowest manhole on the 42-inch extension

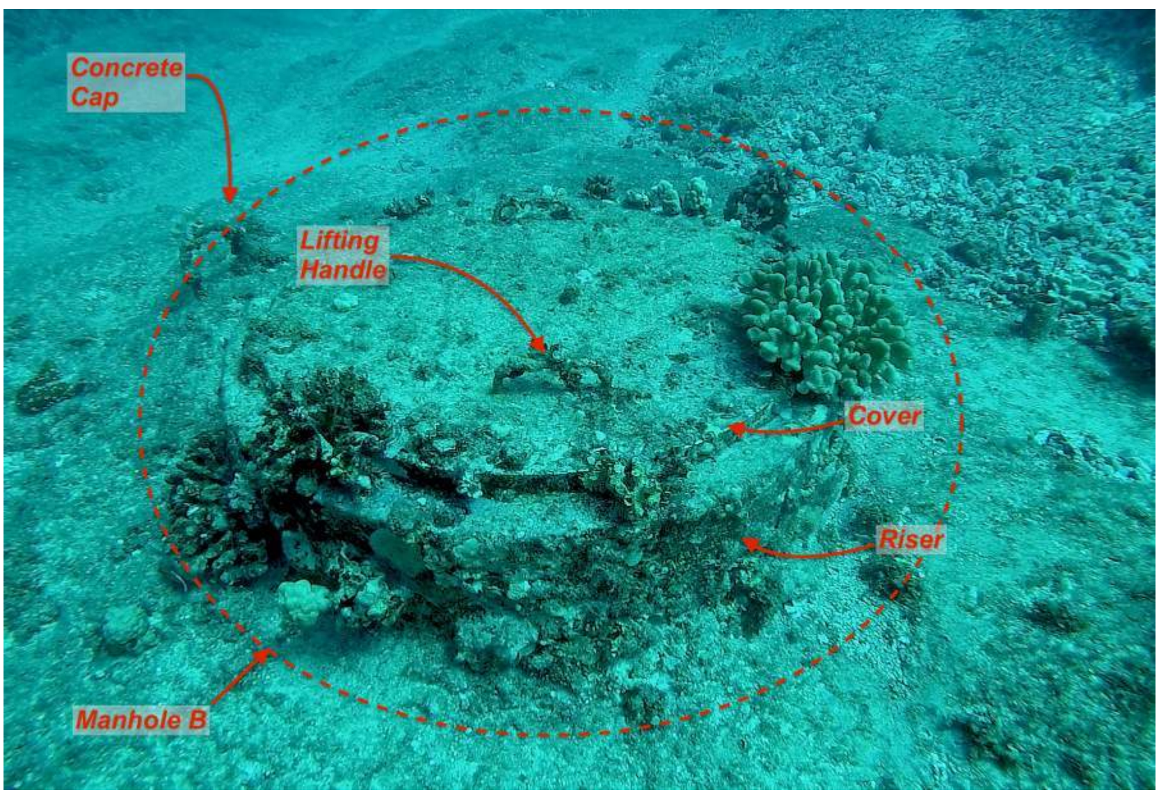


Figure 4-21. Manhole B, on the 42-inch extension

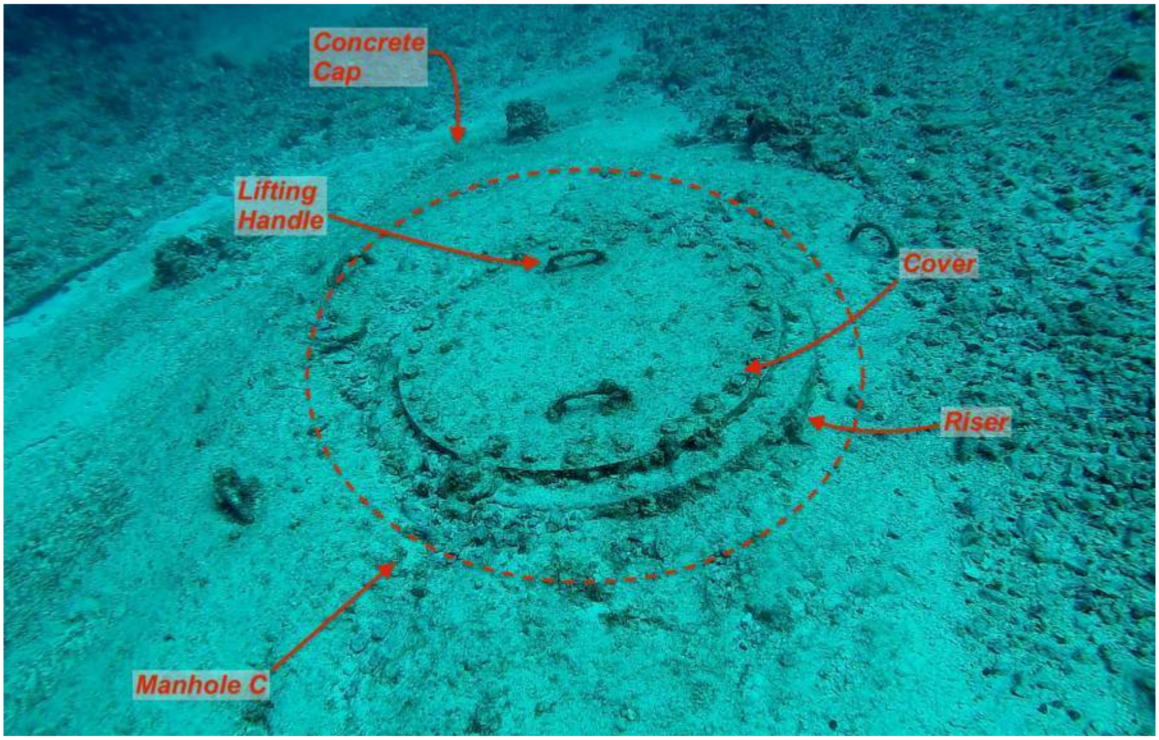


Figure 4-22. Manhole C, on the 42-inch extension

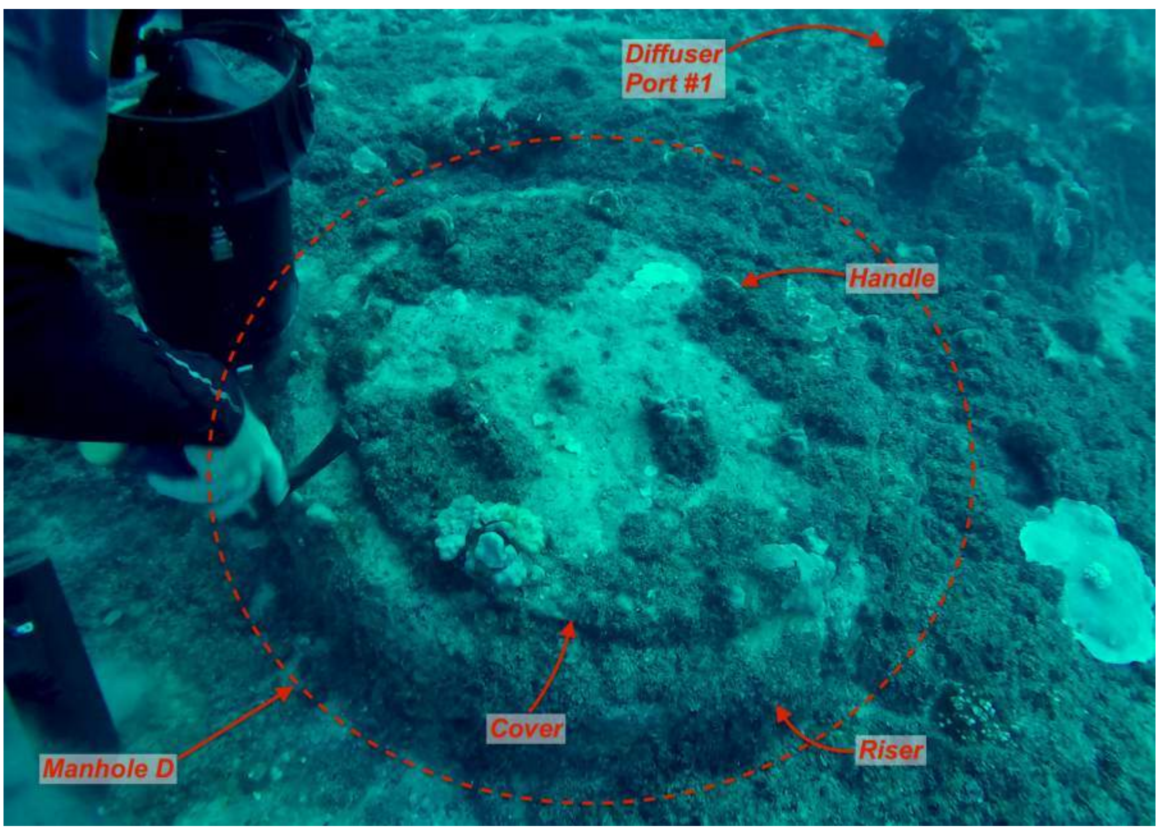


Figure 4-23. Manhole D, deepest manhole on the outfall

Table 4-3. Summary of diffuser port conditions (see **Figure 4-24** for diffuser layout)

Diffuser #	Port Direction	Open/Closed	Flowing	Diffuser #	Port Direction	Open/Closed	Flowing
1	North	Open	Yes	22	South	Closed	No
2	South	Closed	No	23	North	Closed	No
3	North	Closed	No	24	South	Open	Yes
4	South	Open	Yes	25	North	Open	Yes
5	North	Open	Yes	26	South	Closed	No
6	South	Closed	No	27	North	Closed	No
7	North	Closed	No	28	South	Open	Yes
8	South	Open	Yes	29	North	Open	Yes
9	North	Open	Yes	30	South	Closed	No
10	South	Closed	No	31	North	Closed	No
11	North	Closed	No	32	South	Open	Yes
12	South	Open	Yes	33	North	Open	Yes
13	North	Open	Yes	34	South	Closed	No
14	South	Closed	No	35	North	Closed	No
15	North	Closed	No	36	South	Open	Yes
16	South	Open	Yes	37	North	Open	Yes
17	North	Open	Yes	38	South	Closed	No
18	South	Closed	No	39	North	Closed	No
19	North	Closed	No	40	South	Open	Yes
20	South	Open	Yes	41	North	Closed	No
21	North	Open	Yes	42	South	Open	Yes

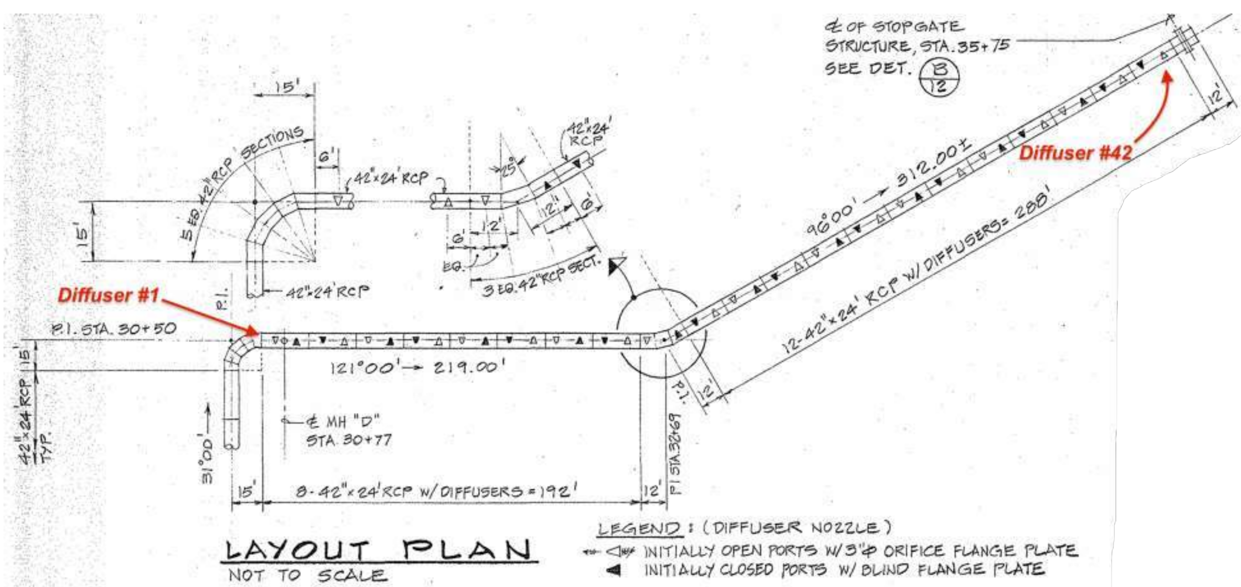


Figure 4-24. Diffuser layout, from 1986 as-built plans

4.4.3 Hardware Inspection

Exposed metallic hardware along the outfall, including manhole covers, diffuser riser bolts, and the slot covers at the special wye structure were visually inspected, and galvanic potential measurements taken with a Polatrak™ CP-gun to assess the existing state of corrosion for the metal surfaces. Pictured in the image in Figure 4-25, an engineering diver is shown obtaining galvanic potential readings on a cast iron manhole cover at MH 4. The readings, which are a measure of the galvanic voltage potential with respect to a silver/silver-chloride (Ag/AgCl) reference electrode, required divers to clean a small patch of the surface in order to expose bright shiny metal on each feature where a reading was needed. On the diffuser ports, only the monel bolts along the flanges were checked, with the diffuser elbows and risers being made of non-corroding fiberglass. Monel is a specialized, highly inert alloy, and is highly resistant to reaction with seawater. However, the bolts were tested in the field as there was some uncertainty among inspectors at the time as to whether they may actually be stainless steel, but have since been confirmed to be monel. Table 4-4 below summarizes the corrosion readings and associated results. The diffuser bolt measurements are not included within this table, though, all diffuser bolts, risers, elbows and flanges were visually inspected with no significant evidence of degradation.

Table 4-4. Galvanic potential voltage readings from CP-gun measurements

Feature	Potential (mV DC)	Indication	Metal Alloy
Manhole D - lid	-219/-221	Minor localized corrosion	316 stainless steel
Manhole C - lid	-135/-132	Minor localized corrosion	316 stainless steel
Manhole C - bolt	-127/-123	Minor localized corrosion	316 stainless steel
Manhole C - lifting handle	-352/-348	Not corroding	316 stainless steel
Manhole B - lid	-136/-132	Minor localized corrosion	316 stainless steel
Manhole B - bolt	-139/-137	Minor localized corrosion	316 stainless steel
Manhole A - lid	-204/-202	Minor localized corrosion	316 stainless steel
Manhole A - bolt	-212/-214	Minor localized corrosion	316 stainless steel
Wye - decommissioned slot cover	-224/-221	Minor localized corrosion	stainless steel
Wye - decommissioned bolt	-222/221	Minor localized corrosion	stainless steel
Wye - active slot cover	-324/-321	Not corroding	stainless steel
Wye - active bolt	-324/-321	Not corroding	stainless steel
Manhole 4 - lid	-595/-597	No protection, corroding	Cast Iron
Manhole 4 - bolt	-594/-597	Not corroding	stainless steel
Manhole 3 -lid	-593/-589	No protection, corroding	Cast Iron
Manhole 2 - lid	-597/-594	No protection, corroding	Cast Iron
Manhole 2 - bolt	-594/-590	Not corroding	stainless steel
Manhole 2 - side	-597/-593	No protection, corroding	Cast Iron

Figure 4-25. Inspector shown obtaining galvanic potential measurements with CP-gun at MH 4.

In addition to the cathodic protection measurements discussed above, the following observations were made regarding the condition of outfall hardware:

- All monel lifting handles that were found (located on the stop gate and extension manholes) appeared to be in excellent condition with no visible degradation to the handles, and no loose concrete or cracks at the entry points.
- The 316 stainless steel manholes on the 42-inch outfall extension (MH A though MH D), as well as the slot covers on the special wye structure, appeared to be in good condition. All gaskets and seals also appeared to be in good condition, with no visible leakage. In areas where marine growth was removed, the newly exposed metal surfaces were bright, shiny, and exhibiting no visual signs of corrosion.
- The cast iron manhole covers (MH 2 through MH 4), located along the original 36-inch pipeline, all displayed signs of advanced corrosion. The metal surfaces were readily eroded when scraped or struck with a rock hammer during the cleaning process for cathodic protection measurements. This suggests that a significant fraction of the cover’s cross section has been corroded and transformed into corrosion byproducts such as ferric oxide (rust). Therefore, the effective structural cross section of the cover has likely been reduced. The lack of provision for any cathodic protection, such as sacrificial anodes, in combination with the locations’ shallow and well-oxygenated waters, have exposed the unprotected and susceptible cast iron covers to a highly corrosive environment, likely explaining their advanced state of corrosion that was observed.

4.4.4 Ballast Stone

Several sections of the pipeline were rocked over with ballast (armor stone), in areas where the pipeline could not be trenched to the required depth into the reef substrate. The majority of ballasted outfall sections were located between stations 27+00 and 12+00, and all ballasted sections are limited to the original 36-inch pipeline. For the locations of all ballasted sections, the reader is referred to Table 4-1 in Section 4.3.2.4.

An excerpt from the 1986 as-built construction drawing set, showing the modified ballast pile repair plan, with a typical rock section calling for quarry run and armor stone placement, is provided in Figure 4-26. The actual installation was similar to that called for in the drawings, with some observed deviation likely due to field fitting requirements and allowed flexibility for transitions between areas with and without stone. In an effort to assess and verify existing stone sizing, representative size measurements were taken at random along the ballast pile from station 27+00 to 12+00, and are summarized in Table 4-5 below.

The image shown in Figure 4-27 is a picture of the typical condition of the ballast pile along the outfall. In general, the stone appeared to be in stable condition and providing the outfall with sufficient protection. Extensive coral growth over many of the ballast units, as seen in Figure 4-27, is indicative of stability since coral grows slowly, and wide spread displacement or overturned ballast stone would therefore be devoid of coral growth. The overall shape of the armoring appeared consistent with design, and showed no significant movement aside from initial settling.

Table 4-5. *Representative ballast stone measurements*

Sample #	Station	Diameter	Sample #	Station	Diameter
1	27+00	27"	11	25+00	16"
2	27+00	23"	12	25+00	26"
3	27+00	22"	13	25+00	12"
4	26+00	42"	14	20+00	10"
5	26+00	31"	15	20+00	15"
6	25+00	36"	16	20+00	11"
7	25+00	13"	17	13+00	35"
8	25+00	10"	18	13+00	28"
9	25+00	9"	19	13+00	14"
10	25+00	14"	20	13+00	16"

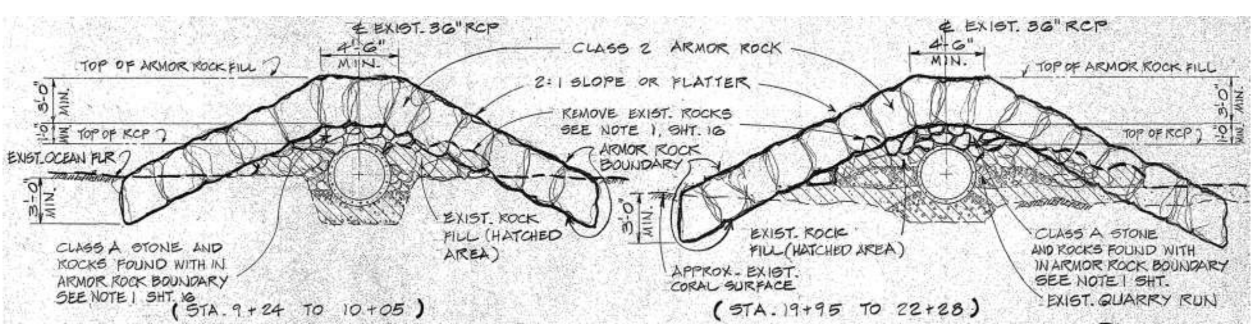


Figure 4-26. Ballast pile modifications, from 1986 as-built plans

Figure 4-27. Typical ballast pile condition, near station 10+00

The original 1965 construction plans specify 6-inch fill covered with 12 to 24-inch diameter (200 pound minimum) stones with filler. The 1986 rock cover modification plans called for *Class A* core stone up to an elevation of 1 ft above the top of pipe, and *Class B* armor stone cover layer up to an elevation of 4 ft above the top of pipe in a 3 ft thick layer, at a 2:1 slope, as shown in Figure 4-26. The stone sizes for Class A and Class B are not defined on the plans. Based on the field measurements, most stones seem to meet the original 1965 specification, while the smaller stones are likely the specified filler stone (placed between the larger stones) that can be seen in the top center detail in Figure 4-27.

For another look at ballast pile stability, cross sections from the high resolution multibeam data were extracted at four representative locations (stations 10+00, 21+00, 23+50, and 26+00) to compare with the rock modification details provided in the 1986 extension and repair plans. Results of the section analysis are presented in Figure 4-28 through Figure 4-35, which for each of the sections, show a close-up plan view of the multibeam DTM with section location indicated in red, followed by the associated as-built detail with multibeam cross section overlaid for comparison. The cross section overlays were developed by first scaling and then *rubber-sheeting* the as-built section over the to-scale bathymetry section plots. Although the two profile sources are at the same scale, the alignment was positioned by matching the surrounding seafloor elevation and centering the peaks, which is clearly not an exact method. However, in spite of the necessity to use inexact methods, the sections do exhibit relatively good agreement between the existing ballast pile and the 1986 as-built plans.

The ballast pile near station 10+00 appears to be 1-½ ft lower than that called for by the plans (refer to Figure 4-29), however, this location could be a low spot along the pile crest. Additionally, the DTM in Figure 4-28 does show an undulating crest height along the pile, with numerous peaks and saddles, both higher and lower than the peak at 10+00. Conversely, the shallow depth and increased exposure to wave energy at this nearshore location may have accelerated settlement of the ballast stone downward into the surrounding sand field, accounting for the lower peak. Furthermore, the exact depth of the pipe under the pile at this location is unknown, and therefore the vertical alignment of the two sections may be offset, but cannot be readily determined.

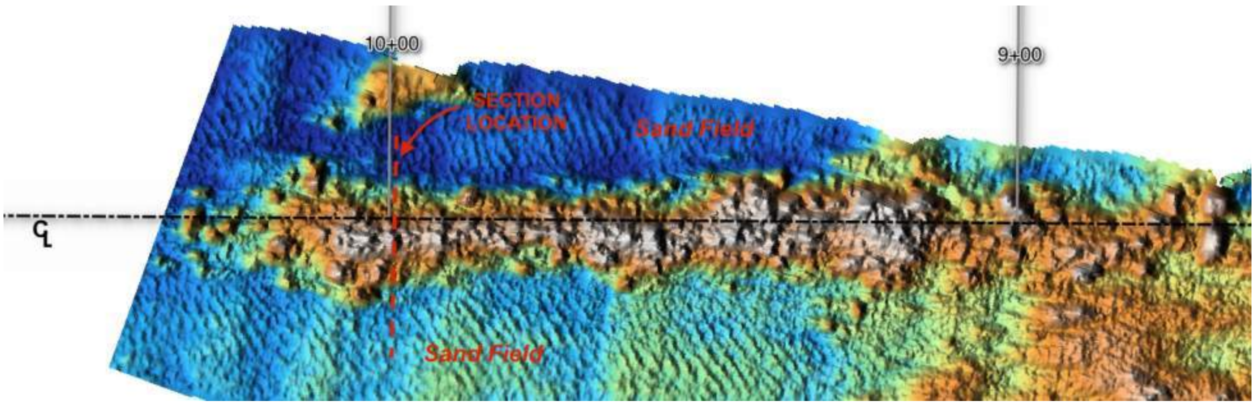


Figure 4-28. Close up of MBES bathymetry, ballast pile near station 10+00

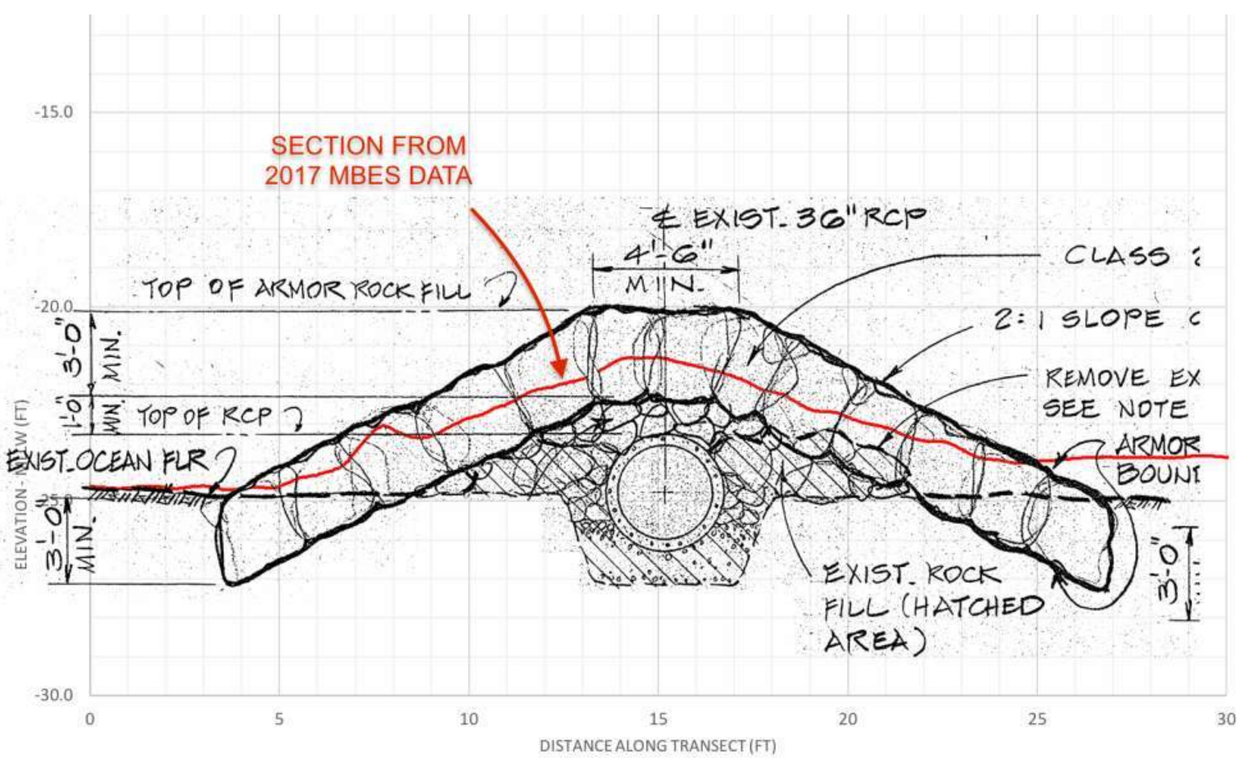


Figure 4-29. Cross section of MBES bathymetry (*red*) near station 10+00, overlaid with as-built profile

The ballast pile cross section at station 21+00, shown in Figure 4-31, follows the as-built typical section for this location generally well. Profile variations are seen where the multibeam has obtained depths in between individual large armor stones, resulting in a jagged curve in places. Those individual armor stones can be identified in the high resolution DTM shown in Figure 4-30. The outfall pipe appears to be well protected with ample reserves of ballast at this location, based on the comparison.

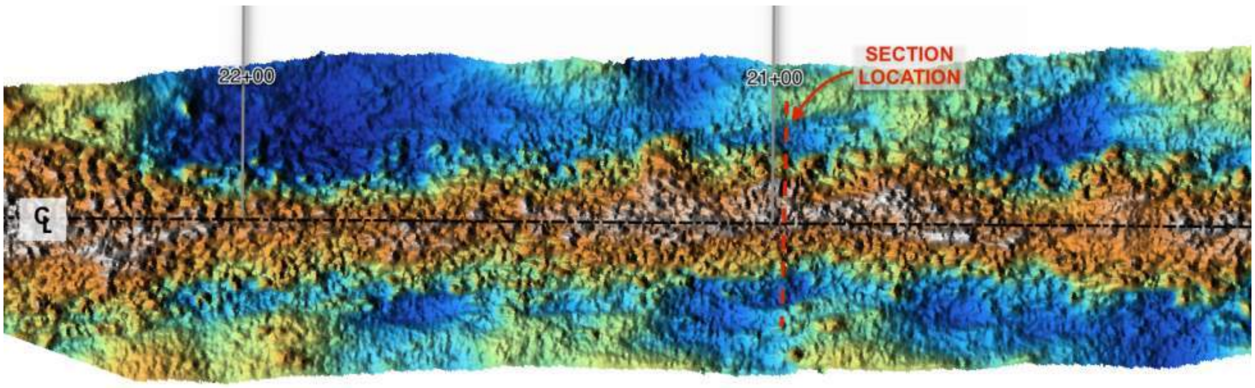


Figure 4-30. Close up of MBES bathymetry, ballast pile near station 21+00

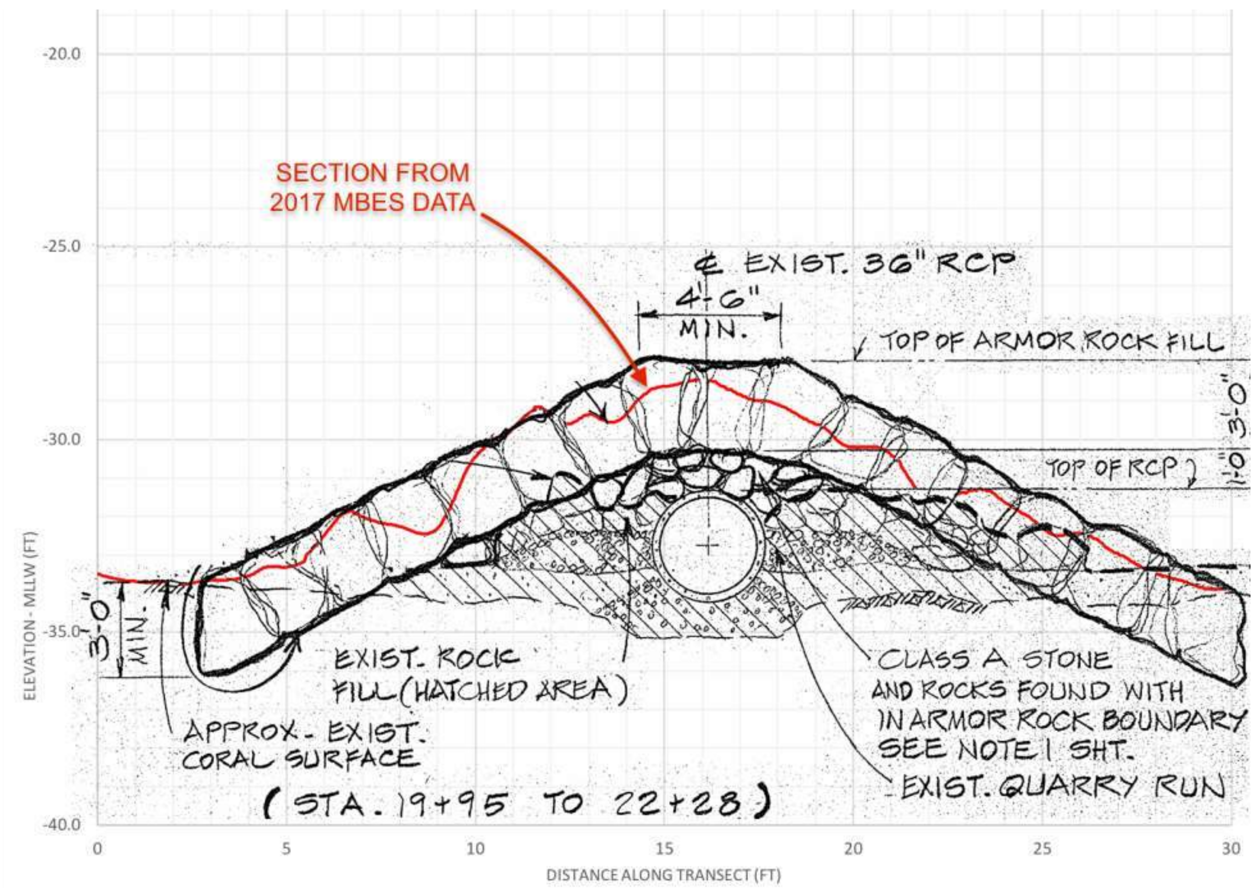


Figure 4-31. Cross section of MBES bathymetry (*red*) near station 21+00, overlaid with as-built profile

The 1986 modification plan to the ballast pile near station 23+50 was a limited area (10 ft x 4 ft) requiring additional stone for an area of previously exposed RCP (location shown in Figure 4-32). The section overlay comparison in Figure 4-33 suggests that the rock cover may be thinner than that called for by design, by approximately 1 ft. Again, the exact depth of the pipe under the pile at this location is unknown, and therefore the vertical alignment of the two sections may be offset. However, with the surrounding seafloor being hard substrate (not shifting sand), confidence with vertical alignment is slightly better than that for station 10+00. Inspectors were unable to see RCP joints between the individual stones at this location, and thus the repair is thought to be adequate. Future monitoring is recommended, however.

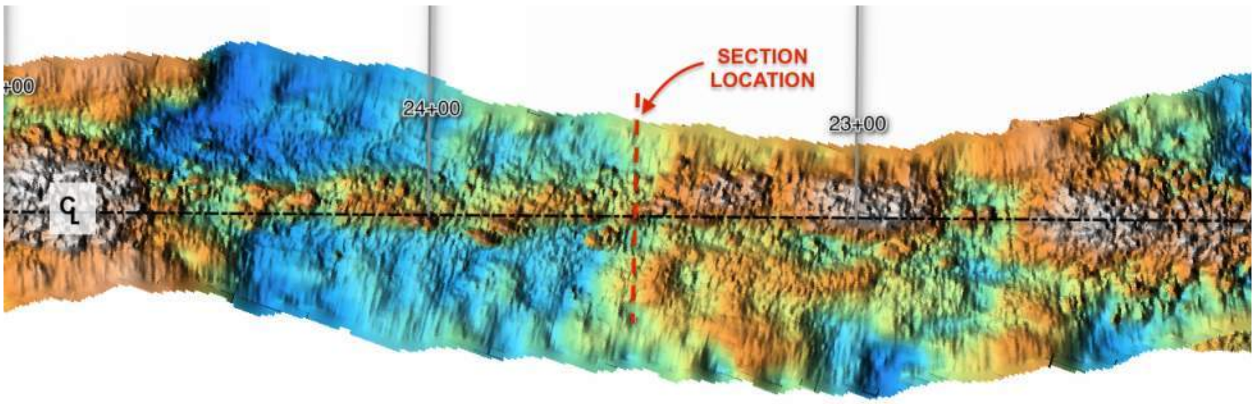


Figure 4-32. Close up of MBES bathymetry, ballast pile near station 23+50

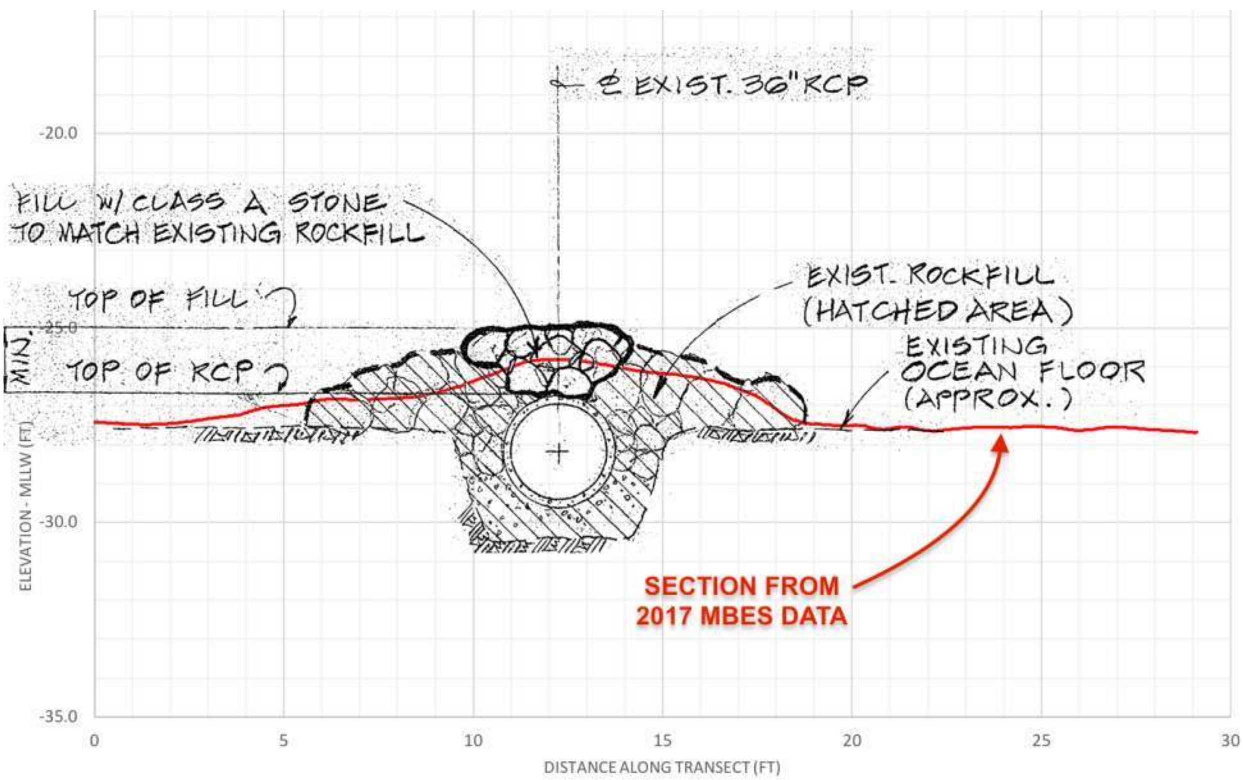


Figure 4-33. Cross section of MBES bathymetry (*red*) near station 23+50, overlaid with as-built profile

The section of ballasted outfall in the vicinity of Manhole 4, shown in plan view in Figure 4-34, is represented by the typical cross section illustrated in Figure 4-35. The as-built cross section and existing section profile (*red*) generally agree quite well at this location as shown, and suggest that the outfall pipe is well protected with ample reserves of ballast, based on the comparison.

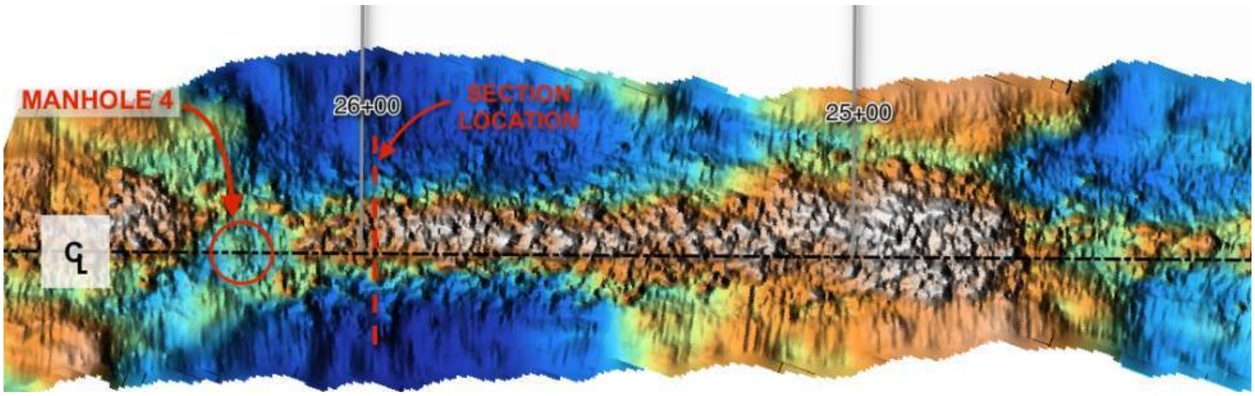


Figure 4-34. Close up of MBES bathymetry, ballast pile near station 26+00

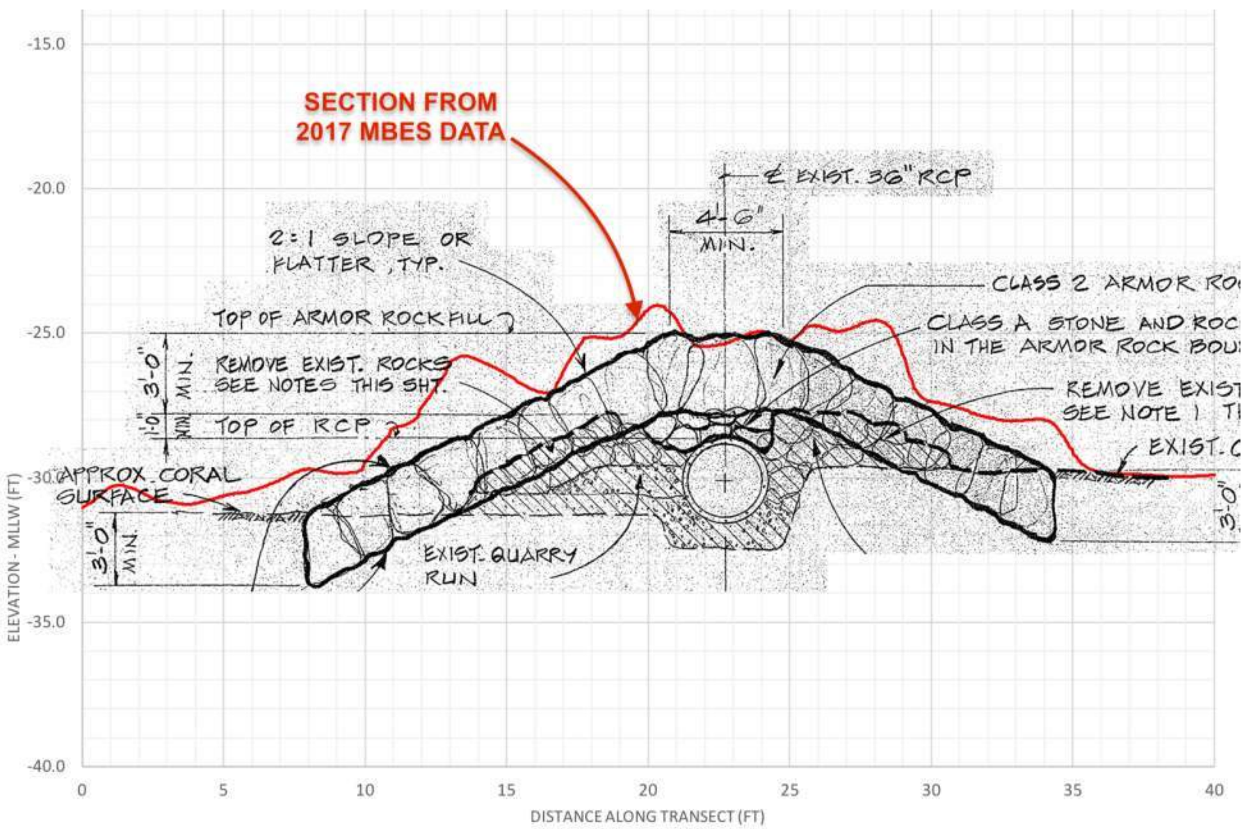


Figure 4-35. Cross section of MBES bathymetry (*red*) near station 26+00, overlaid with as-built profile

4.5 Summary

The submerged portions of Waianae Ocean Outfall appear to be in overall good condition. The underwater visual inspection findings include the following points:

- High resolution multibeam bathymetry of the outfall from 2017 combined with results from this visual inspection have shown that the adjacent surrounding seafloor within the outfall corridor appears to be in stable condition, with no indications of significant scour or seafloor displacements, and is providing the outfall with a stable foundation.

- In the vicinity of station 02+50 E, the concrete jacket/cap was fractured into several large masses. However, damage appeared limited to the cap, which did not exhibit signs of significant displacement, appears to still sufficiently protect the pipe within the underlying trench, and therefore does not appear to impact the integrity of the outfall itself.

- The ballast stone size and placement generally matched what was specified in the original and modified designs. Field fitting and transition sections show a slight deviation from the plans in some places, however these relatively minor deviations during installation were likely necessary to assure the RCP joints were fully protected in all areas. In general, the ballast pile sections were found in good condition, appear stable, and currently providing ample protection and reserve material for the pipeline in those areas.

- The entire length of submerged outfall appears to be well protected—either fully trenched, jacketed in concrete, or covered in ballast stone, with no part of the actual reinforced concrete pipe joints visible at any portion.

- The four manholes on the 42-inch extension (MH A – MH D) are in excellent condition with no signs of damage, corrosion, or leakage. However, the cast iron manholes on the original 36-inch pipeline (MH 2 – MH 4) displayed signs of advanced corrosion, and loss of effective material thickness of the manhole covers.

- The stopgate structure and special wye structure were found to be in good condition with no signs of leakage. The stainless steel slot covers and underlying gaskets on the special wye structure were found in good condition, with no evidence of significant corrosion and no leakage.

5. SHORELINE ASSESSMENT AT LANDFALL (TASK B1)

5.1 Introduction

The Waianae Ocean Outfall pipeline makes landfall at the northern end of Mailiili Beach Park, directly across Farrington Highway from Waianae WWTP. The shoreline in this vicinity is characterized by a mix of monolithic and broken limestone formations, beach rock, coral rubble, and some limited sand pockets. The outfall configuration at this location is illustrated by an excerpt from the 1965 as-built plans, presented in Figure 5-1 below. The plans show that approximately 100 feet landward from the waterline lies the 24-inch by-pass line junction and valve box, as well as the nearby Pressure Manhole Number 1, which additionally serves as the origin for outfall station numbering (that is, 0+00). A photographic perspective of this shoreline landing area, looking from north to south, is shown in Figure 5-2, which shows the unused by-pass line in the foreground and the 36-inch main barrel with valve box and manhole in the background. The trenched-pipe-with-grouted-cap/jacket type construction of the outfall is clearly visible in the image. A typical design cross section for the outfall at this location is shown in Figure 5-3, which was also excerpted from the 1965 as-built plans.

SEI engineers visited and inspected the landfall and shoreline location on three separate visits, including: 25 August 2015; 23 June 2017; and, 05 July 2017. This section details the engineers' notes, findings, and recommendations regarding the existing state of the outfall at the shoreline.

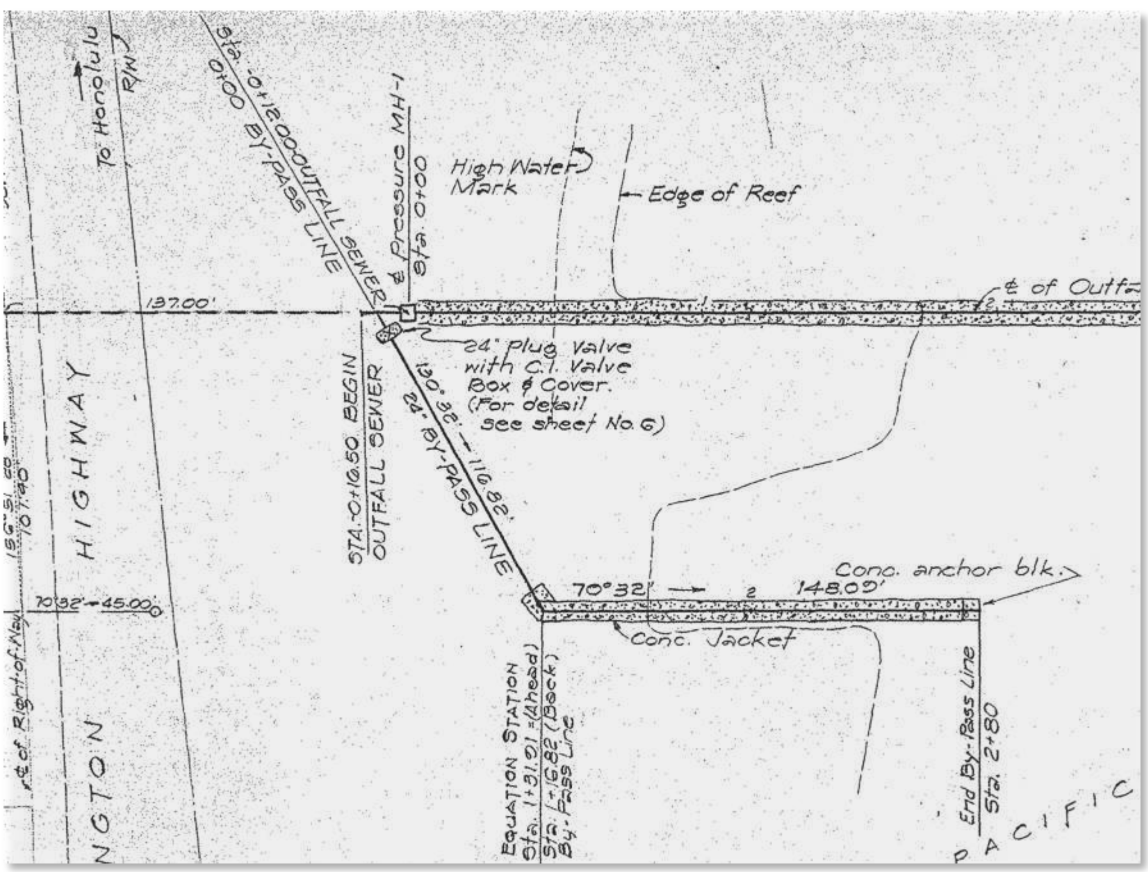


Figure 5-1. Outfall landing per original 1965 as-built plans

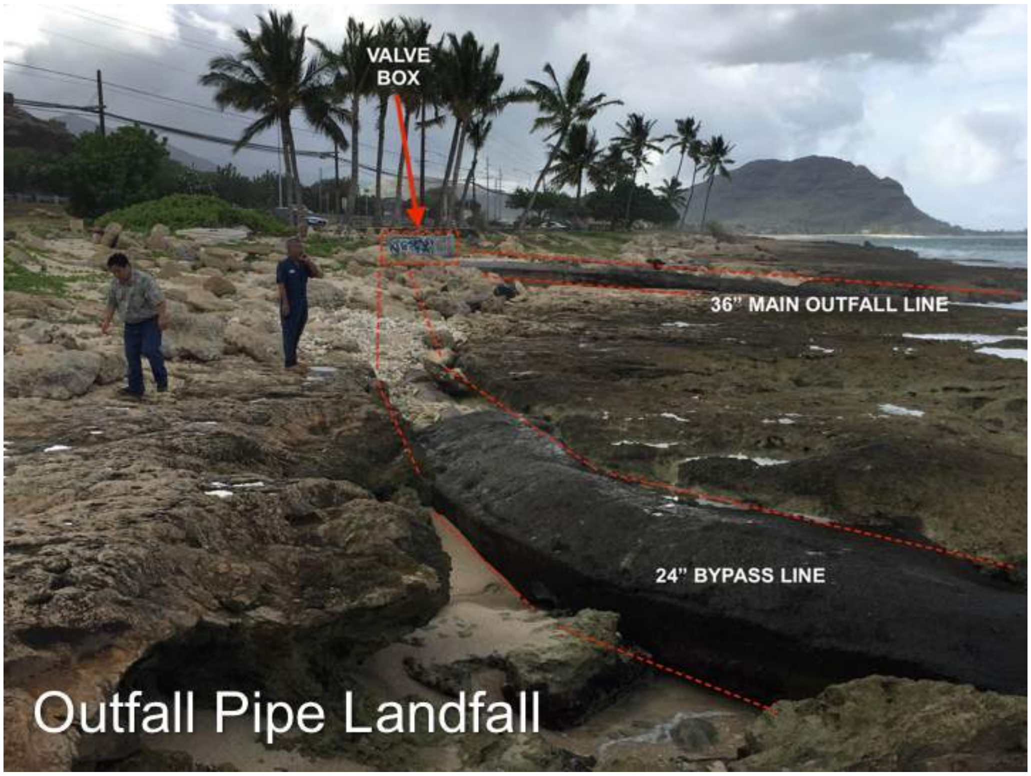


Figure 5-2. Outfall landing, with by-pass line (foreground) and main barrel (background) with MH 1 and valve box

Figure 5-3. Outfall landing typical design cross section

5.2 Site Observations

5.2.1 General Shoreline Condition

As noted previously in this section, the shoreline in the vicinity of the outfall landing site is typically rocky, and generally appears well suited as a stable substrate for installation of the RCP joints that comprise the concrete pipeline. The actual waterline generally follows an irregular and variegated rocky step, both up and down the shoreline, that in profile drops sharply several feet into the water. As viewed from aerial imagery, the shoreline resembles a sawtooth pattern as the waterline traces the spur-and-groove limestone formations that emerge from the seafloor, as shown in Figure 5-4.

Figure 5-4. Outfall landing vicinity and surrounding shoreline, circa 2017 (*source: Apple Maps, 2019)*

The historic shoreline as it existed in 1975, ten years after construction of the original outfall, is shown in Figure 5-5 below. It indicates that the outfall trench was aligned to enter the water at the apex of one of the smaller 'teeth' of the sawtooth shoreline noted above. The image also shows that the outfall largely appears to have supportive rock on both sides of the pipe as it enters the water. When the as-built plan is overlain on the 1975 image, as shown in Figure 5-6, it is estimated that the shoreline south of the pipe (*image top*) is approximately 75 feet from Pressure Manhole 1 (MH 1), and the shoreline to the north of the pipe (*image bottom*) is approximately 100 feet from MH 1. Thirty-two years later in 2007, the image in Figure 5-7 was taken, which indicates that some erosion of the southern flank of the trench has apparently occurred. Once more, it is useful to overlay the as-built plan as shown in Figure 5-8, where it is estimated that 25 – 30 feet of shoreline retreat has taken place along the south side of the pipe. In general, compared to the 1975 imagery in Figure 5-5, it appears that the entire mass of rock adjacent to the waterline along the southern flank has been fractured, broken up, and eroded away from the pipe.

Figure 5-5. Outfall landing shoreline condition, 1975 (*source: UH Coastal Geology Group, 2019)*

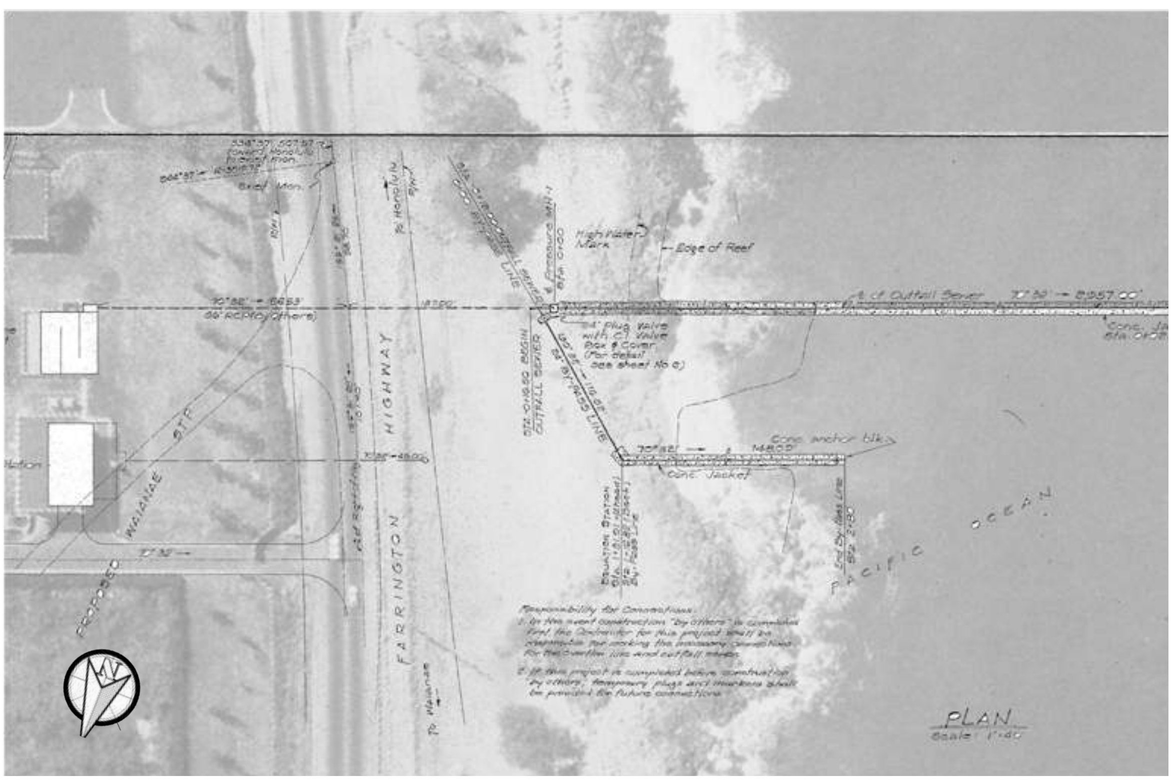


Figure 5-6. Outfall landing condition, 1975, with as-built plan overlay (*source: UH CGG, 2019)*

Figure 5-7. Outfall landing shoreline condition, 2007 (*source: UH Coastal Geology Group, 2019)*

Figure 5-8. Outfall landing condition, 2007, with as-built plan overlay (*source: UH CGG, 2019)*

5.2.2 Outfall Condition At Shoreline

Observations from the site revealed an approximate 20-foot length of the 36-inch main barrel to be unsupported, with a gap of up to 1 foot as measured from the bottom of the pipe to the under laying natural substrate. The spanning section of unsupported pipe is located in the same general vicinity as the area of rock failure and erosion previously identified at the end of Section 5.2.1 above, and is illustrated by the image in Figure 5-9, where the red line indicates the approximate length of unsupported pipe.

Figure 5-9. Section of unsupported pipe on southern flank of outfall, near the waterline

The exposed flat vertical surface of the grout jacket visible in Figure 5-9 (from image center to center right) indicates where the original supportive trench wall was located when the concrete mix was poured. The trench wall at this location has over time subsequently failed, broken apart and eroded away from the pipe, leaving the smooth surface grout face where it once supported the pipe. It is also noted that following south trench wall failure, the bed of supportive crushed coral and rock shown in Figure 5-3 (inset detail) has been scoured away, and replaced with adjacent natural beach material.

While at the site, further investigation of the unsupported span using a hand-held probe obtained measurements that resulted in the approximate representative section shown in Figure 5-10, which illustrates the void areas beneath and adjacent to the pipe, along with the remaining supportive rock formations. The approximate section in Figure 5-10 is typical for the identified spanned length of pipe.

In this same region but approximately 20 to 30 feet landward of the spanned section, on the north flank of the pipeline, a gap or void space between the existing trench wall and grout jacket was observed. The gap is discontinuous, limited in length, and does not extend to the trench floor, as shown by the photograph in Figure 5-11. Further seaward on the north flank, in the region of the spanned section, several small holes (approximately 1 - 2 inches) were observed with bubbling water and air during wave action, indicating void spaces underneath, as illustrated by Figure 5-10.

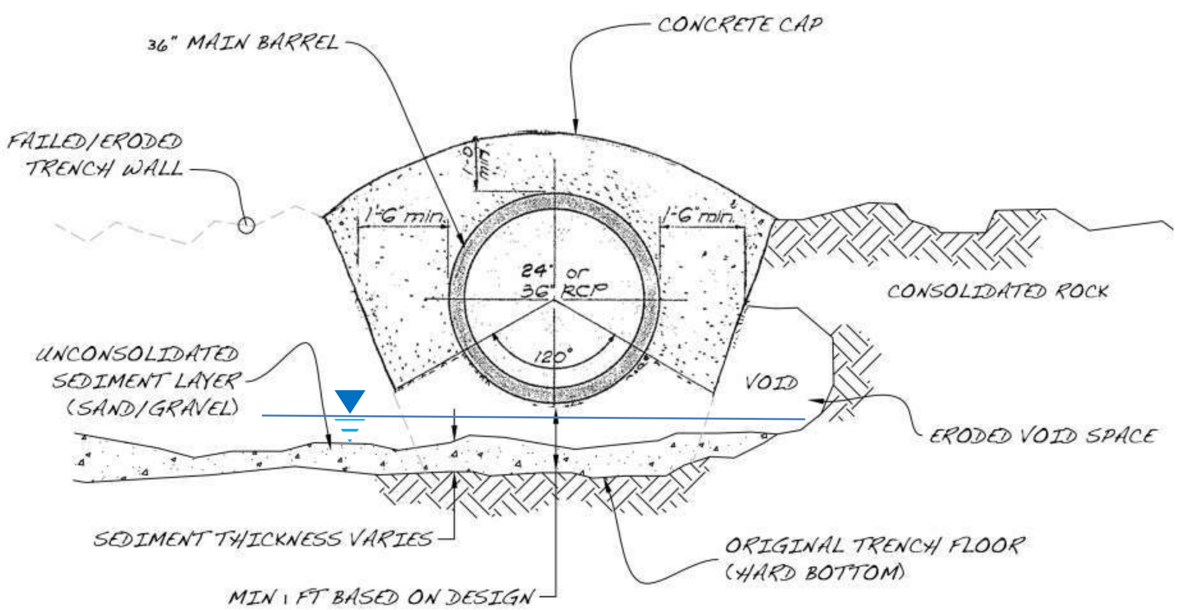


Figure 5-10. Typical section of unsupported span of 36-inch main barrel, looking offshore near waterline

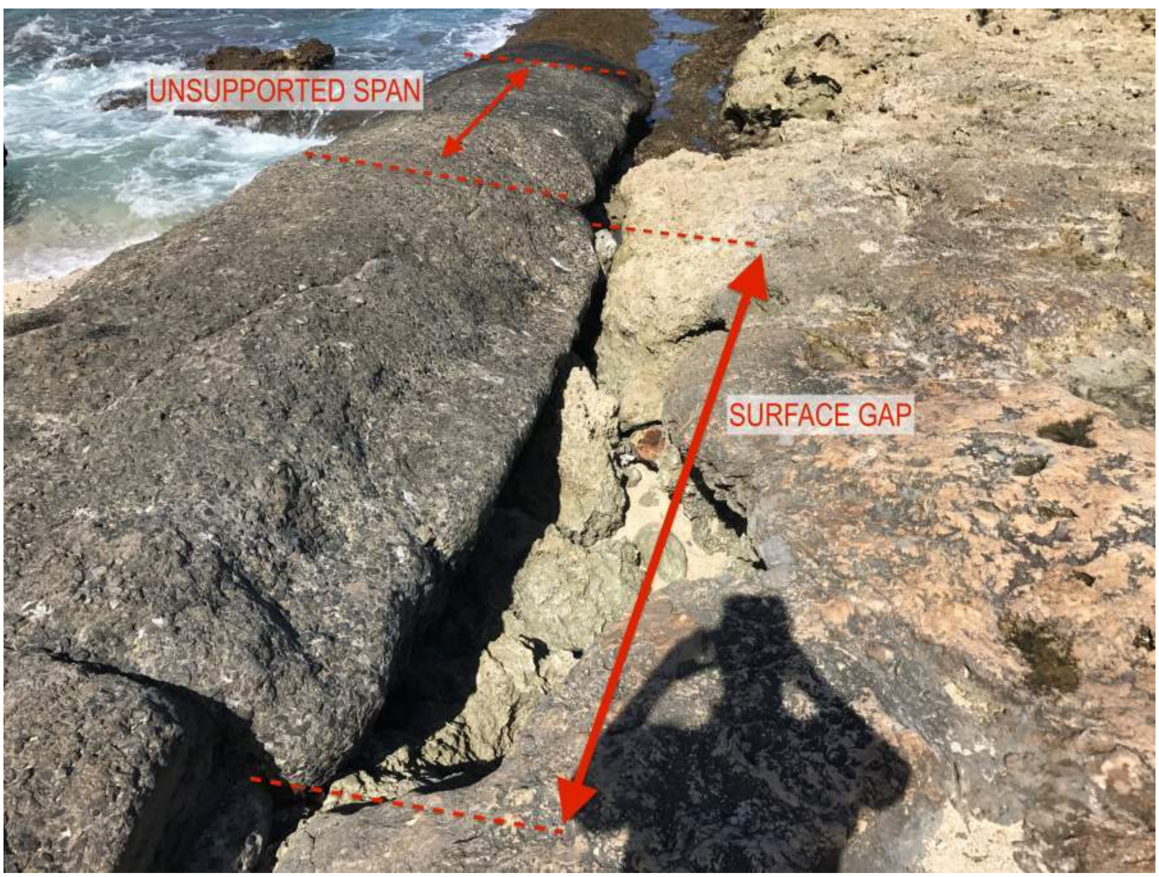


Figure 5-11. Surface gap and voids along north flank of pipeline near waterline/shoreline

5.2.3 By-pass Pipeline

The 24-inch by-pass line—which branches off to the north from the main barrel onshore just before MH 1 and terminates near the edge of the reef near the waterline—has no known record of ever being engaged (i.e., valve box near Sta. 0+00 with valve in open position). Construction of the by-pass line was performed using the same methods as the 36-inch main barrel, with a trench and grout jacket configuration. At the time of this report, the basis for design or other supportive planning and engineering documents for Waianae Ocean Outfall were unlocatable or otherwise unavailable, and therefore the specific reason for the by-pass line is not known.

However, it is known that if the by-pass line ever was to be engaged, it would result in large volumes of effluent being discharged at the shoreline, likely creating an immediate health risk and potentially violating State and Federal environmental regulations. For these reasons, this inspection effort is considering the by-pass line as abandoned-in-place and not inspected.

5.3 Emergency Repairs

In order to mitigate the immediate hazard of potential failure of the pipeline at the unsupported span, an emergency repair was quickly designed and implemented until a permanent repair is possible. The conceptual cross section in Figure 5-12 illustrates the repair strategy, which basically involves removal of all loose beach material under the span, creation of a small cofferdam around the repair area using sandbags, installation of wooden forms, placement of strengthening rebar beneath the pipe, and finally pouring of marine concrete into the void space as shown. A conceptual plan view illustrating the horizontal extents of the repair is provided in Figure 5-13. The emergency repairs were implemented in June and July of 2018. Photographs of the construction process and final repaired condition are provided in Figure 5-14 through Figure 5-16. Note the difference in sand levels between Figure 5-9 and Figure 5-16.

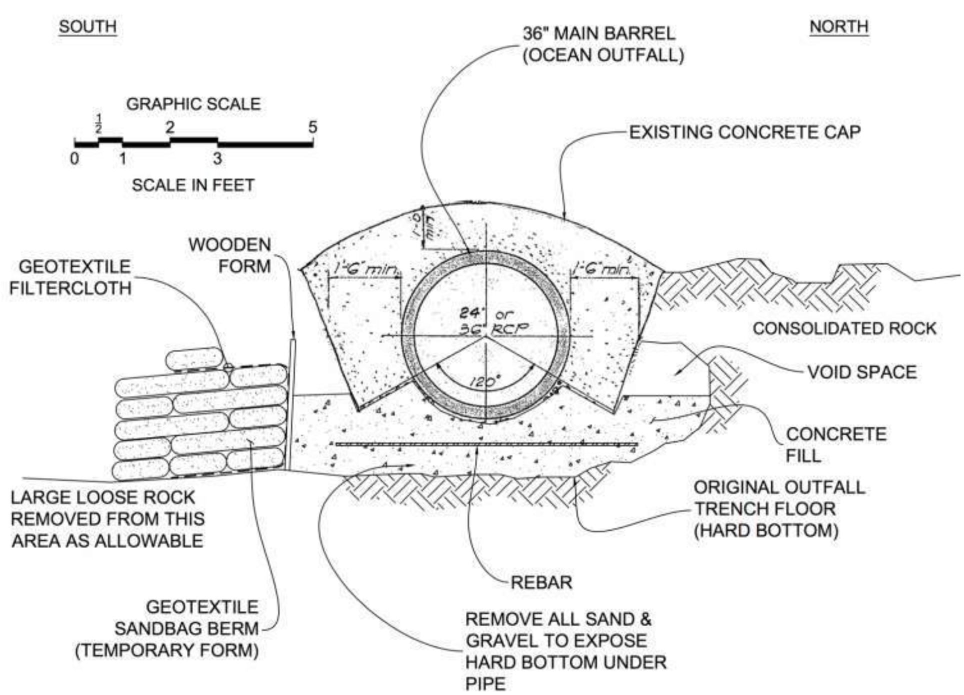


Figure 5-12. Conceptual repair cross section

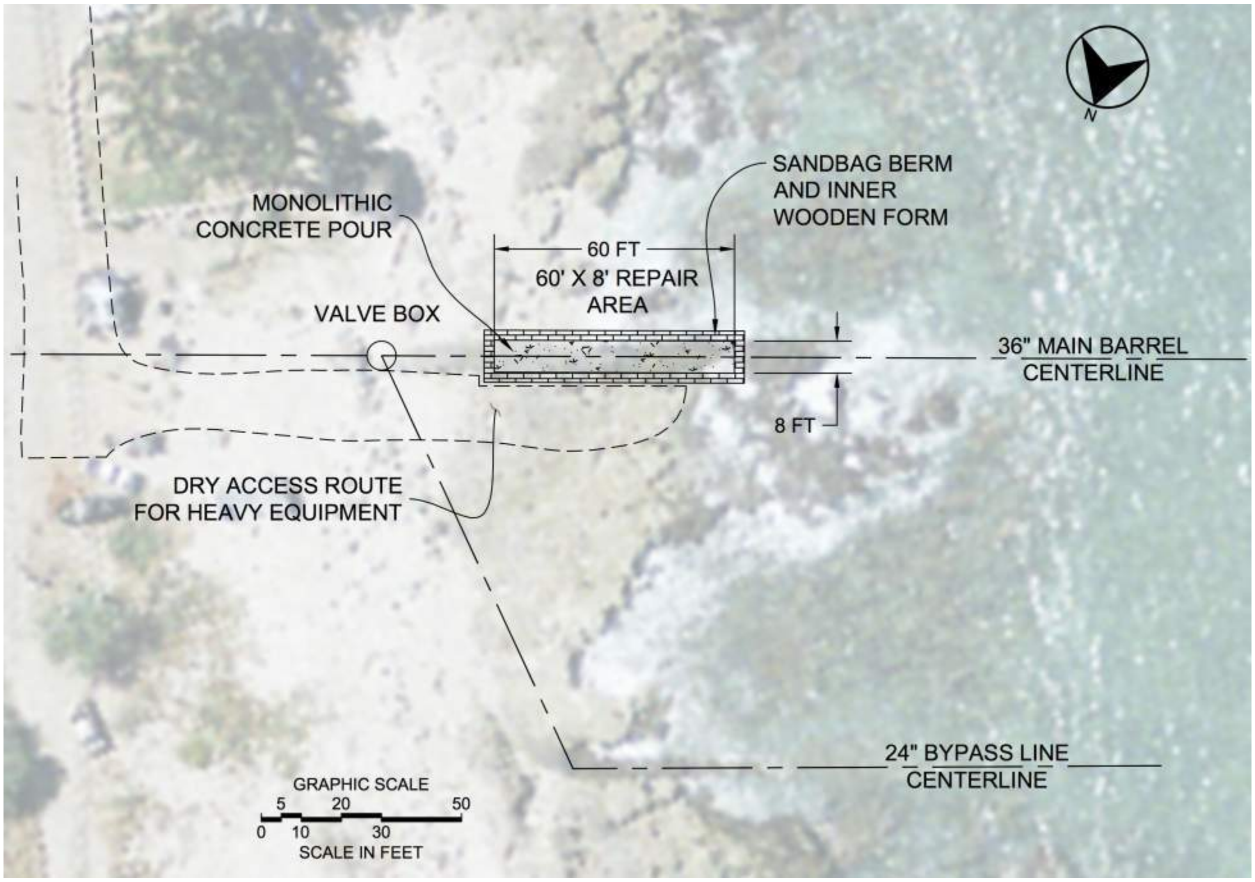


Figure 5-13. Conceptual repair plan view

Figure 5-14. Sandbag caisson with plywood forms installation (*left*); close-up of void area within forms (*right*)

Figure 5-15. Concrete placement within formworks via boom truck (*left*); concrete pumped into gap (*right*)

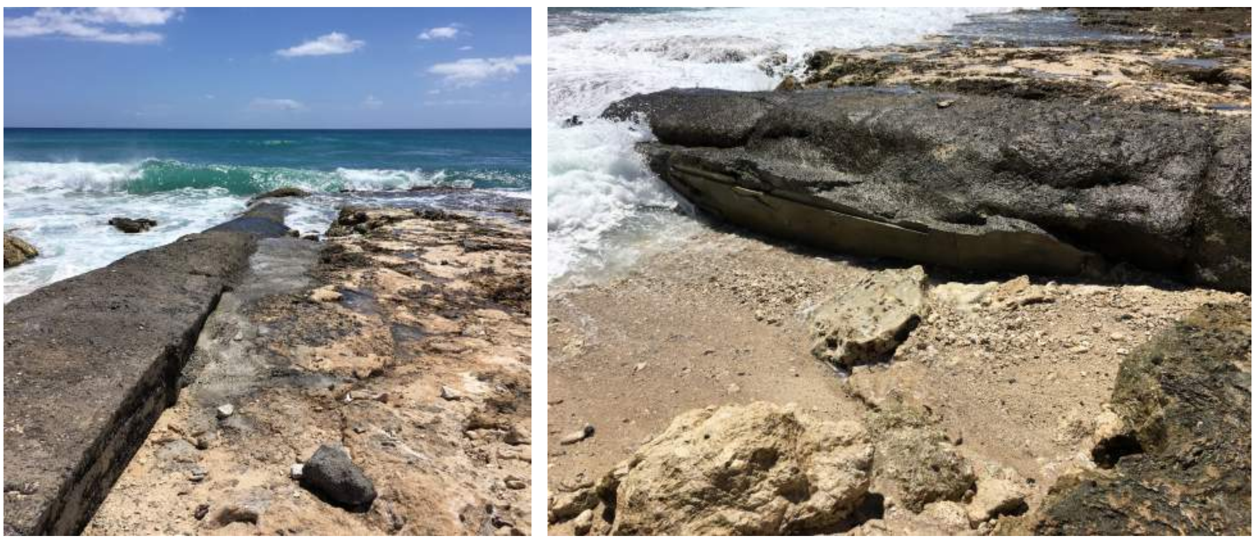


Figure 5-16. Finished repair, north side gap (*left*) and unsupported span (*right*)

5.4 Conclusions

Based on the shoreline assessment results it appears that gradual erosion of the limestone mass, into which the outfall is trenched, poses a legitimate threat to future stability of the land-based segment of outfall in the vicinity of MH 1 to the waterline. In light of this assessment, the following recommendations are offered:

- Periodically monitor the above water portion of the outfall for signs of movement, displacement, or erosion of the supportive rock mass. Additionally monitor the temporary repair for stability with particular focus on signs of degradation of the concrete.
- Begin the planning and design effort for a permanent repair concept which not only protects the pipe at the emergency repair area, but also stabilizes and armors the nearby adjacent rock formations and shoreline upon which the pipeline is founded.
- Monitor the fluctuating level of beach sediments adjacent to the repaired section of outfall.

6. STABILITY ANALYSIS (TASK D1)

6.1 Introduction

6.1.1 Preface

The Waianae Wastewater Treatment Plant serves as the primary sewage reception, treatment and disposal facility for a large portion of West Oahu. The facility utilizes a reinforced concrete pipe (RCP) ocean outfall structure for transferring treated effluent from the treatment plant to offshore waters for disposal. The project location and vicinity is illustrated in Figure 1-1, located in Section 1 of this report.

Since construction of the Waianae Wastewater Treatment Plant (WWTP) and its original ocean outfall in the mid-1960's, two powerful hurricanes, *Iwa* (1982) and *Iniki* (1992), have impacted Oahu. In recent years, several close approaches including Category 3 Hector (2018) which pounded south and west shores of Oahu with dangerously large surf, and Category 5 Lane (2018) which was forecasted to potentially make landfall on Oahu but weakened unexpectedly and veered off to open ocean just hours before a predicted landfall.

Storm waves produced by Hurricane Iwa were found to have caused significant damage to the submerged oil pipelines from the Single Point Mooring (SPH) at Barbers Point, where a 30-inch pipeline was laterally displaced up to 140 ft (43 m) in water depths of 45 to 60 ft (14 – 18 m) by wave and current forces. The damage sustained by Hurricane Iwa, and the occurrence of Hurricane Iniki a decade later, highlighted the potential risk to submerged pipelines and other seafloor infrastructure from extreme wave events such as those caused by hurricanes.

For as long as official records have been kept, tropical storms and hurricanes have had a relatively low probability of occurrence in the vicinity of the Hawaiian Islands; yet the potential for damage to Hawaii's offshore and nearshore coastal infrastructure is substantial and likely increasing due to rising ocean temperatures driven by global warming. Using revised hurricane design criteria, a 1998 study by Sea Engineering, Inc., (SEI) found that the existing condition of the Honouliuli ocean outfall was not stable, and resulted in additional ballast rock being placed along some sections of the pipe. A similar study completed in 2014 by SEI for the Sand Island WWTP's ocean outfall found that the outfall structure was estimated to remain generally stable in scenario hurricane conditions due to its location partially in deep water, ample reserves of stone where ballasted, and the trench and grout configuration used in shallower water.

6.1.2 Project Scope

The outfall stability analysis effort herein represents the third major task of the condition assessment activities, as defined by the approved work plan (full document provided in Appendix A)—this document presents and summarizes the procedures, results, and analysis of this study which has been commissioned by the City and County of Honolulu to analyze plausible impacts on the outfall structure resulting from reasonably expected extreme environmental conditions generated by scenario hurricanes directly impacting the island of Oahu.

6.1.3 Background

The Waianae Waste Water Treatment Plant (WWTP) is located approximately 1.5 miles south of Waianae Small Boat Harbor, on the western shoreline of the island of Oahu, in the State of Hawaii. The facility's relative location is illustrated in Figure 1-1. The treatment plant utilizes an ocean outfall structure for conveying treated effluent from the facility to offshore waters for disposal, where it is released at a water depth of 105 feet by an array of diffusers for dilution and dispersal in the water column by natural oceanographic processes. For reference, a plan overview of the entire outfall, including the 42-inch extension project, is presented in Figure 1-2 in Section 1, which was extracted from the 1986-dated as-built plans.

6.2 Methodology & Procedures

Ocean outfalls such as Waianae, that use riprap armor (ballast) to protect and secure their underlying pipeline, are considered composite structures. In contrast to estimating forces on a simple monolithic pipeline placed on the seafloor using straightforward approaches such as the Morison equation, the composite outfall materials of pipe, trench, underlying bedding material, concrete cap, and ballast make force calculations much more complex. Additionally, for an underwater armor stone ballasted pipeline, no clear design guidance exists to aide in stability assessment.

The objective of this study is to assess the stability of the outfall in response to the most extreme but reasonably expected wave events possible in Hawaii, which are waves generated by hurricane conditions. The analysis focuses on exposed portions Waianae's ocean outfall, which are the limited sections where the pipe is not fully trenched and is partially protected by ballast rock, which are described in full detail in Sections 5 and 6. For the purposes of this investigation, the portions of outfall that are fully trenched and grouted are assumed stable in all wave conditions, including the diffuser section, the entire 42-inch extension, and the majority of the original 36-inch line. The following investigation utilizes a combination of wind and wave models in concert with computational fluid dynamics (CFD) simulations to numerically estimate the resulting hydrodynamic loads on the outfall ballast pile structure. Figure 6-1 is a diagram of the general work flow elements, including scenario hurricane wind field modeling, a wind-driven deep water wave generation model, a coupled nearshore wave and circulation model, and near-field high resolution CFD model for estimation of local forces on the pipeline.

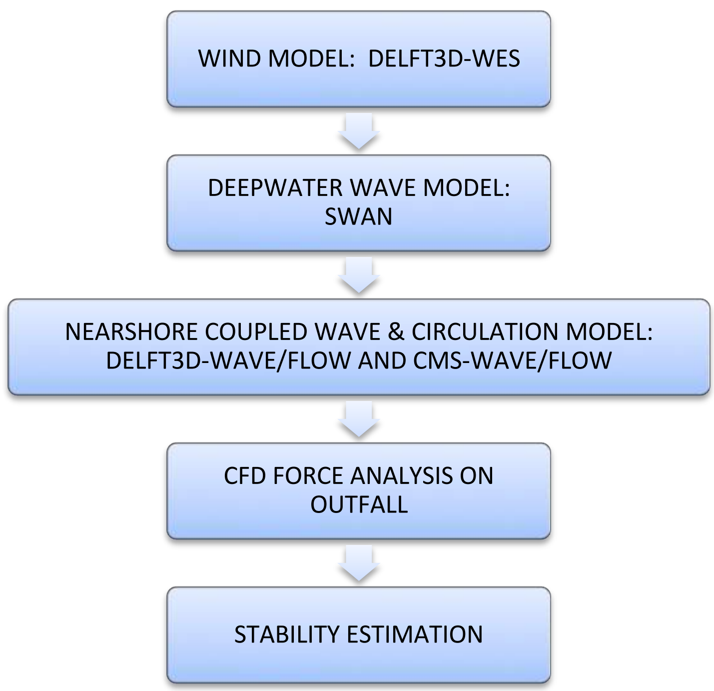


Figure 6-1. Modeling and analysis work flow

6.2.1 Hurricane Modeling

Hurricanes with their associated high winds and elevated water levels have the potential for creating localized extreme surf, possibly resulting in wave heights that could far surpass the usual seasonally-high surf episodes that shorelines in Hawaii typically experience on an annual basis. For coastal or nearshore structures constructed in Hawaii, the extreme nearfield water velocities and dynamic pressures generated by hurricane swells are often considered as the maximum design conditions that these structures might experience in their design life and be expected to withstand with limited damage.

Hurricanes can range widely in terms of overall size, strength and speed of movement. In order to define appropriate criteria and storm characteristics for use in the following modeling and analysis procedure, this study incorporates data on historic storm tracks and intensities, along with statistics on predicted recurrence in the vicinity of the main Hawaiian Islands to develop realistic 'worst case' scenarios.

It is acknowledged that tsunami and earthquakes may potentially exert forces on the outfall that exceed those during hurricane conditions, however they are not considered in this study.

6.2.1.1 Wind Field Modeling – Delft3D-WES Module

Hurricane wind fields were modeled for this effort using the Wind Enhance Scheme (WES) originally developed by the United Kingdom's Met Office. WES is incorporated as a module within the Delft3D ocean modeling suite (Delft3D-WES) and is a modification of the well-known Holland model (Holland, 1980) for simulating tropical cyclone wind fields. The winds generated with this approach are geostrophic in nature, and include the effects of pressure gradients and *Coriolis* forces. Asymmetry, which is typically encountered in observed wind fields, is represented by vector-based addition of the translational movement of the tropical cyclone.

Inputs required to run Delft3D-WES include a multi-parameter time-series of the storm's central pressure, radii of hurricane wind speeds, geographic location (center of rotation), and the storm's forward speed and direction. Output from this model is a moving snapshot of the hurricane wind field in the form of a 'spiderweb' grid centered on the instantaneous position of the hurricane.

6.2.1.2 Deep Water Wave Model – Delft3D-Wave

The wind fields developed with Delft3D-WES were subsequently used as input to generate corresponding wave fields using the SWAN (Simulating Waves Nearshore) model, version 41.20A. SWAN is a third-generation wave model developed by Delft University of Technology (Netherlands) that computes random, short-crested, wind-generated waves in coastal regions and inland waters. The SWAN model can be applied as a steady state or non-steady state model, and is fully spectral (i.e., it covers the total range of wave frequencies/periods). Wave propagation is based on linear wave theory, and includes the effects of wave generated currents (i.e., Doppler effect). SWAN provides many output quantities including two-dimensional spectra, significant wave height and mean wave period, and average wave direction and directional spreading.

6.2.1.3 Nearshore Coupled Wave & Circulation Models – Delft3D-Wave+Delft3D-Flow

Because wave conditions affect currents, and the currents they produce may then affect the waves themselves, the strength of coupled models for this project is the capability for steering results from one model to the other. This interaction means that for every time step in the simulation, the wave model can pass calculated wave height and other parameters to the flow model for its calculations, which in turn can pass back wave-induced current data to the wave model, enabling a direct solution for a seemingly difficult iterative process.

Nearshore wave heights and wave-generated currents were analyzed numerically using the coupled Delft3D-Wave and Delft3D-Flow models as part of the Delft3D modeling suite, developed by Deltares. Delft3D is an industry-leading 3D modeling suite used globally to investigate ocean hydrodynamics, sediment transport and morphology and water quality for fluvial, estuarine and coastal environments.

Delft3D-Wave relies on the previously mentioned spectral wave model SWAN, while Delft3D-Flow is a multi-dimensional (2D depth-averaged or 3D) hydrodynamic and transport simulation model which solves the non-steady shallow-water equations with the hydrostatic and Boussinesq assumptions.

6.2.1.4 Nearfield CFD Hydrodynamic Model of Outfall

The computational fluid dynamics (CFD) system used for this analysis is known as *OpenFOAM*® (Open Field Operation and Manipulation). The CFD toolbox is an open source software package produced by OpenCFD Ltd, and has a large user base across many areas of engineering and science, including both commercial and academic organizations. *OpenFOAM* has an extensive range of features to solve complex fluid flow problems, including tools for meshing complex CAD geometries, and for pre- and post-processing. In particular, *OpenFOAM* provides the necessary solver for transient, multiple fraction incompressible, isothermal, immiscible fluids using a VOF (volume of fluid) phase-fraction based interface (i.e., free surface) capturing approach, with optional mesh motion and mesh topology changes including adaptive re-meshing. These features allow for the effective modeling of complicated three-dimensional problems such as turbulent flow over a rigid body in an incompressible fluid, in both time-dependent and steady state flow regimes, with or without a free surface.

6.2.2 Fluid Components for Force Estimation

There are multiple fluid flow components in the ocean environment that contribute to forces on a stationary submerged structure such as an ocean outfall, and include: wave orbital motion; tidal currents; and, wave-driven currents.

Although each component may be associated with a different average orientation or phase, as a conservative assessment it is assumed for this project that the flow components may be additive. In the chaotic conditions associated with a hurricane event this assumption is not unrealistic, as the momentary alignment of disparate flow components may become probable and lead to maximum fluid forces exerted on the pipeline.

WAVE ORBITAL VELOCITIES Water waves are the propagation of energy through the seawater medium with no net movement of the medium itself. However, as the waveform passes, local water particles experience an orbital displacement, with the consequent velocity and acceleration a function of wave phase, as shown in Figure 6-2. The water particle orbital velocities are also dependent on water depth,

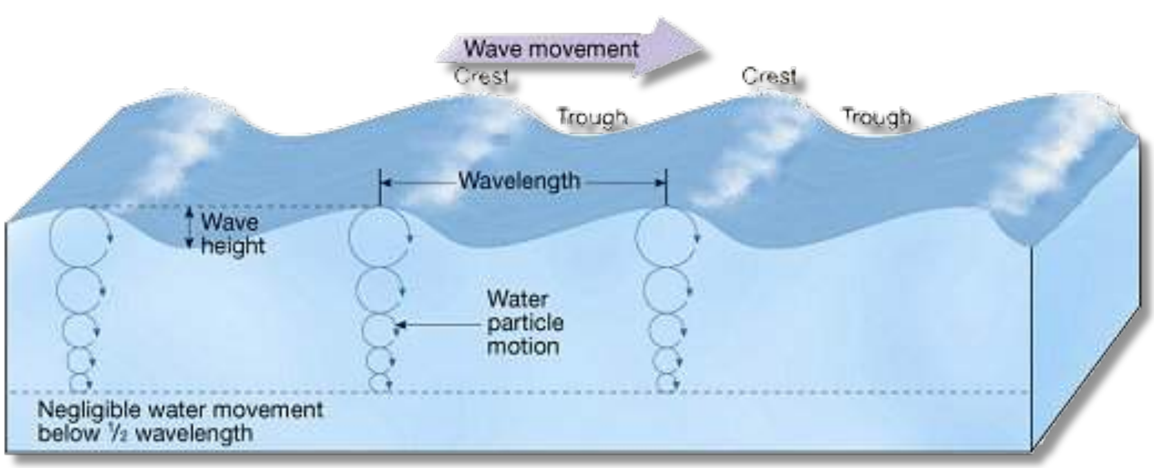


Figure 6-2. Deep Water Wave Orbitals

height of the water particle within the water column, wave height, wave length, and wave period. Orbital velocities attenuate with depth in the water column, as shown in the figure. In shallow water, the orbits become flattened into an elliptical path. Orbital velocities at the sea floor become purely horizontal due to the bottom boundary.

<u>TIDES</u> Tidal currents are varied around the coastal waters of Hawaii, and range from weak to relatively strong depending on location. These currents are driven by tidal-based differences of sea level elevation; the resulting nearshore currents are typically stronger than the large scale island-wide circulation patterns. An example of typical semidiurnal and diurnal tidal currents around the Island of Oahu is shown in Figure 6-3 (Flament et al., 1997), which shows that the tidal currents tend to be aligned with the shoreline and reverse in direction with the changing tidal phase. Maximum tidal currents in the vicinity of Waianae Ocean Outfall appear to be approximately 0.60 m/s (1.17 knots), as taken from Figure 6-3.

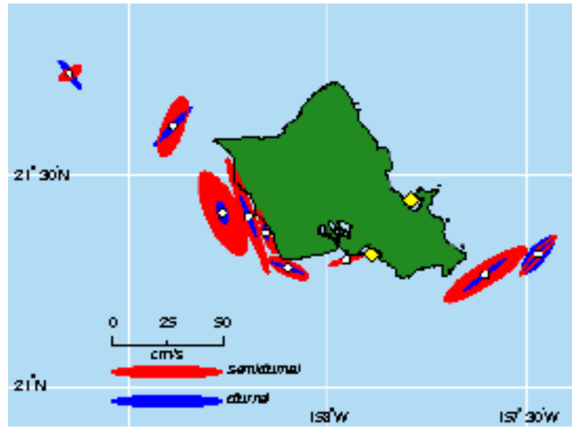


Figure 6-3. Tidal currents around Oahu (Flament, 1996)

From previous nearshore studies (SEI, 2012), evidence has suggested that tidal currents are typically much smaller inshore along the shallow reef near the surf zone in comparison to the stronger breaking wave-driven currents. Because tidal currents have been observed to become more dominant offshore of the surf zone in deeper water 60 to 100 ft in depth (SEI, 2012), this component will be neglected for the analysis.

<u>BREAKING WAVES</u> Deep water waves approach the shoreline at varying angles, and as they propagate over increasingly shallower water, they begin to transform due to the effects of shoaling, bottom friction, *refraction* and *diffraction*. Diffraction is the process that is responsible for wave propagation into what are thought of as shadow zones, such as behind a breakwater or headland. In shallow water, wave speed is directly related to water depth—in areas of unequal bathymetry (variable bottom), or where waves approach the shoreline at an angle, the wave will bend or refract due to the differing wave speed along-crest caused by varying bottom contours. This is known as the process of refraction.

Wave shoaling occurs when a wave encounters water less than half a wavelength in depth, and causes the wave face to steepen and eventually break. A notable consequence of breaking waves, particularly during periods of elevated surf or storms, is the evolution of *wave setup* and *wave set-down*. Wave setup is a local rise in water level due to the mass influx of water trapped against a land boundary forced landward by breaking waves. Wave setup occurs across the breaker zone (surf zone) and into shore. Wave setup is approximately 10 percent to 20 percent of the breaking wave height, and can vary spatially within the surf zone, as well as temporally with the arrival of bigger or smaller sets of waves. Wave setup gradients are responsible for the generation of strong currents associated with large waves, including *rip currents* and *longshore currents*.

Empirical methods are often used to estimate wave-generated currents in areas with long, straight coastlines and simple bathymetry. However, sea floor contours in the nearshore waters of the Hawaiian Islands, with its jagged volcanic coastline, are typically not simple and are more often complex with high relief, such as the deep channels or fissures and steep reef slopes with spurs and grooves, like that which surrounds the project area, illustrated in Figure 1-1 and Figure 4-2. Additionally, the extreme hurricane wave heights used in this study are likely not well represented using empirical methods that are developed for lesser, more prevailing conditions. For these reasons, numerical modeling techniques were found necessary for this study to quantify the storm-induced wave and flow field near the outfall.

6.2.2.1 Combined Local Maximum Water Velocities

The combined fluid flow elements acting on the outfall due to hurricane passage may be assumed as a scalar summation of velocity magnitudes for tidal currents, wave orbital motion, and wave-generated currents; or in shallow water, as simply the summation of wave orbital motion and wave-generated currents. However, the direction of each individual flow component varies with time and location, and because of this complexity, usage of a transient (i.e., time-varying) wave model which combines both near-bottom wave orbital velocities as well as 'steady-state' currents will be required to accurately solve for hydrodynamic forces on the outfall.

6.2.2.2 Numerical Calculation of Estimated Forces on the Outfall

In recent years, great advances have been made in the field of numerical wave modeling and computational fluid dynamics (CFD). In this investigation, the flexibility and resilience of CFD modeling was harnessed to simulate the effects of hurricane scenario conditions on vulnerable portions of the outfall structure and provide quantitative results. The ability of CFD modeling to capture the combined effects of periodic breaking waves and steady current, from independent sources and directions, is key. The high-resolution multibeam bathymetry data (SEI, 2017) shown in Figure 4-2 and Figure 4-1 were used to form an accurate physical bottom boundary for the simulation. To assess critical forces on the outfall, a number of idealized ballast units, which can be numerically queried within the model, were added into the existing bathymetry to quantify pressure forces on the units. The resultant forces were analyzed for two principle directions: horizontal forces (*drag*) and vertical forces (*lift*). A detailed description of the actual CFD setup is provided in Section 5. The CFD analysis focuses on the most vulnerable section of the outfall, which is located just inshore of the Special Wye Structure near station 26+00 and is in the vicinity of depths where the largest storm scenario-based waves are expected to break and therefore likely to be exposed to the largest forces experienced anywhere along the pipe.

6.2.3 Stability Estimation

The entire length of Waianae Ocean Outfall's reinforced concrete pipeline was installed within a trench that was excavated from the reef, and following placement, was backfilled with stone and capped with tremie concrete. In the limited cases—all of which are along the original 36-inch pipe in water depths of 30 feet or less—where the trench wall was determined to be insufficiently high, the pipe was ballasted with stone. Assuming the fully trenched (grouted and capped) portions of the structure are intrinsically safe from movement, stability of the outfall was assessed for the existing ballast pile sections. More specifically, the stability of ballast units was calculated by balancing the horizontal and vertical forces acting per unit, which in this case, is the resulting numerically calculated hydrodynamic forces acting on the units.

Drag force (F_{drag}) is balanced by the resistive overturning force (R_h). In essence, if $F_{drag} \leq R_h$, then the ballast unit is statically stable; otherwise if the drag force exceeds the resistive force $F_{drag} > R_h$, then movement of the unit may occur. Similarly, stability in the vertical direction was assessed by balancing the unit weight of the ballast (W) with the lift force (F_{lift}). As with horizontal stability, the structure was assumed statically stable if the weight exceeded the lift force $W > F_{lift}$.

For the ballasted section of the outfall, stability is related to maintaining the design ballast pile profile. Failure along the ballast pile section would be expected to occur progressively, with the attrition of individual ballast stones over time culminating in eventual exposure of the pipe itself. Once sufficiently exposed to the greater hydrodynamic forces of shallower waters, the unrestrained pipe may subsequently undergo displacement due to lift forces or loss of supportive bed material.

For this analysis, in addition to the numerical method discussed above, stability of the ballasted section will also be considered empirically by estimating the velocity of incipient motion to displace the design ballast stone size. The velocity of incipient motion is the velocity of a fluid (seawater in this case) at which a body of specific size and mass at rest will just begin to move.

6.3 Hurricane Scenario Development

6.3.1 Hurricane Wind Model Selection

Hurricane wind models generally calculate wind field speed and direction as a function of its central pressure and radial distance from the center of rotation, as given by the curves in Figure 6-4. The profile slope is the pressure gradient, dP/dr. The *cyclostrophic wind* is the theoretical wind speed based on the pressure gradient, and is the balance between the centripetal force directed toward the center of the hurricane, and the force due to the pressure gradient:

$$V^2_{cr} = r\,(dP/\rho_a\,dr) \qquad \text{Equation 6.1}$$

where,

V_{cr} = cyclostrophic wind velocity

P = atmospheric pressure

r = radial distance from the hurricane center

ρ_a = air density.

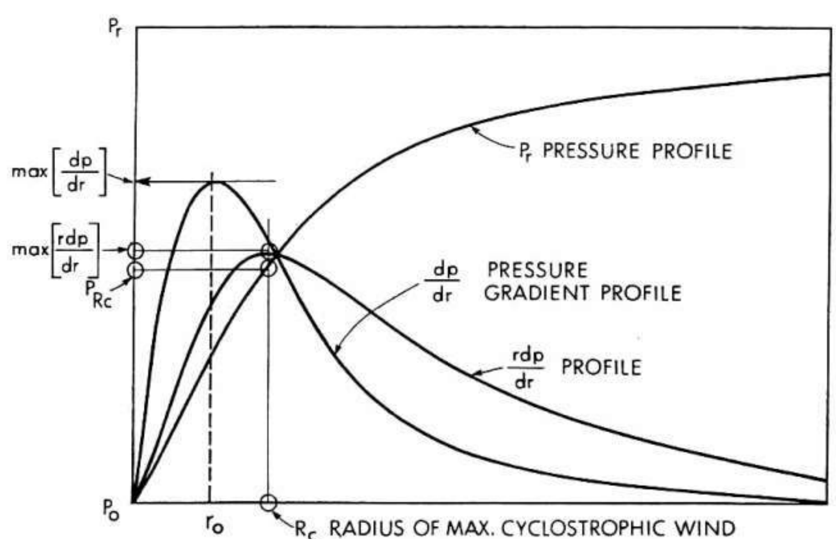


Figure 6-4. Hurricane pressure and pressure gradient profiles (from Bretschneider, 1984)

The radius of maximum cyclostrophic winds occurs at the location where the term (r(*d*P/*d*r)) of Equation 3.1 is at a maximum value as shown in Figure 6-4. The introduction of the *Coriolis* effect, based on the hurricane's latitude, gives the *gradient wind* equation:

$$V^2_g + f\,rV_g = r\,dP/\rho_a\,dr \qquad \text{Equation 6.2}$$

where,

V_g = geostrophic wind velocity

f = Coriolis parameter = 2ω sin ϕ

and,

ω = angular speed of the earth, and

ϕ = latitude of the hurricane.

Equations 3.1 and 3.2 (from Bretschneider, 1984) result in a relatively symmetrical wind field around the center of rotation of the hurricane. Imparting a forward velocity to the hurricane (storm track) will effectively skew the cyclone's wind field to increase wind speeds in the forward quadrant or leading edge of the hurricane. Consequently, this is the most destructive quadrant of any hurricane.

A number of parametric hurricane wind models exist that will adequately estimate a hurricane's wind field for a given set of parameters for the storm. Three of these models are known as the modified Rankine vortex, SLOSH wind, and Holland models. The Delft3D-WES module (see Section 6.2.1.1) which was used for this study, adopts the Holland model, originally developed by Greg Holland (1980) and recently revised by Holland et. al (2010), and which defines the *geostrophic wind* speed (V_g) of a hurricane as follows:

$$V_g(r) = \sqrt{\left({R_w}/{r}\right)^B {V_{max}}^2 \exp\left(1 - \left({R_w}/{r}\right)^B\right) + r^2 f^2/4} - \frac{rf}{2}$$

where,

R_w = radius of maximum winds

r = distance from the center of the hurricane

V_{max} = maximum wind speed

f = Coriolis parameter

and,

$$B = \frac{\rho e V_{max}^2}{p_{drop}}$$

where,

ρ = density of air

p_{drop} = pressure drop between ambient and central pressure

Wind fields calculated from the above equation were then adjusted to account for cyclone movement, based on Chan and Gray (1982), which imposes an asymmetry to the cyclone wind field. In the northern hemisphere this asymmetry causes an increase in the wind field on the right-hand side of the cyclone (looking in the direction of propagation) where wind direction is in the same direction as the cyclone forward movement. On the left-hand side of the cyclone (again looking in the direction of propagation) wind speeds are reduced, as illustrated by the conceptual sketch in Figure 6-5.

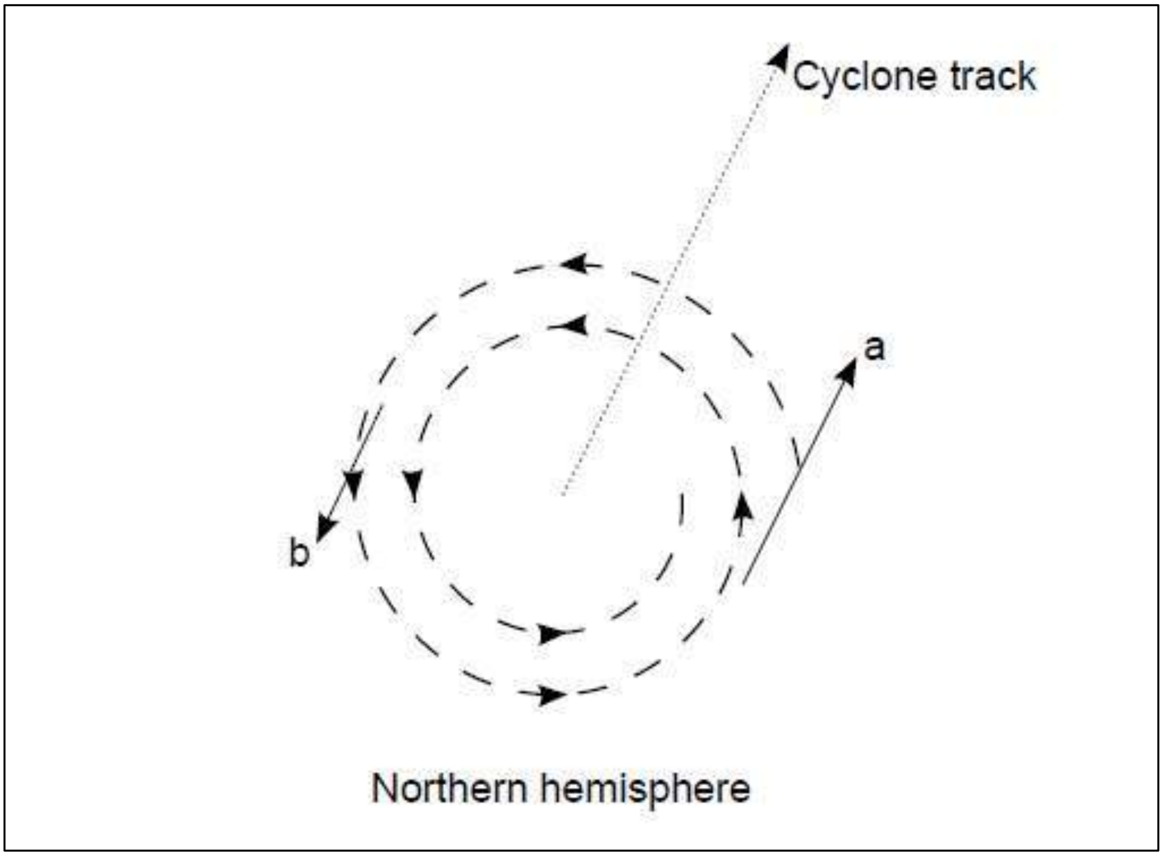


Figure 6-5. Asymmetric wind field due to cyclone forward movement (Deltares, 2017)

6.3.2 Storm Scenario Selection

6.3.2.1 Hawaiian Hurricanes

The term *hurricane* is used for tropical cyclonic storms with sustained wind speeds exceeding 64 knots or 73.6 miles per hour (32.9 m/s). The United States weather services use the Saffir-Simpson hurricane intensity scale, which is based on sustained wind speed, to provide a standard categorization for hurricane strength. The term 'sustained wind speed' refers to a one-minute average wind speed measured 10 meters above the ground or water surface. Table 6-1 below summarizes the range of maximum sustained wind speeds and approximate minimum central pressures for each hurricane category. Category 5 hurricanes are the most severe hurricanes with sustained wind speeds exceeding 137 knots or 157.7 miles per hour (70.5 m/s).

Table 6-1. Saffir-Simpson Hurricane Scale

Saffir-Simpson Category	**Max. Sustained Wind Speed** (kts)
1	64 – 82
2	83 – 95
3	96 – 112
4	113 – 136
5	137 <

In past years, hurricanes have been infrequent visitors in Hawaiian waters. Figure 6-6 illustrates hurricane, tropical storm, and tropical depression track lines that have passed within 200 miles of Hawaii between 1949 and 1997. In that time, only five of the close approach storms attained hurricane intensity. The most recent hurricanes that produced significant widespread damage in Hawaii were Hurricane Iniki (1992) and Hurricane Iwa (1982). Hurricane Iniki passed directly over the island of Kauai while Hurricane Iwa passed within 30 miles of the same island. Hurricane Iniki approached Kauai from the south and was relatively small in diameter but intense when it made landfall. Hurricane Iwa approached Kauai from the southwest and was a large Category 1 hurricane when it passed just northwest of the island.

More recently, hurricanes have become more frequent in Hawaiian waters. The 2018 Pacific hurricane season produced a total of 23 named storms and is the fourth-most active season on record. Out of those 23 storms, five threatened the main Hawaiian Islands by either close approach or direct landfall. Figure 6-7 plots the tracks and intensities of the five 2018 hurricanes which posed a threat to Hawaii. Hurricane Hector passed to the south of the Hawaiian Islands and generated large surf for most south-facing shoreline exposures along the island chain. Hurricane Walaka also sent large waves towards Hawaii but did not come close enough for its winds to pose a threat. However, Walaka made direct landfall over a small islet in French Frigate Shoals (the Northwest Hawaiian Islands are an incorporated part of the City & County of Honolulu) to the west of Kauai, and essentially erased the island from existence. Tropical Storm Olivia was the only storm to make direct landfall over any of the main Hawaiian Islands. By far, the most threatening storm was Hurricane Lane, which reached Category 5 intensity approximately 350 miles south of the Big Island and continued on a hooking NW to N trajectory straight towards Oahu. Fortuitously—at a distance of approximately 150 miles south of Oahu—Hurricane Lane rapidly weakened from unpredictable wind shear and was downgraded to a tropical storm, at which point it became embedded into the low-level easterly trade wind flow, which both destroyed the life-giving cyclonic circulation of the storm and redirected it in a sharp turn east and away from Hawaii.

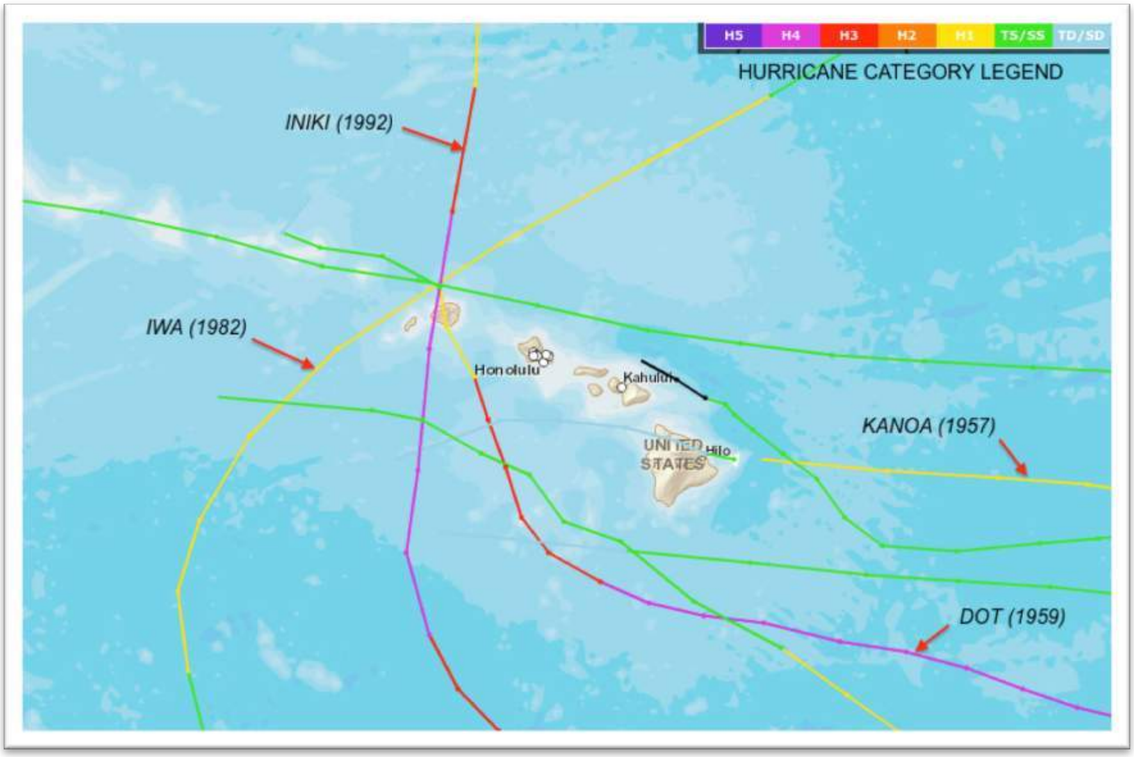


Figure 6-6. Hawaii hurricane tracks (1900 – 2012). Image courtesy NOAA.

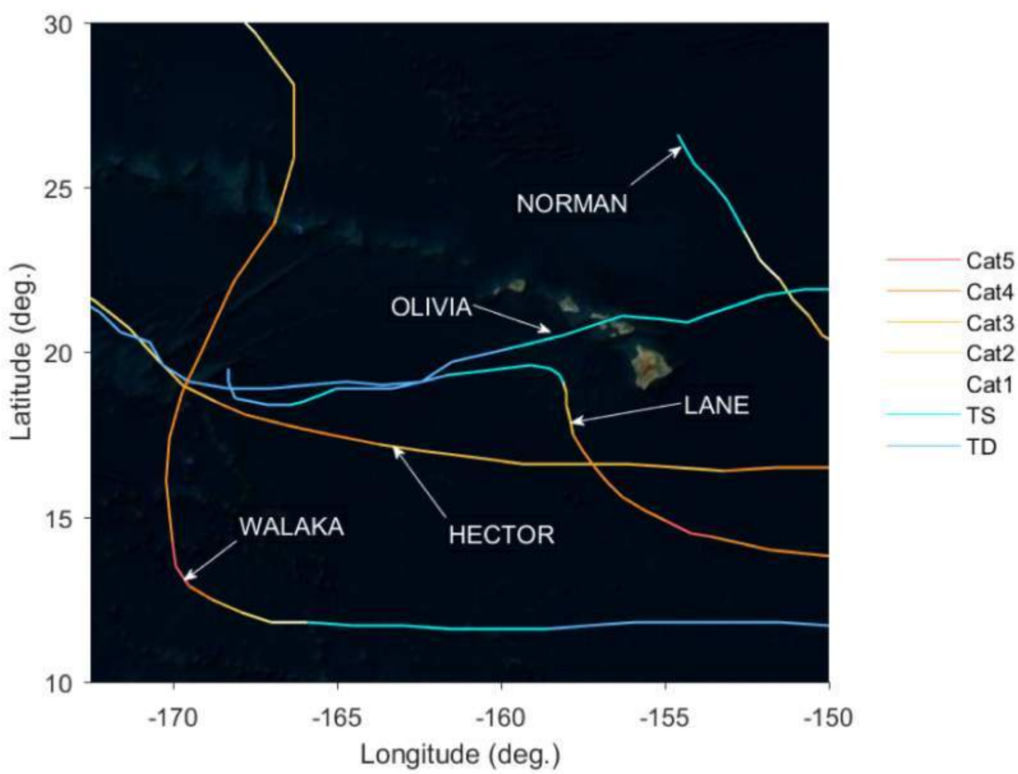


Figure 6-7. Close approach hurricane tracks for Hawaii, 2018.

6.3.2.2 Return Period of Hawaiian Hurricanes

The *return period*, or recurrence interval is a useful concept for engineering design, because it forms a statistical, yet intuitive basis for establishing a level of design criteria. Chu and Wang (1998) used the historical record of tropical cyclonic storms within 250 nautical miles (nm) of the Hawaiian Islands to derive storm return periods. Because the actual number of storms from record is actually quite small, they used a Monte Carlo simulation technique based on extreme-value distribution results to augment the statistical database.

The study used a pressure differential parameter for cyclone evaluation. Table 6-2 below summarizes some of the study results with the pressure parameter converted to a wind speed value. The statistical return period for winds of 125 knots (kts) or 144 miles per hour (64.3 m/s) is 137 years, with a true value between the 95% confidence values of 88 and 250 years.

Table 6-2. Tropical cyclone wind speed return periods (Chu and Wang, 1998)

Max Wind Speed (kts)	Max Wind Speed (m/s)	Return Period (Years)	Equivalent Hurricane
34	17.5	3.2	-
50	25.7	4	-
64	32.9	6.6	-
80	41.2	12	Iwa
100	51.4	33	Fico
110	56.6	59	Dot
125	64.3	137	Iniki

It is important to note that the maximum wave height generated from a particular storm is not just dependent on wind speed, but on additional hurricane parameters as well. In particular, the radius of maximum winds of the hurricane will determine the maximum fetch length available for wave generation. The forward velocity is also important as the storm's direction of propagation can influence the area of generation and trajectory of the largest waves within the storm; and the forward speed of propagation can influence wave growth if, for example, the storm allows waves to escape from the generating area as with a slow-moving storm, or if it keeps waves growing inside the same zone within the storm by matching the wave group speed (also known as a "captured fetch" which produces the largest waves); or, if the storm's forward speed outpaces the generated waves being generated (a fast storm).

6.3.2.3 FEMA Hurricane Scenarios

The Hawaii Emergency Management Agency, along with the Federal Emergency Management Agency (FEMA), and other state and local stake holders conduct an annual desktop exercise for catastrophic hurricane response plans for the City and County of Honolulu. The exercise, last conducted in 2018, is known as *Makani Pahili* (Hawaiian: *strong winds*), which studies potential effects of a hurricane disaster and exercises the necessary emergency response, resulting from the impact of a theoretical Category 4 hurricane making landfall on the island of Oahu. Part of this exercise is the annual update of realistic or most-probable hurricane strike scenarios. This family of 'worst case' scenarios was developed by the State and Federal government agencies and used as a starting point for this effort.

The final scenario storm tracks for this study were developed with the assistance of the National Weather Service's (NWS) Warning Coordination Meteorologist, John Bravender. From his office at the Central Pacific Hurricane Center, housed by the National Oceanic and Atmospheric Administration's (NOAA) Weather Forecast Office Honolulu, Mr. Bravender developed multiple storm scenarios, largely inspired by the close approach to Oahu by Hurricane Lane during the 2018 hurricane season. Three of the scenario hurricanes are labeled *2ab_12kt*, *3ab_12kt*, and *5a_12kt*, respectively, which correspond to the tracks created by FEMA labeled *2ab*, *3ab*, and *5a*, respectively, with a hurricane forward speed of 12 knots. The fourth scenario is labeled *10kt* and represents a scenario where Hurricane Lane maintained intensity and continued north making landfall on Oahu. The actual Hurricane Lane track was modeled to provide a validation of the model developed for this study. Figure 6-8 illustrates hurricane tracks used for the scenario hurricanes developed for the pilot *Makani Pahili* study in 2009.

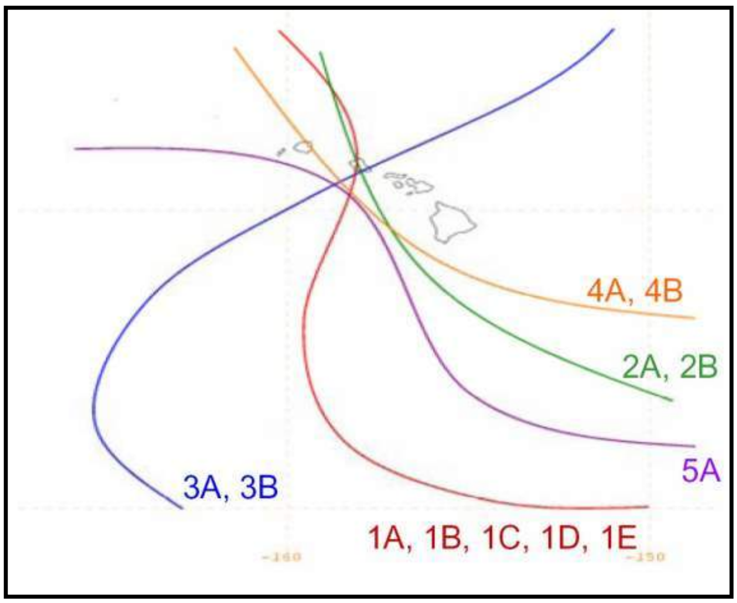


Figure 6-8. Original FEMA scenario hurricane tracks

6.3.2.4 Hurricane Lane Scenarios

For this study, Hurricane Lane was chosen as the basis for development of our hurricane scenarios, due to its impressive intensity and close approach to Oahu. Four hurricane scenarios were then developed by Mr. Bravender for use in this study; these tracks were established using the track and intensity data for Hurricane Lane combined with the original FEMA tracks (2A/2B, 3A/3B, and 5A) shown in Figure 6-8. Scenario *2ab_12kt* closely follows the FEMA 2A/2B case with a forward speed of 12 knots and wind speed of 125 knots before landfall, and 115 knots over Oahu. Scenario *3ab_12kt* propagates further west initially and then back to the northeast, similar to the FEMA 3A/3B track, with a forward speed of 12 knots and wind speed of 125 knots before landfall and 115 knots over Oahu. Scenario *5a_12kt* is shifted to the southwest of Oahu as a close approach but no landfall, similar to the FEMA 5A track. The *10kt* scenario follows the original Hurricane Lane track but continues north towards Oahu with a forward speed of 10 knots with it making landfall with a wind speed of 105 knots over Oahu.

Track data for Hurricane Lane and each of the four scenario hurricanes was provided at 6-hour intervals and included the following parameters:

1. Date/Time (yyyy-mm-dd hh:mm:ss)
2. Latitude (deg.)
3. Longitude (deg.)
4. Maximum Wind Speed, V_{max} (knots)
5. Central Pressure, P_c (hPa)
6. Radius of Maximum Winds, R_{max} (nm)
7. Radius of 35 knot winds, R_{35} (nm)
8. Radius of 50 knot winds, R_{50} (nm)
9. Radius of 65 knots winds, R_{65} (nm)

The finalized scenario hurricane tracks developed for this study are presented in Figure 6-9 along with their nominal parameters listed in Table 6-3.

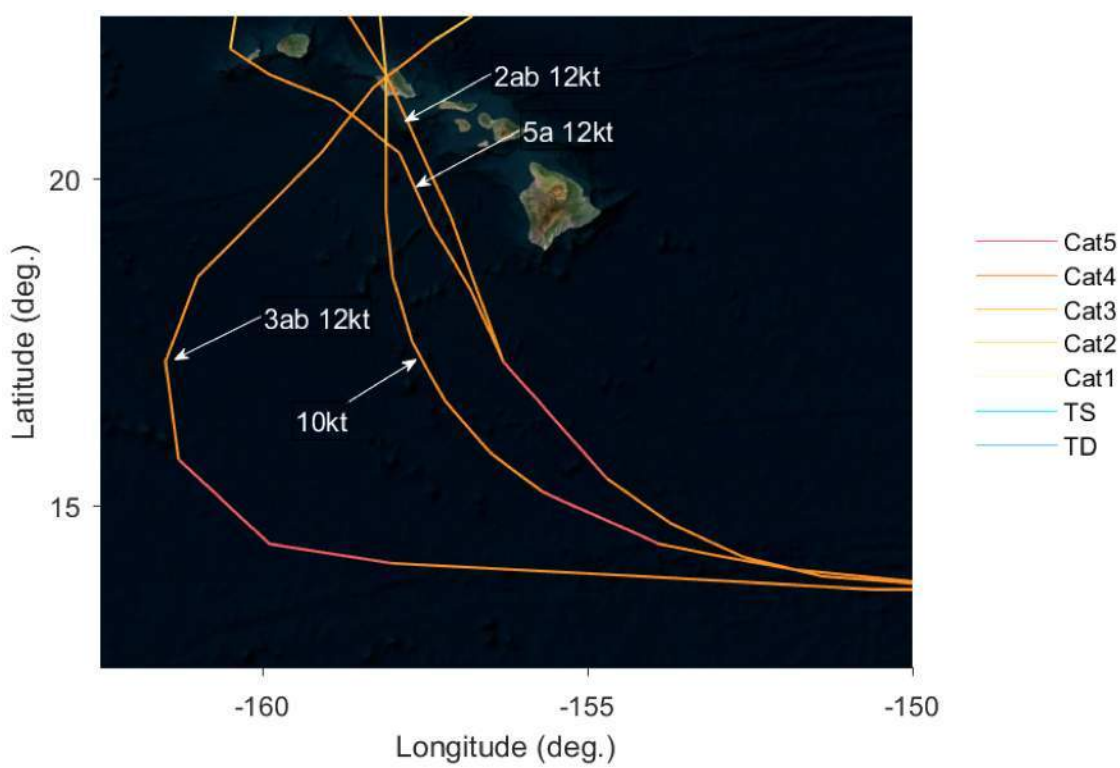


Figure 6-9. Finalized scenario hurricane tracks

Table 6-3. Scenario hurricane parameters reported at Closest Point of Approach (CPA)

Scenario Hurricane	Max Wind Speed (kts)	Category	Wind Speed @ CPA (kts)	Category @ CPA	Radius @ CPA (nm)	Approach Direction
2ab_12kt	140	5	125	4	20	SSE
3ab_12kt	140	5	115	4	15	SW
5a_12kt	140	5	125	4	20	SE
10kt	140	5	105	3	15	S

6.3.3 Model Configuration

Each of the four hurricane tracks above were used to generate corresponding wind fields using the Delft3D-WES module. Track data were linearly interpolated from 6-hour intervals to 15-min intervals to provide a smooth transition of the hurricane structure between each time step. A spiderweb grid was generated for each 15-min time step for all four hurricanes. Figure 6-10 shows the definition of the 'spiderweb' grid used to generate the moving wind field of Hurricane Lane and the four Hurricane Lane scenarios.

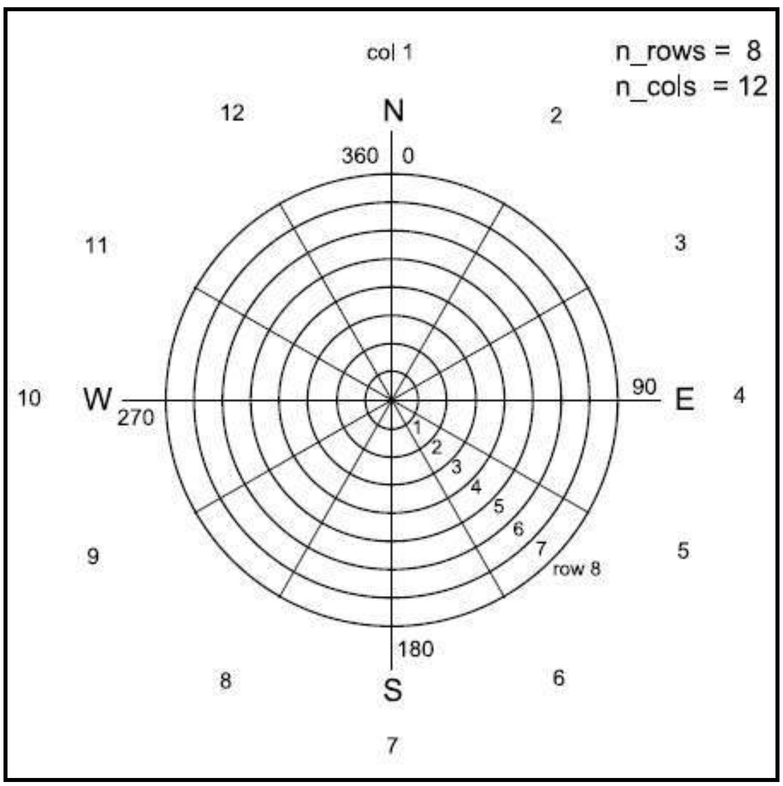


Figure 6-10. Definition of the spiderweb (polar) grid, example with 8 radial bins and 12 directional bins (Deltares, 2017)

Delft3D-WES includes a number of user configurable parameters or settings that are independent of the hurricane scenario characteristics. These settings include wind profile model, ambient atmospheric pressure, inflow angle, wind conversion (to convert 1-min wind speed to 10-min), and the spiderweb (polar coordinates) grid resolution. These parameters are combined into an input file which is read by the program. Model settings for all scenarios were configured as follows:

o Wind Profile:	Holland 2010
o Background Pressure:	1,012 Pa
o Inflow Angle (*phi*):	20°
o Wind Conversion Factor (converts 1-min to 10-min):	0.92
o Spiderweb Radius:	2,000 km
o Number of Directional Bins (*n_cols*):	72
o Number of Radial Bins (*n_rows*):	1,200

The settings and input parameters listed above were selected and optimized based on an extensive literature review of past studies using this method.

6.3.4 Wind Field Results

Time series wind field data resulting from each of the four scenario model cases (2ab_12kt, 3ab_12kt, 5a_12kt, and 10kt) were generated and stored for use as input to the next step in the analysis, the deep water (far field) wave modeling. The wind field data for each case were calculated over the entire spatial domain of the deep water wave model, and over the entire temporal domain from approach to passage of the hurricane. Figure 6-11 through Figure 6-15 present graphical output of the modeled wind fields for each case, shown at a 12-hour increment, as they traverse through the Hawaiian Islands domain. The images represent a color-shaded grid (matrix) of predicted wind as a scalar map of velocity magnitude, with dark blue indicating low velocity, and red indicating the highest velocities. The color ramp velocity scale is in knots, from 0 to 130 knots. Overlaid vector arrows indicate wind direction, with arrow length scaled relative to wind speed magnitude. The solid black line represents the track traveled by the storm, as measured from the center of rotation. The dashed black line represents the actual observed track from Hurricane Lane, provided for the reader's reference.

Hurricane Lane (shown in Figure 6-11) was used as a simplified validation, to compare with actual data collected during the storm's passage and verify the model's handling of the case. Lane's track took the storm on a westward course, a few hundred miles south of the Big Island as a Category 5 storm (a.), where after passing the island it began a sweeping hard turn to the north with a new trajectory placing Oahu directly in its path (b. through d.). Entering a region of increasing vertical shear, Lane rapidly weakened to Category 1 and then tropical storm strength (e.) and became quickly entrained into low-level trade wind flow, carrying the storm off safely to the east (f.). Scenario *2ab_12kt*, shown in Figure 6-12, closely follows the FEMA 2A/2B case (see Figure 6-8) with a forward speed of 12 kts and wind speed of 125 kts before landfall (a. through d.), and 115 kts as it overruns Oahu. Scenario *3ab_12kt* (Figure 6-13) propagates the storm further west initially (a.) and then back to the northeast (b. through c.), similar to the FEMA 3A/3B track, with a forward speed of 12 kts and wind speed of 125 kts before landfall (d.) and 115 kts over Oahu (e. and f.). Scenario *5a_12kt* in Figure 6-14 is shifted to the southwest of Oahu (a. through d.) as a close approach but no landfall (e. and f.), similar to the FEMA 5A track. The *10kt* scenario in Figure 6-15 follows the original Hurricane Lane track (a. and b.) but then continues north towards Oahu (c. and d.) with a forward speed of 10 kts, eventually making landfall with a wind speed of 105 kts over Oahu (e. and f.).

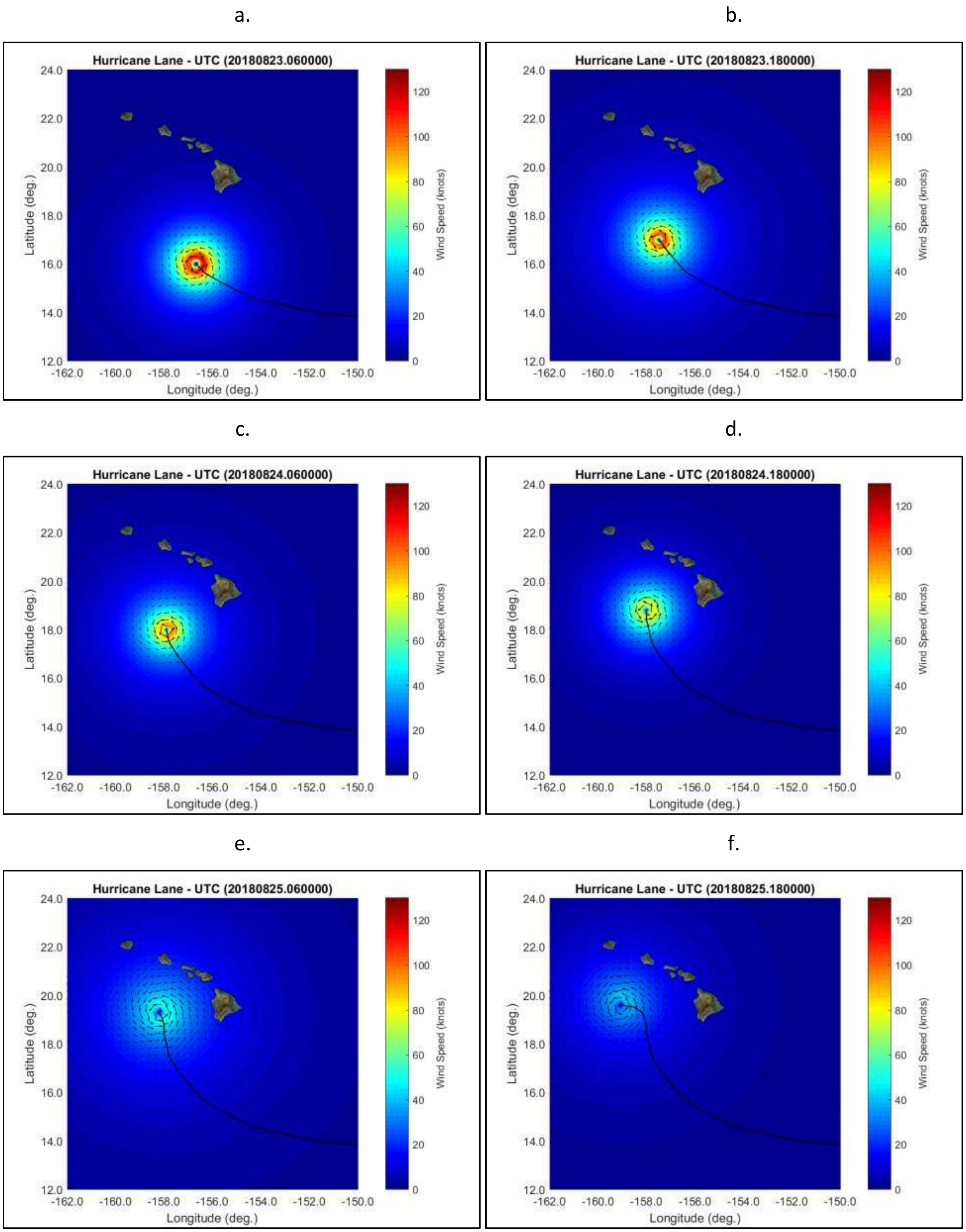


Figure 6-11. Hurricane Lane modeled wind field through the Hawaii domain (solid line indicates hurricane track)

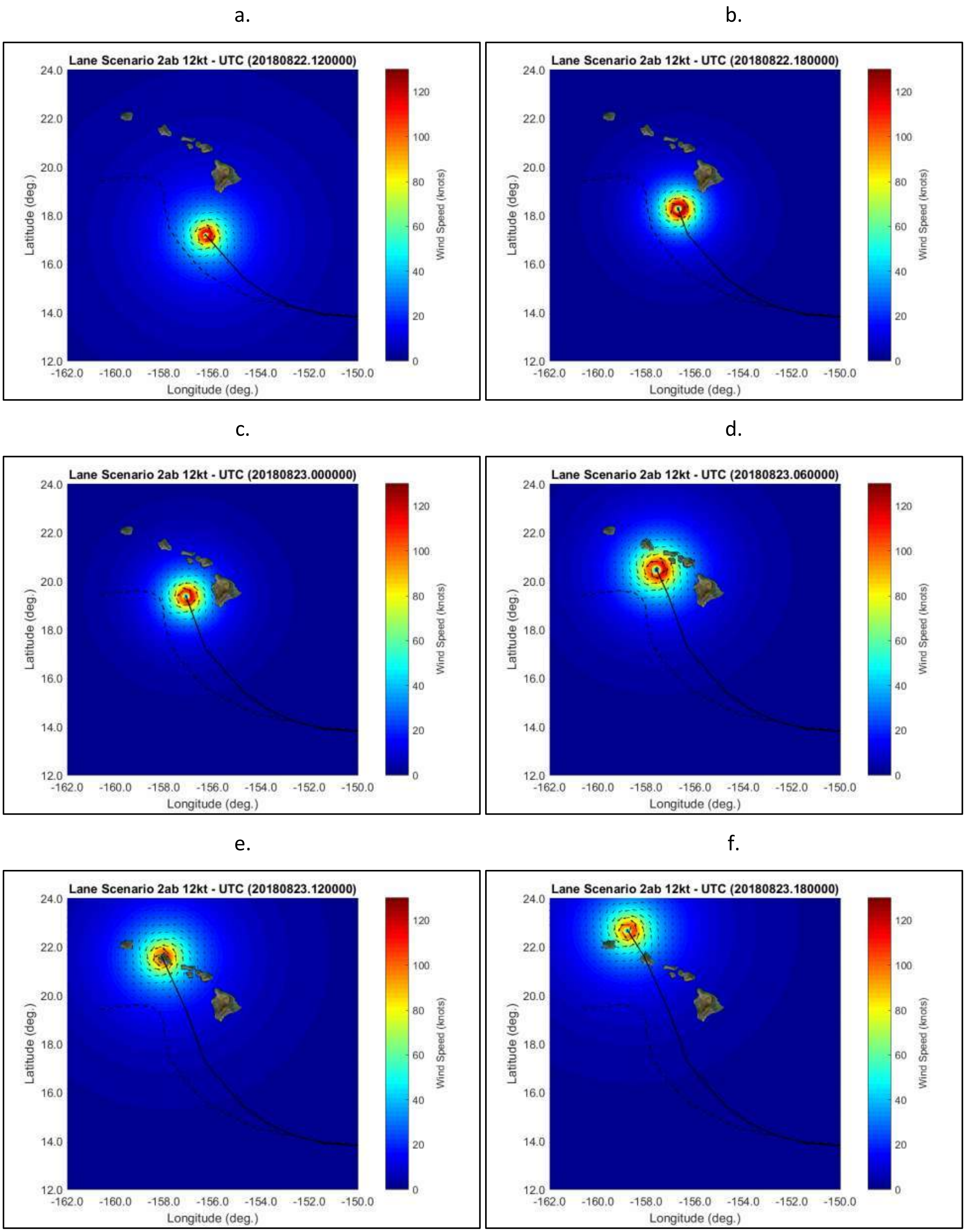


Figure 6-12. Hurricane scenario *2ab_12kt* modeled wind field through the Hawaii domain (solid line indicates hurricane scenario track; dashed line indicates original hurricane Lane track)

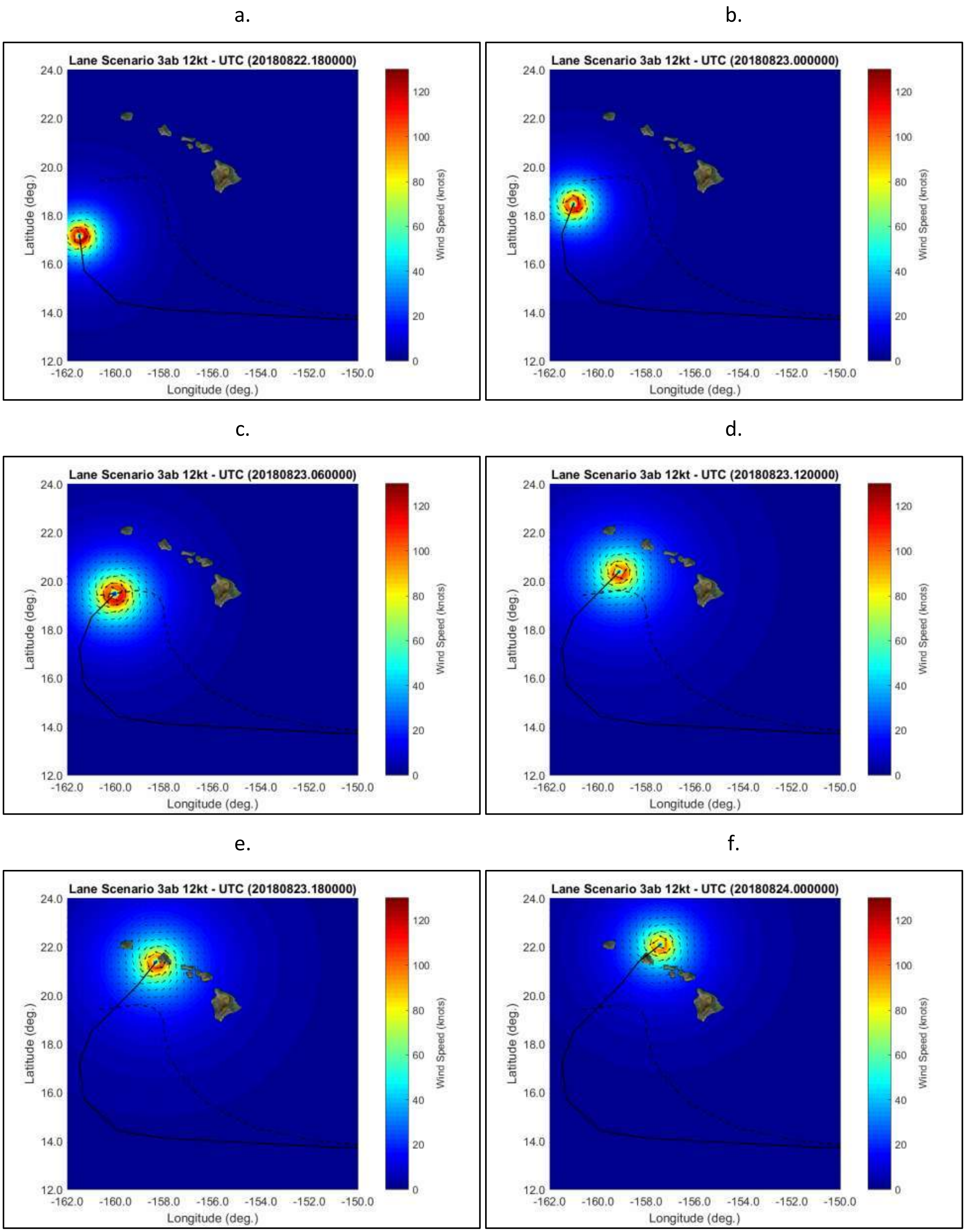


Figure 6-13. Hurricane scenario *3ab_12kt* modeled wind field through the Hawaii domain (solid line indicates hurricane scenario track; dashed line indicates original hurricane Lane track)

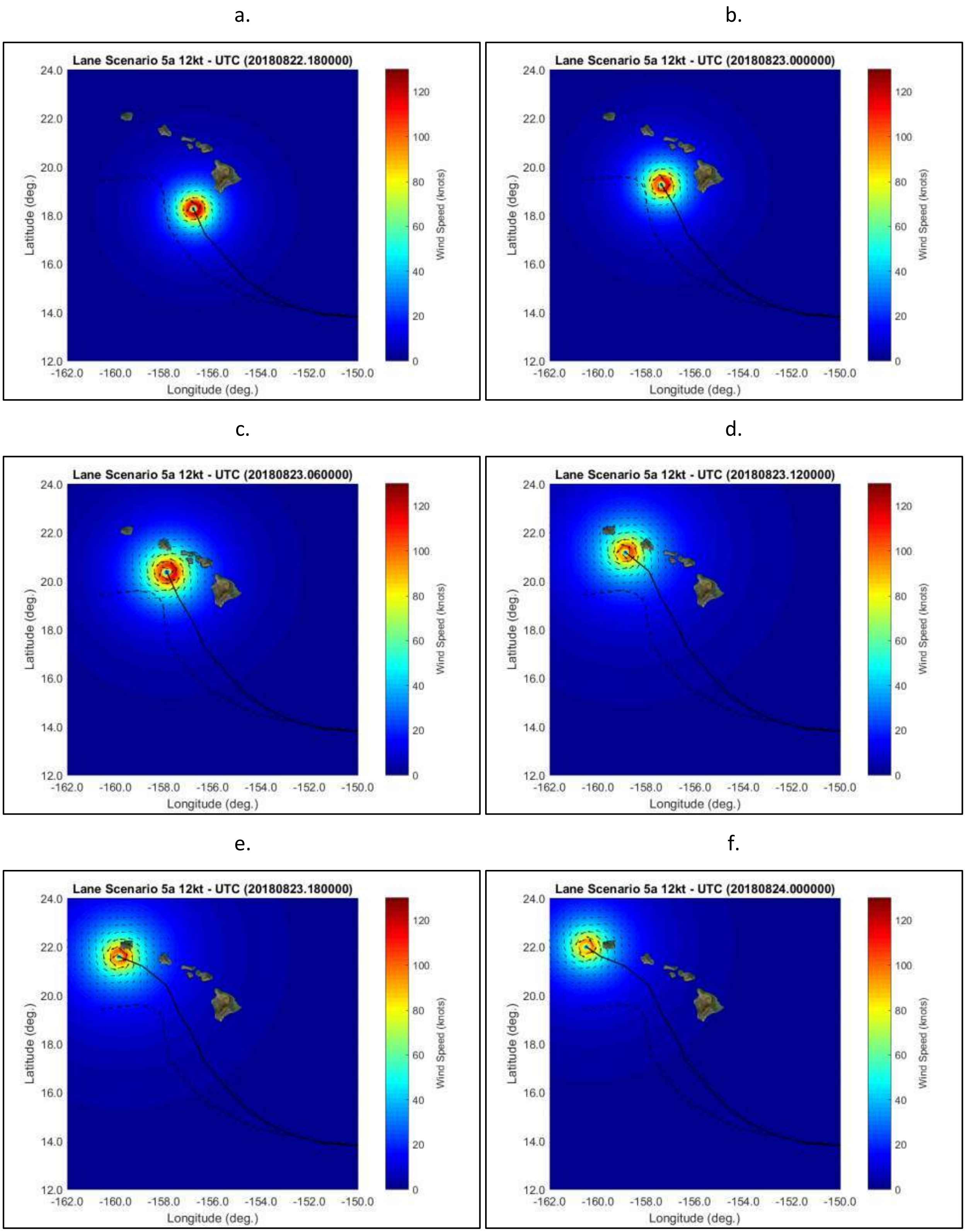


Figure 6-14. Hurricane scenario *5a_12kt* modeled wind field through the Hawaii domain (solid line indicates hurricane scenario track; dashed line indicates original hurricane Lane track)

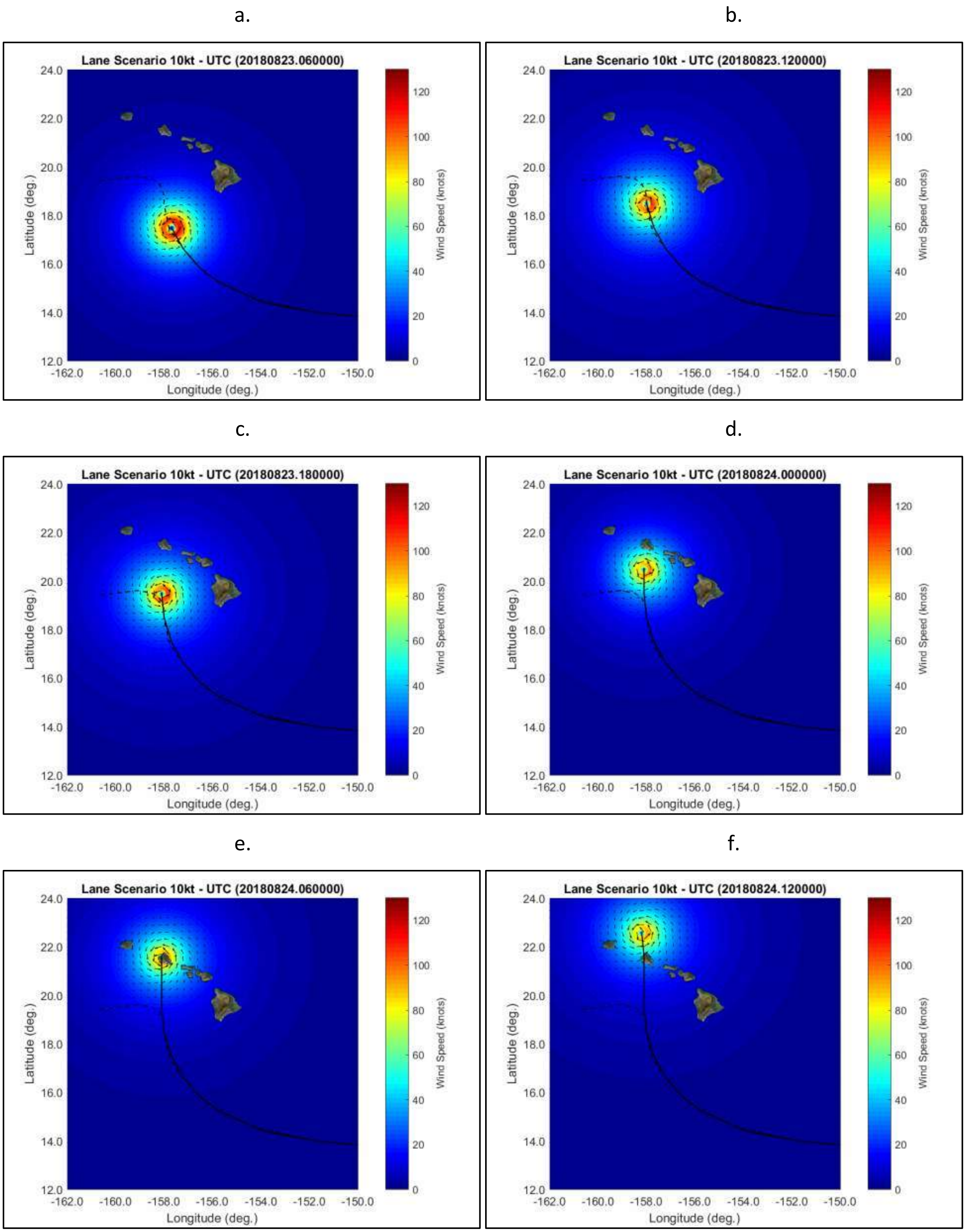


Figure 6-15. Hurricane scenario *10kt* modeled wind field through the Hawaii domain (solid line indicates hurricane scenario track; dashed line indicates original hurricane Lane track)

6.4 Wave Modeling

6.4.1 Introduction

The intent behind the hurricane wind modeling presented in the preceding section was to obtain the temporally and spatially changing theoretical wind fields for a specific duration of time for Hurricane Lane, as well as those associated with the four scenario hurricane tracks; the wind field data will serve as the driving mechanism for wave generation in the following models. Resulting wind field data consisted of a *hindcast*‡ of Hurricane Lane along with the four alternate Hurricane Lane scenario cases provided by NOAA.

When site-specific wave conditions are required, it is common practice in numerical wave modeling to start with a large-scale model at a relatively low resolution, and *nest* successively higher resolution models within the larger domain. This strategy allows for satisfactory representation of large-scale oceanic wave conditions at a corresponding lower resolution, while reserving the computationally intensive high-resolution modeling for the nearshore areas of interest where conditions change rapidly over short distances. This configuration is also required for hurricane tracks which travel over large distances and may generate wave fields over a large fetch. In this type of configuration, the higher resolution model exists 'inside' the lower resolution model and is provided input wave or other relevant conditions at the boundary between the inner and outer models.

As the first step, the large scale (lower resolution) model, Delft3D-WAVE is utilized to generate and propagate waves within the central Pacific domain, which covers an area much larger than the Hawaiian Islands themselves. Delft3D-WAVE is computationally efficient and suitable for use in both deep and shallow water regions for this application. Finer resolution domains were nested within the central Pacific domain to resolve wave transformation around the Hawaiian Islands and into shallow water around Oahu and West Oahu.

The SWAN model, used by Delft3D-WAVE, is a spectral model, meaning it calculates the propagation of energy contained in a distribution of wave frequencies. The distributions are sensitive to wave transformation and propagation phenomena such as wave generation and growth, frequency dispersion, and wave breaking. Wave frequency dispersion causes low frequency waves (i.e., longer period waves) to travel faster than high frequency (shorter period) waves in deep water. The mixed seas represented by a broad spectrum within a storm (energy spread over many wave frequencies) will tend to be transformed into a narrow band spectrum (energy contained within a narrow range of wave frequencies—a self-sorting process) at large distances from the source storm as the lower frequency waves outrun those of higher frequencies. Similar types of transformations can occur within a surf zone as the highest waves (the most energetic part of the spectrum) break preferentially in deeper water. The spectral models are able to account for these changes and reproduce the range of wave heights and frequencies from their initial generation to dissipation in the surf zone.

The significant wave height, H_s is a useful parameter which is defined as the average of the highest one-third of waves in a given data set. It is often represented in spectral models by the term H_{mo}, which is the significant spectral wave height calculated using the variance of the energy density spectrum. The two

‡ *In oceanography and meteorology, hindcasting (also known as back-testing) is a method of testing a numerical model; researchers enter known or closely estimated inputs for past events into the model to see how well the output matches the known results.*

terms are approximately equivalent, and the H_s descriptor is used preferentially for the purposes of this study.

6.4.2 Deep Water Wave Model

The main purpose of the first tier SWAN model was to accurately apply scenario hurricane wind fields to the sea surface over all model domains in order to initiate and propagate wind driven waves into the model. These simulations assume that no other wave conditions are present (that is, there are no other distant or local source swells occurring at the same time such as a north or west swell, or trade wind waves). Figure 6-16 illustrates the deep water Delft3D-WAVE nesting scheme boundaries, with boundary coordinates and associated grid resolutions given in Table 6-4.

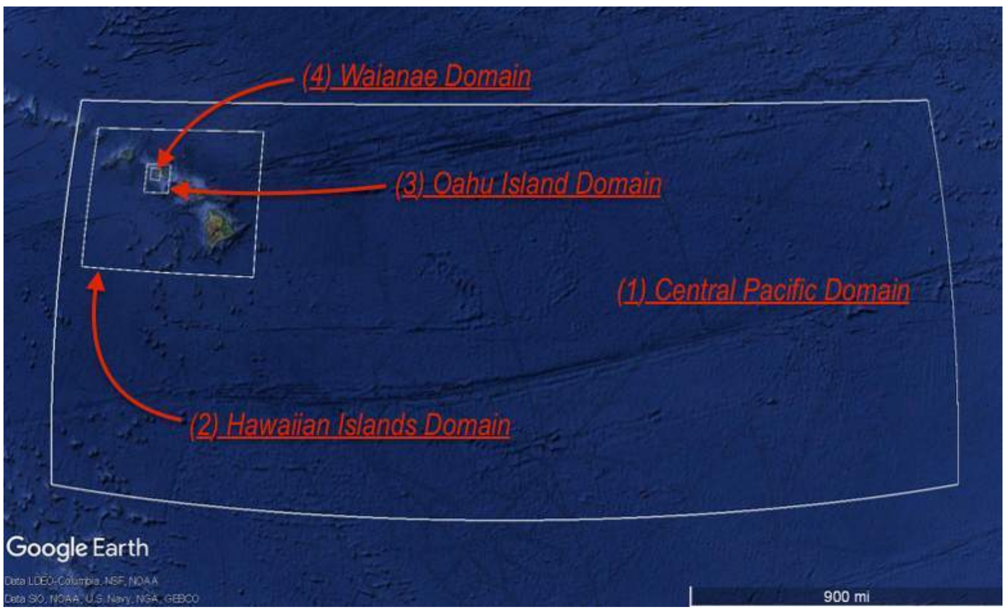


Figure 6-16. SWAN model domain - nesting layout. (*Background map credit: Google Earth)*

Table 6-4. SWAN grid boundaries and resolutions

Domain	Boundaries	Model Resolution
Central Pacific	10° N to 24°N Latitude, 128° E to 162° E Longitude	0.1°
Hawaii	18° N to 23°N Latitude, 154° E to 161° E Longitude	0.05°
Oahu	20.75° N to 21.75°N Latitude, 157.6° E to 158.6° E Longitude	0.01°
West Oahu	21.2° N to 21.6°N Latitude, 158° E to 158.4° E Longitude	0.002°

The SWAN model was run in a non-stationary mode, a setting which accounts for the propagation of the wave field through space and time. This is necessary for hurricane wave modeling over large distances where the wave field is changing with the moving wind field. Key inputs to the model included bathymetry (depths) and predicted scenario wind fields. Other model parameters included the following:

- Wave frequency range: 1.0 Hz – 0.05 Hz (Period range: 1.0 – 20.0 s)
- Wave frequency bins: 25
- Wave direction bins: 72 (5° resolution)
- Time step: 15 minutes

Bathymetric data for the SWAN model domains were obtained from the General Bathymetric Chart of the Oceans (GEBCO). The geographic resolution of the bathymetry for this dataset is approximately 0.01° (1 km).

6.4.2.1 Model Validation

It is important to validate numerical wave or other weather models using historical events with measured data in order to test the accuracy of the model. It was decided to use Hurricane Lane for such validation in this case, since the scenario hurricanes for this study were specifically developed from that particular storm, and sufficient data from that storm are readily available. The Delft3D-WAVE model was used to simulate waves generated by the theoretical wind field developed for Hurricane Lane, as previously discussed. Measured data obtained from the National Data Buoy Center (NDBC) buoy numbers 51002, 51003, 51004, and 51212 were used to validate the model output. Spatial output from the model as the hurricane propagates into and through the Hawaii domain are illustrated in Figure 6-17. The figure also provides the relative locations of the wave buoys, indicated by NDBC buoy number, with respect to the storm track. Figure 6-18 through Figure 6-21 plot the modeled wave parameters at each of the buoy locations (red lines) along with the measured observations plotted as discrete points marked by ‘X’.

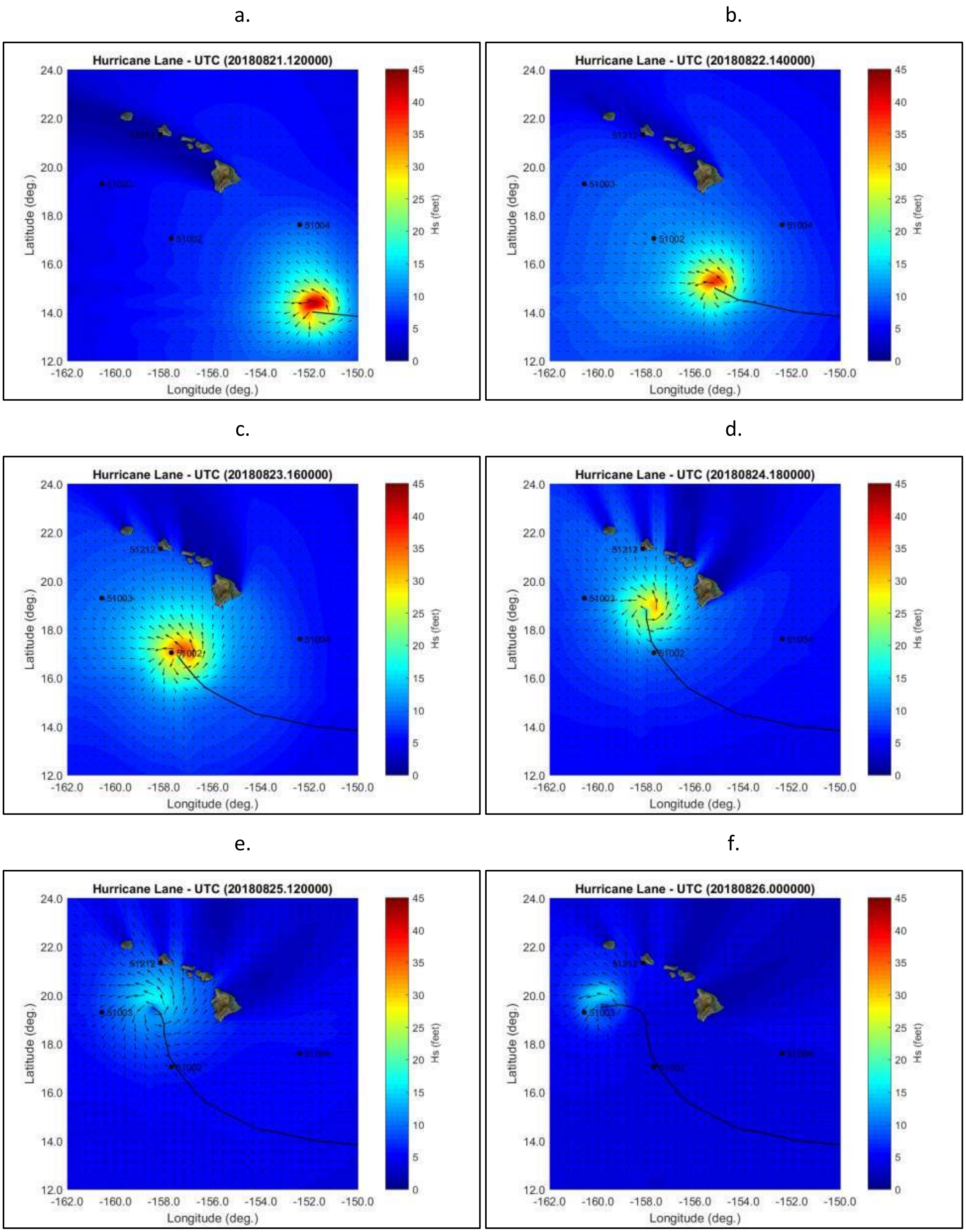


Figure 6-17. Hurricane Lane modeled significant wave height through the Hawaii domain (solid line indicates hurricane track)

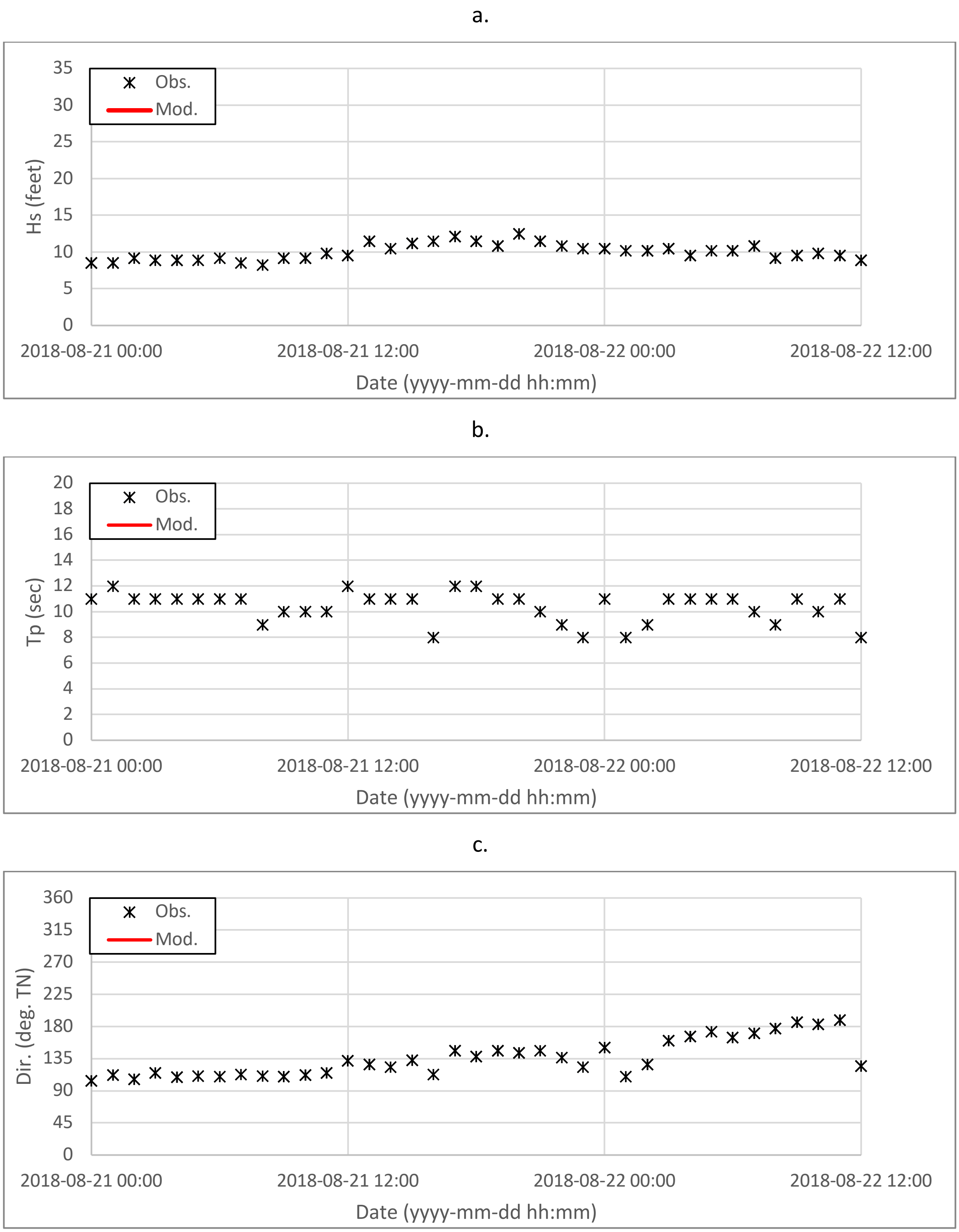


Figure 6-18. Comparison of model output at NDBC buoy 51004 (red line indicated model output; black dots indicate buoy observations)

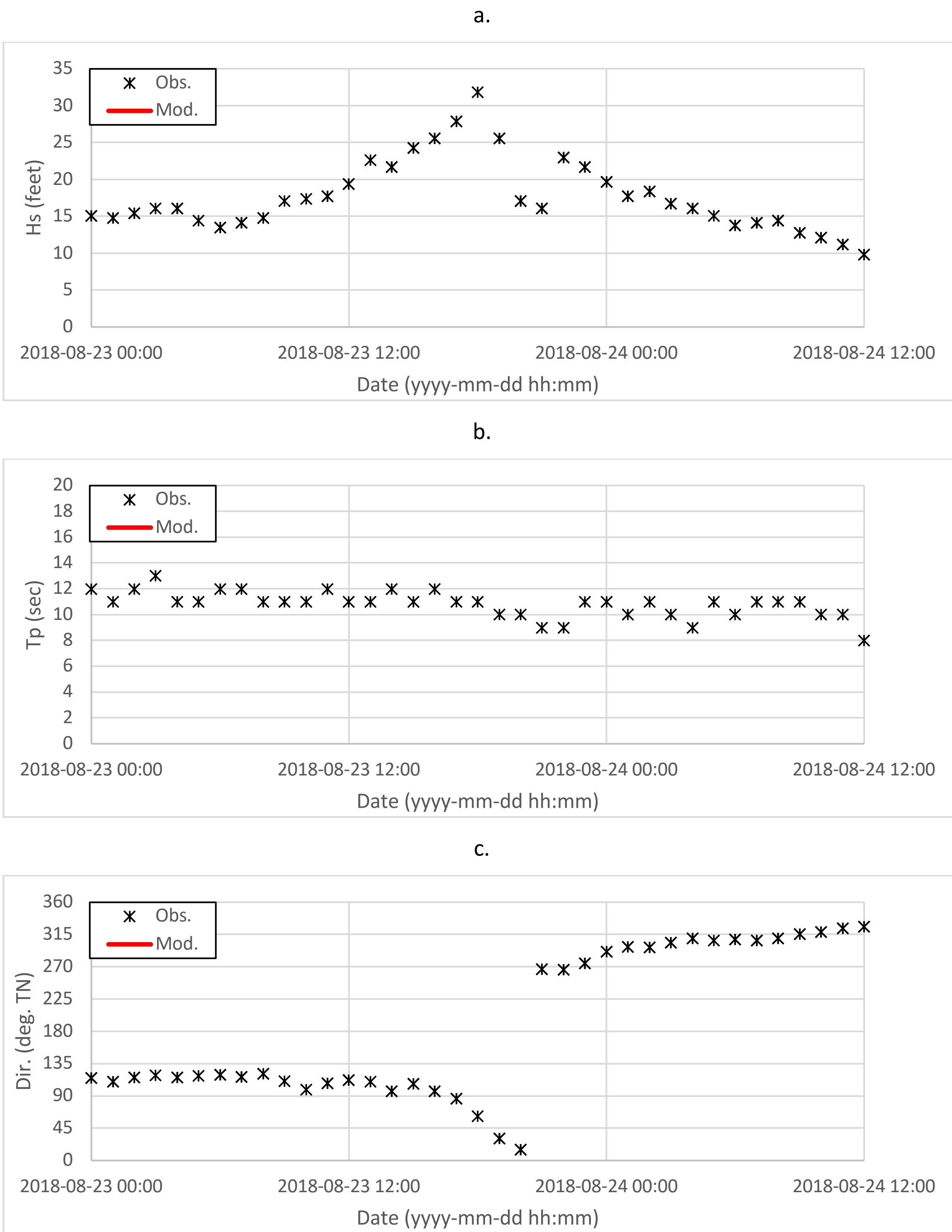
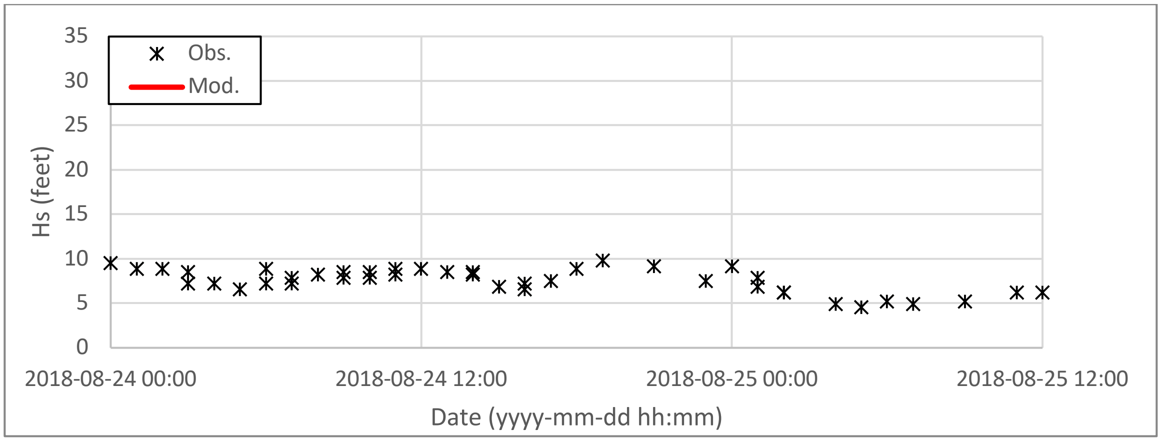
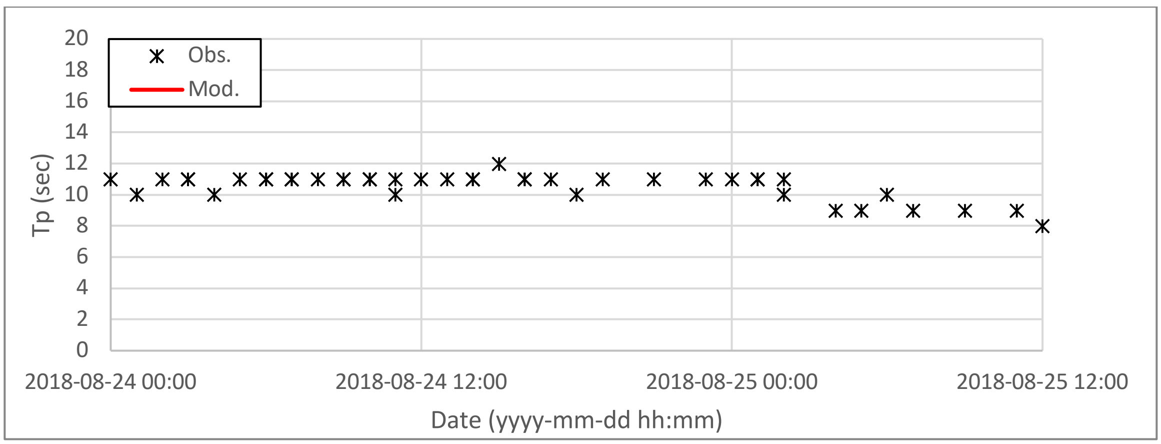


Figure 6-19. Comparison of model output at NDBC buoy 51002 (red line indicated model output; black dots indicate buoy observations)

a.



b.



c.

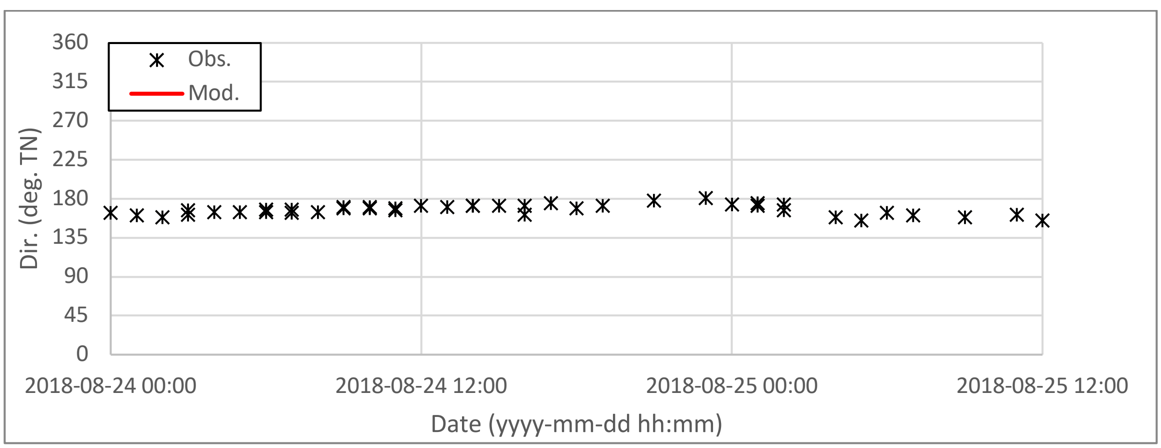


Figure 6-20. Comparison of model output at NDBC buoy 51212 (red line indicated model output; black dots indicate buoy observations)

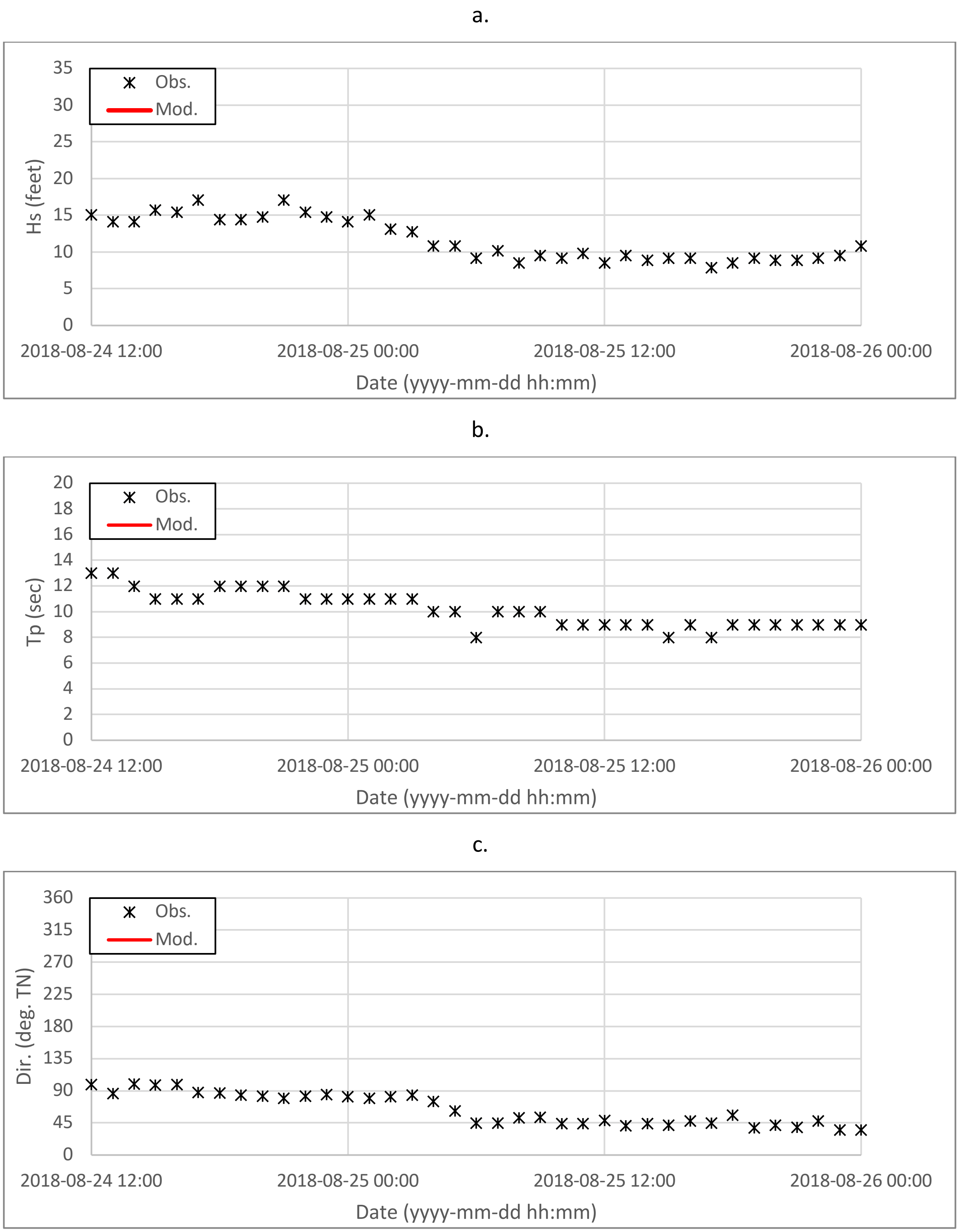


Figure 6-21. Comparison of model output at NDBC buoy 51003 (red line indicated model output; black dots indicate buoy observations

Buoy 51002 (Figure 6-19) shows that modeled arrival time of peak wave heights is a little earlier than reality, however it still resolves well the magnitude of the peak wave heights and general trends. Buoy 51003 (Figure 6-21) reveals an underprediction of the wave height as the hurricane travels north but shows good agreement as the storm tracks towards the buoy. Overall, the model shows good agreement with observations.

6.4.2.2 Scenario Hurricane Wave Fields

The deep water wave modeling process was used to generate wave fields for each of the scenario hurricane tracks developed for this study. Figure 6-22 through Figure 6-25 present the spatial output from the model for each of the hurricane scenarios at 6-hour increments as they move through the Hawaii domain. Time-varying output at the offshore boundary of the nearshore Delft3D-WAVE/FLOW model are shown in Figure 6-26 through Figure 6-28. The maximum wave conditions at the offshore boundary are summarized in Table 6-5.

The figures illustrate the wave field as it propagates through the Hawaiian Islands for each scenario storm, and reveal graphically how the swell interacts with the islands at each time step, creating shadow areas in some locations (dark blue areas in Figure 6-22 through Figure 6-25) and focusing energy in others (dark red areas). The actual path of Hurricane Lane is shown for reference in the figures, plotted as a dashed black line.

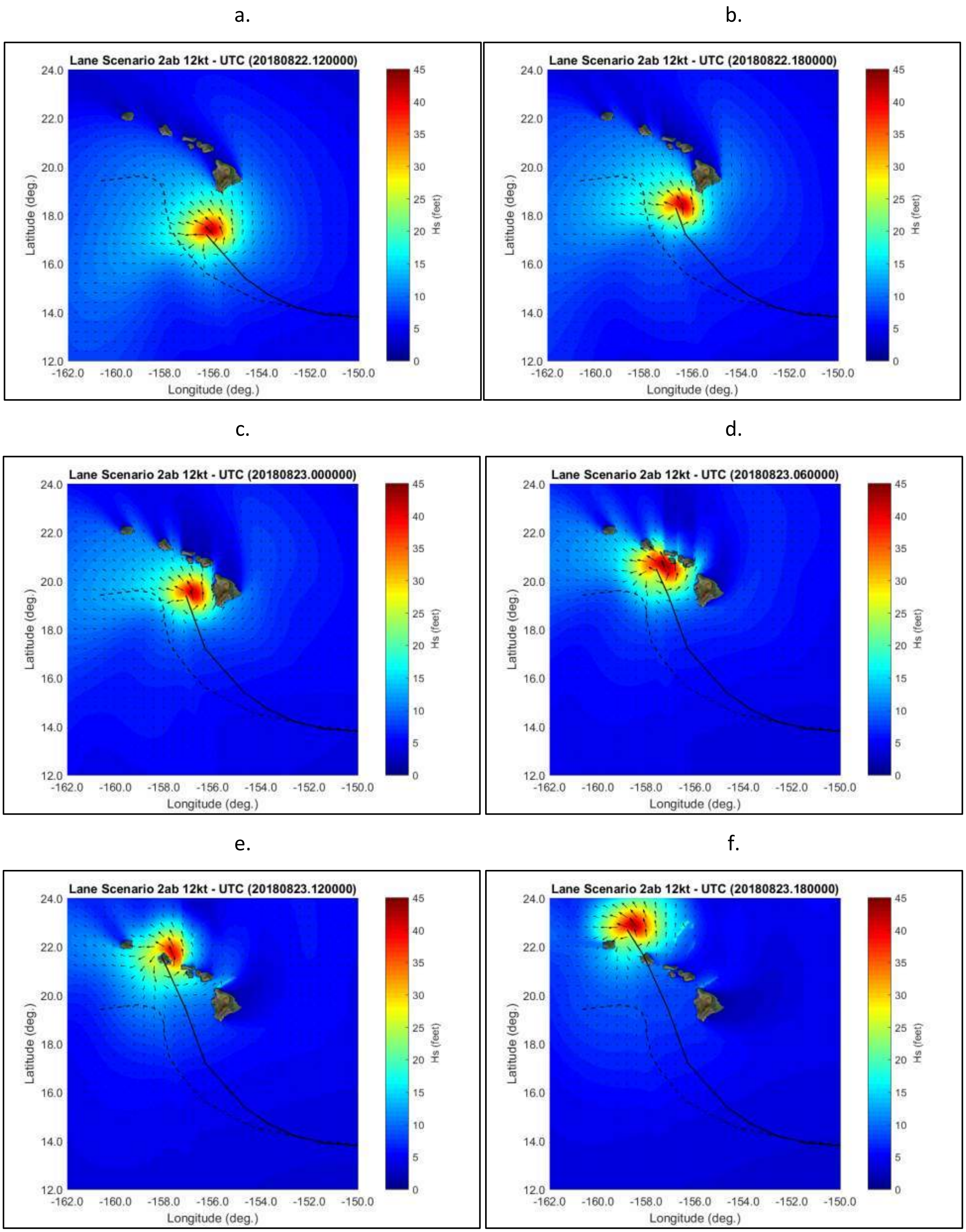


Figure 6-22. Hurricane Lane Scenario *2ab_12kt* modeled significant wave height through the Hawaii domain (solid line indicates hurricane scenario track; dashed line indicates original hurricane Lane track)

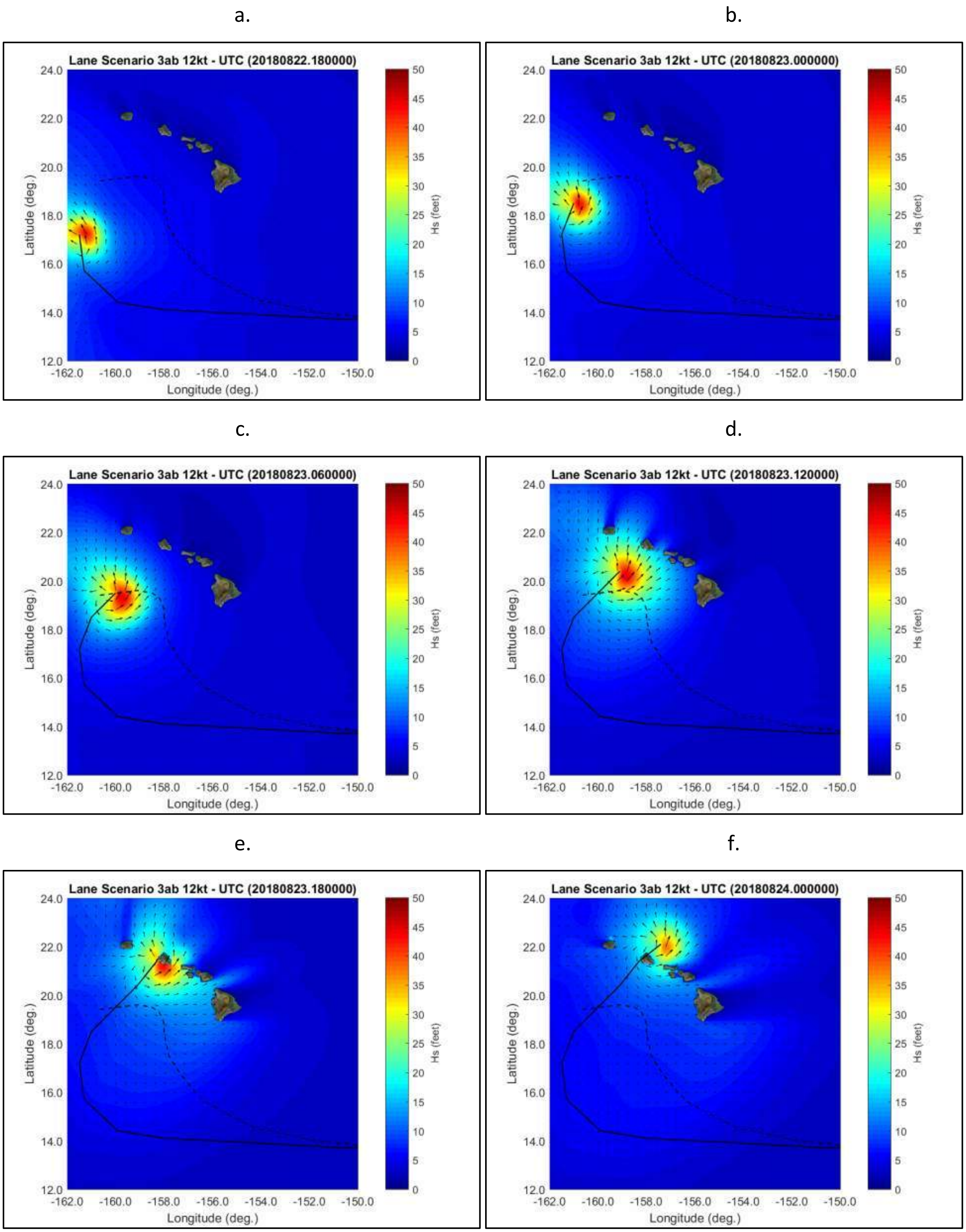


Figure 6-23. Hurricane Lane Scenario *3ab_12kt* modeled significant wave height through the Hawaii domain (solid line indicates hurricane scenario track; dashed line indicates original hurricane Lane track)

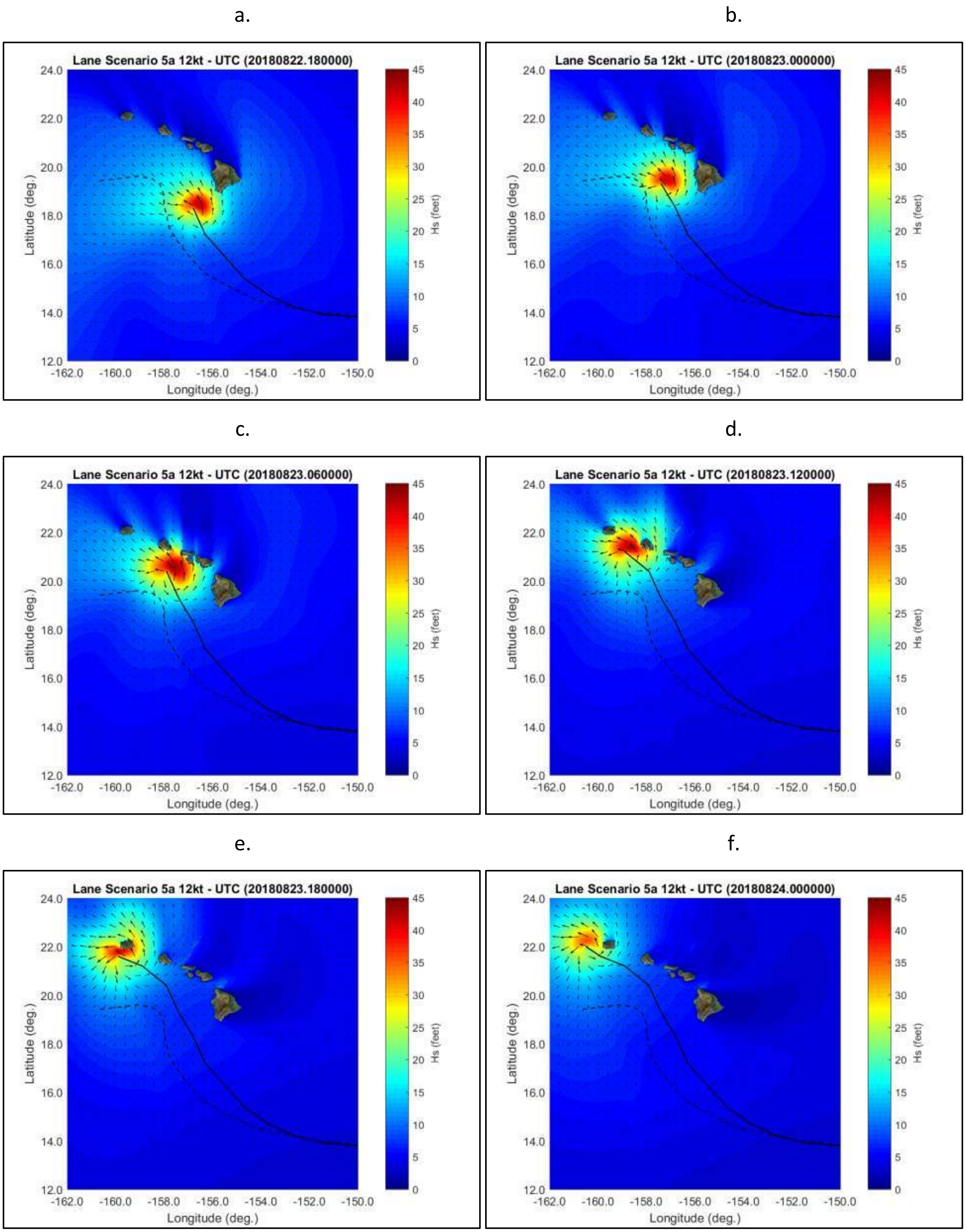


Figure 6-24. Hurricane Lane Scenario *5a_12kt* modeled significant wave height through the Hawaii domain (solid line indicates hurricane scenario track; dashed line indicates original hurricane Lane track)

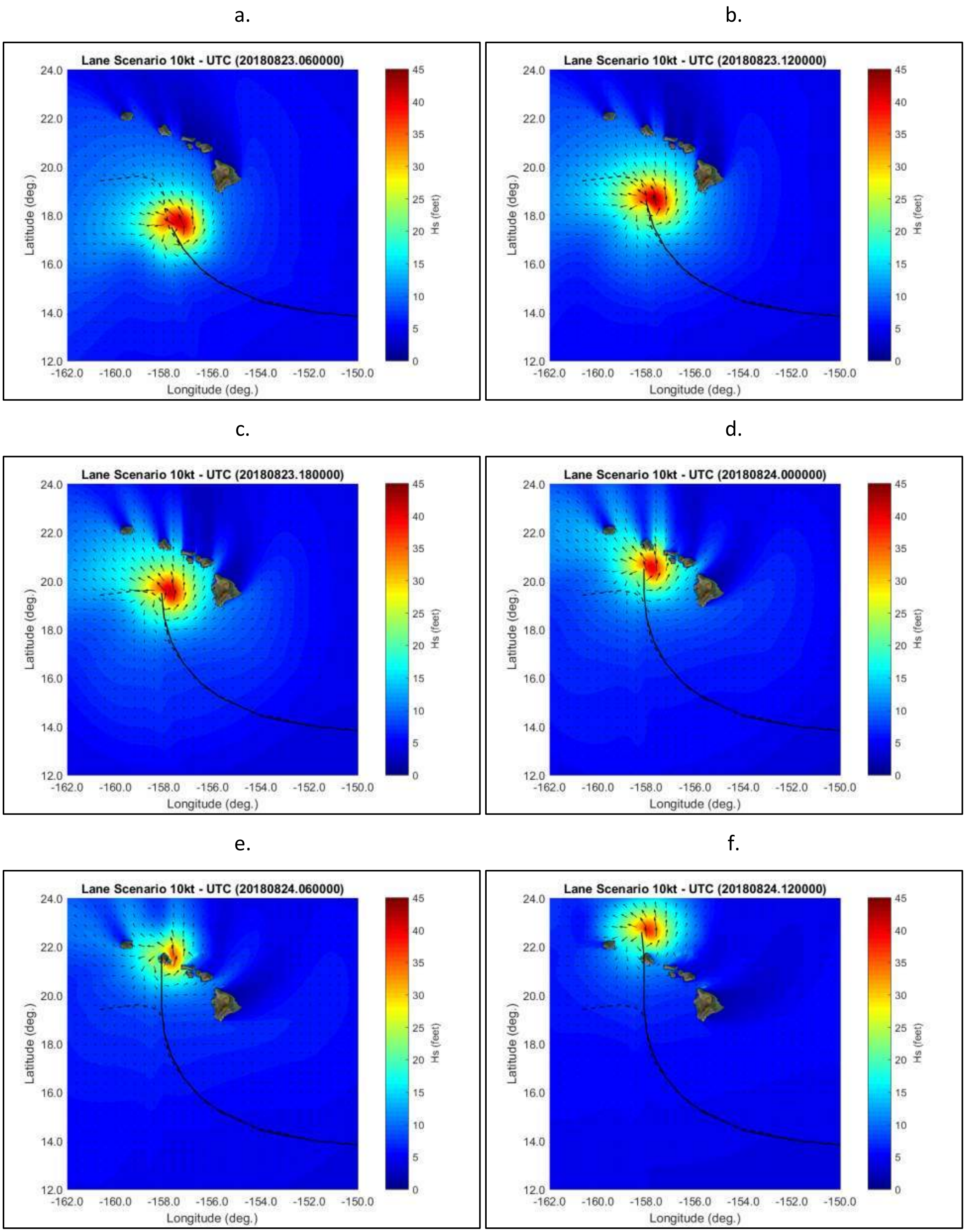


Figure 6-25. Hurricane Lane Scenario *10kt* modeled significant wave height through the Hawaii domain (solid line indicates hurricane scenario track; dashed line indicates original hurricane Lane track)

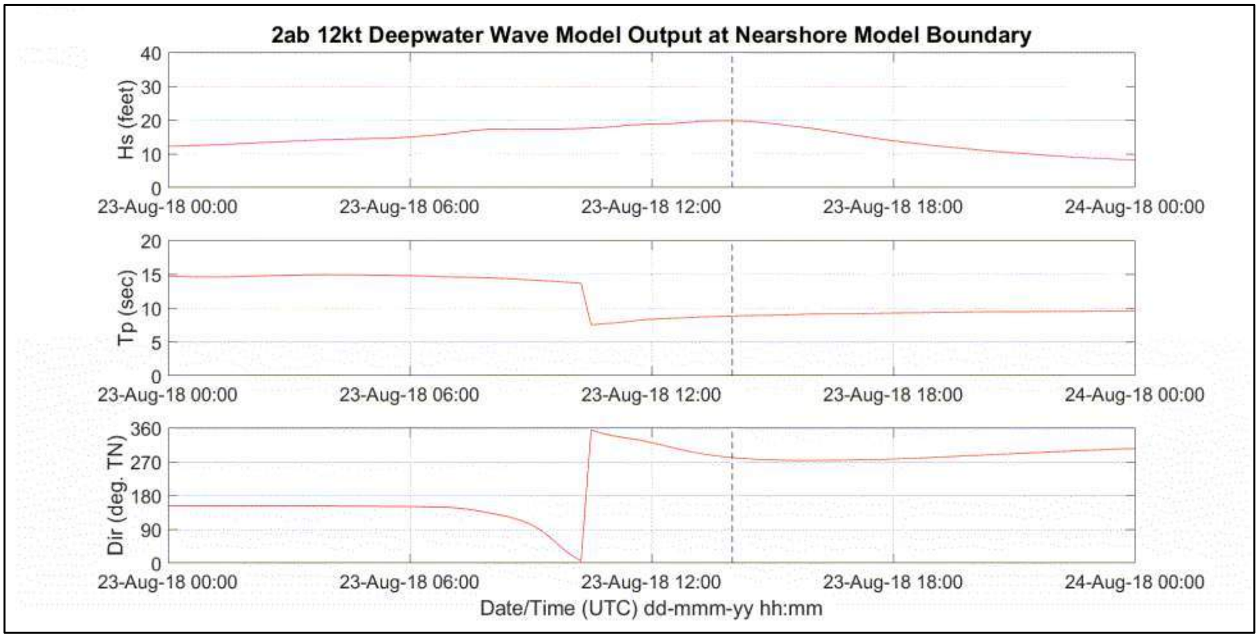


Figure 6-26. Scenario *2ab_12kt* modeled wave parameters at offshore location of nearshore WAVE/FLOW model (dashed line indicates the maximum wave height and corresponding peak period and direction)

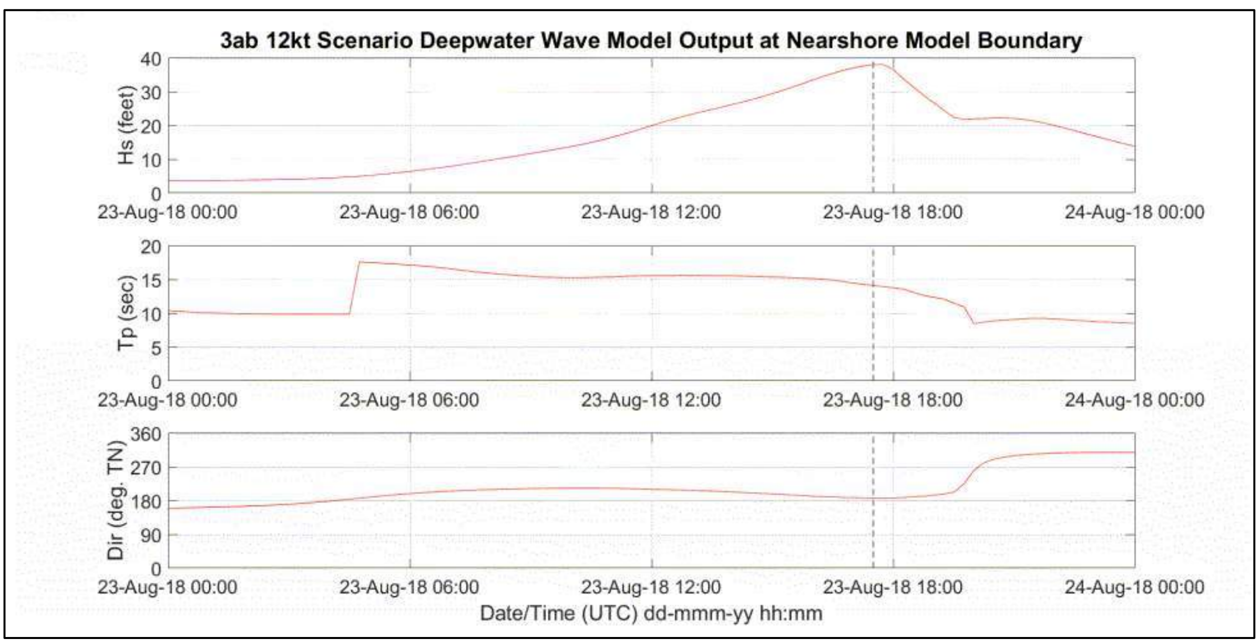


Figure 6-27. Scenario *3ab_12kt* modeled wave parameters at offshore location of nearshore WAVE/FLOW model (dashed line indicates the maximum wave height and corresponding peak period and direction)

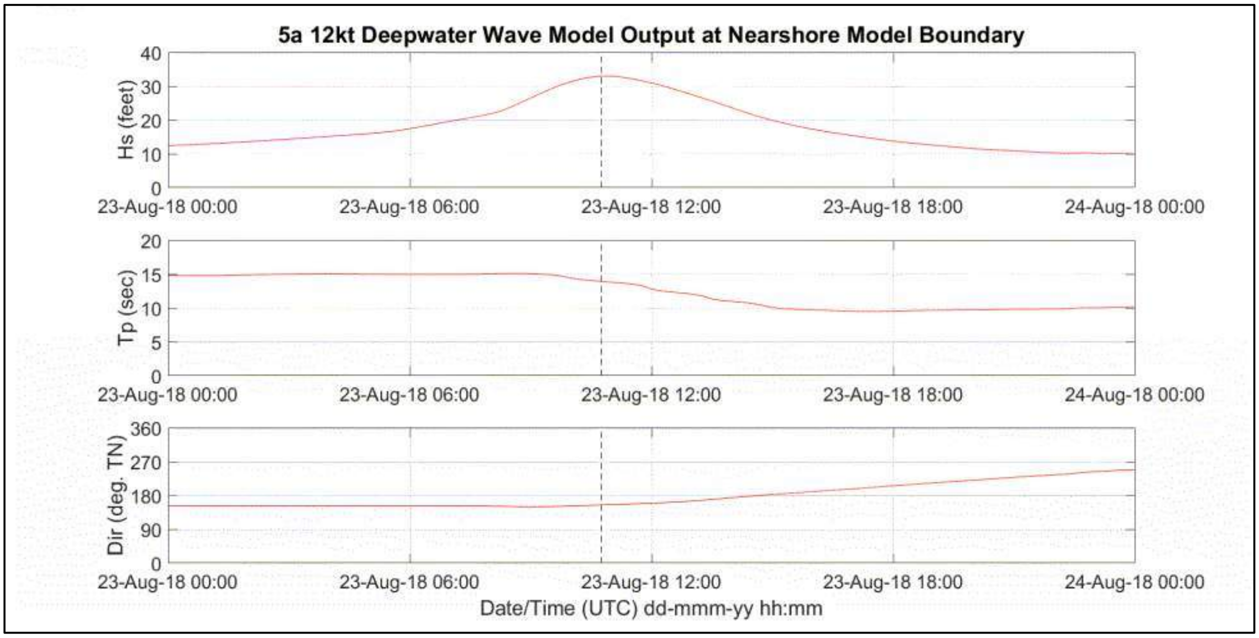


Figure 6-28. Scenario *5a_12kt* modeled wave parameters at offshore location of nearshore WAVE/FLOW model (dashed line indicates the maximum wave height and corresponding peak period and direction)

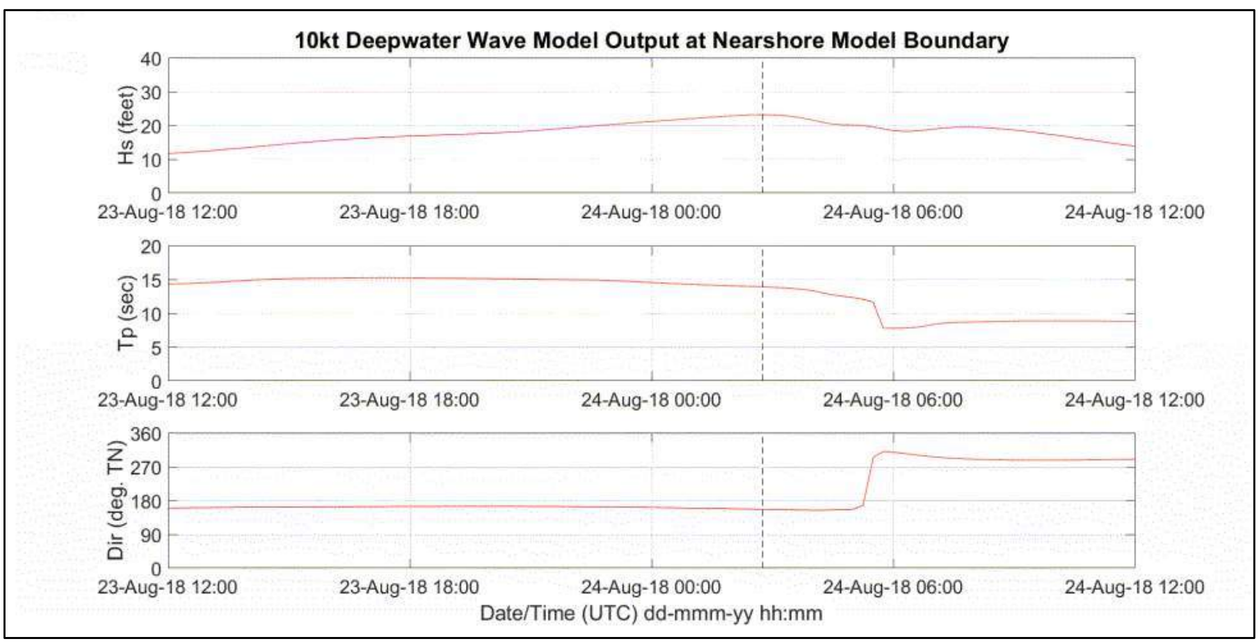


Figure 6-29. Scenario 10kt modeled wave parameters at offshore location of nearshore WAVE/FLOW model (dashed line indicates the maximum wave height and corresponding peak period and direction)

Table 6-5. Summary of peak wave conditions at the Delft3D-WAVE/FLOW model boundary

Hurricane Scenario	Date/Time (UTC) yyyymmdd hh:mm	H_s (ft)	H_s (m)	T_p (s)	D_p (deg. TN)
2ab_12kt	20180823 14:00	19.8	6.0	8.8	281
3ab_12kt	20180823 17:30	38.0	11.6	14.1	186
5a_12kt	20180823 10:45	33.0	10.1	13.9	155
10kt	20180824 02:45	23.2	7.1	13.9	156

6.4.3 Nearshore Wave Model

A key objective of the nearshore coupled Delft3D-WAVE/FLOW model was to take the deep water hurricane wave conditions modeled by the Delft3D-WAVE (SWAN) model and transform them from the offshore boundary into transitional and shallow water within the Waianae ocean outfall vicinity. A second goal of the model was to quantify wave-generated currents around the outfall from the scenario conditions. The online coupled configuration between the Delft3D-WAVE and Delft3D-FLOW models develops a depth-averaged flow and wave height field for each time step in the scenario conditions.

A telescoping grid was developed for the nearshore WAVE/FLOW model domain where the grid is made variable over the model domain. The grid generated for this study has a resolution of approximately 165 feet near the deep offshore boundaries of the model and a resolution of approximately 30 feet in the vicinity of the outfall. The Delft3D-WAVE/FLOW model domain boundary is shown in Figure 6-30 relative to the outfall (black line). The gridded input model bathymetry in the vicinity of the outfall is shown in Figure 6-31.

Figure 6-30. Boundaries of the Delft3D-WAVE/FLOW domain relative to the outfall.

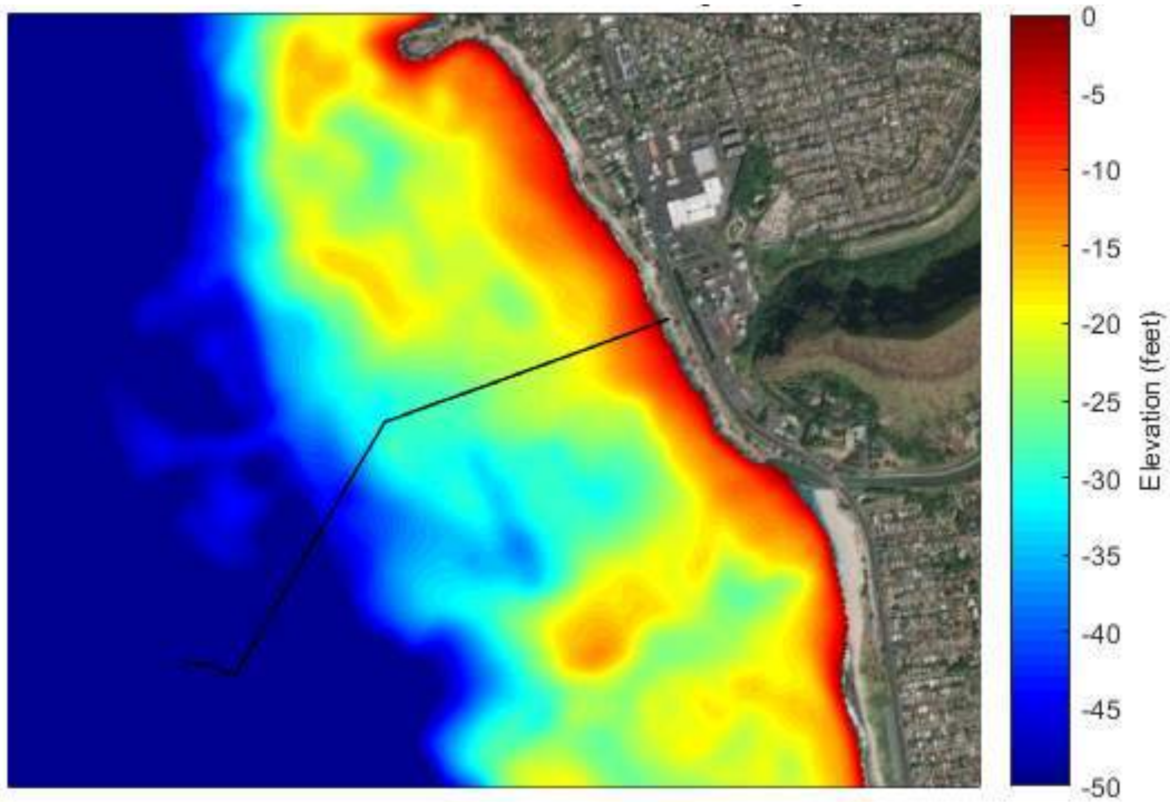


Figure 6-31. Delft3D-WAVE/-FLOW model bathymetry in the vicinity of the outfall (bathymetry only shows inshore of the breaker zone at the 50-foot contour)

6.4.3.1 Nearshore Scenario Hurricane Wave Heights

Each wave transformation model was driven by a time series of spectral wave heights generated by SWAN and imposed at the offshore (deep water) boundaries. The time series was 24 hours in duration for each scenario during maximum wave conditions. Figure 6-32 through Figure 6-35 show significant wave heights in the project area for each hurricane scenario. The direction of wave propagation is indicated by the field of vector arrows. The wave height scale is consistent between figures for ease of comparison.

For all scenarios the wave approach is generally from the southwest direction with wave approach just offshore of the outfall ranging from near orthogonal to highly oblique with respect to the general trend of the shoreline and bathymetry. The outfall alignment is provided in each figure for reference and color scale ranges from 0 to 30 feet for all cases for ease of comparison. From the results, it is clear that scenario 3ab_12kt (Figure 6-33) causes the largest wave heights in the immediate vicinity of the outfall pipeline.

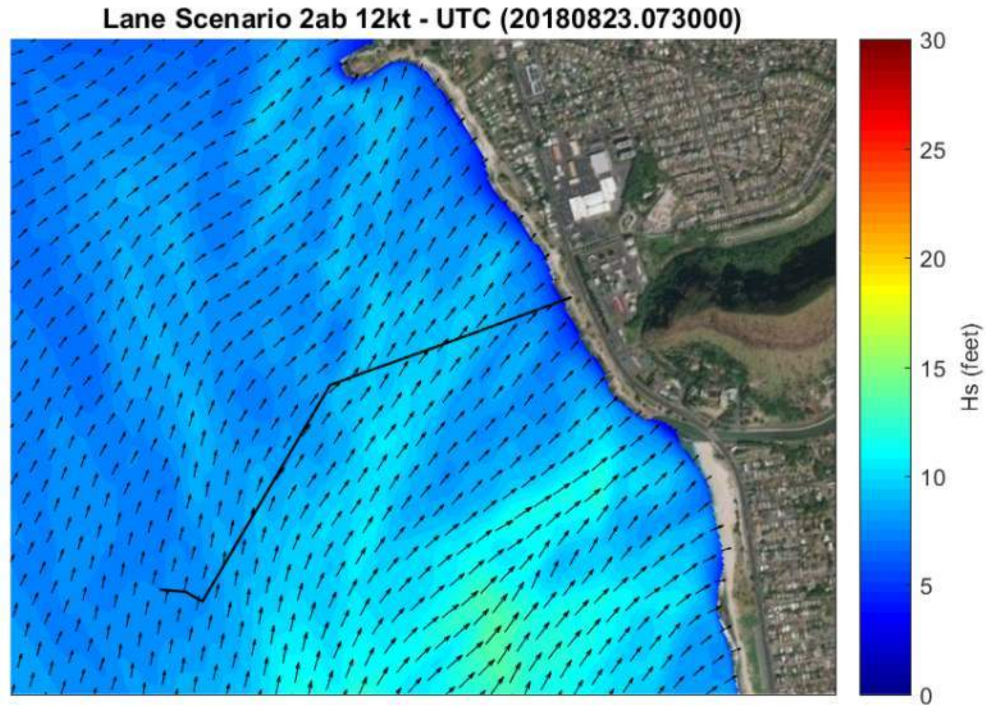


Figure 6-32. Lane Scenario 2ab_12kt modeled wave heights in the vicinity of the outfall

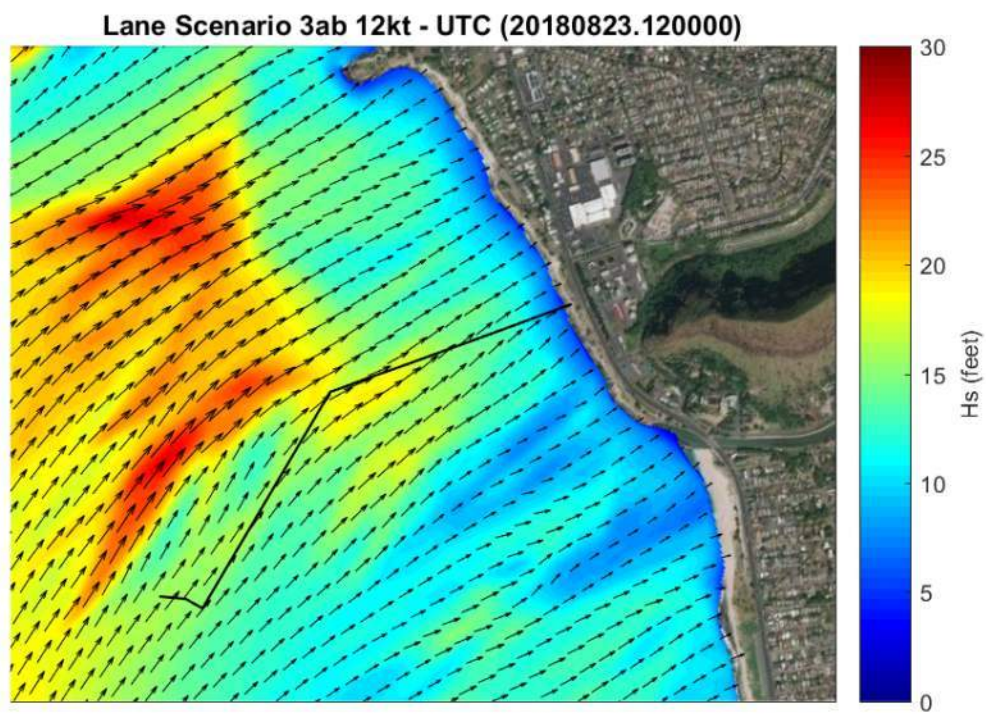


Figure 6-33. Lane Scenario 3ab_12kt modeled wave heights in the vicinity of the outfall

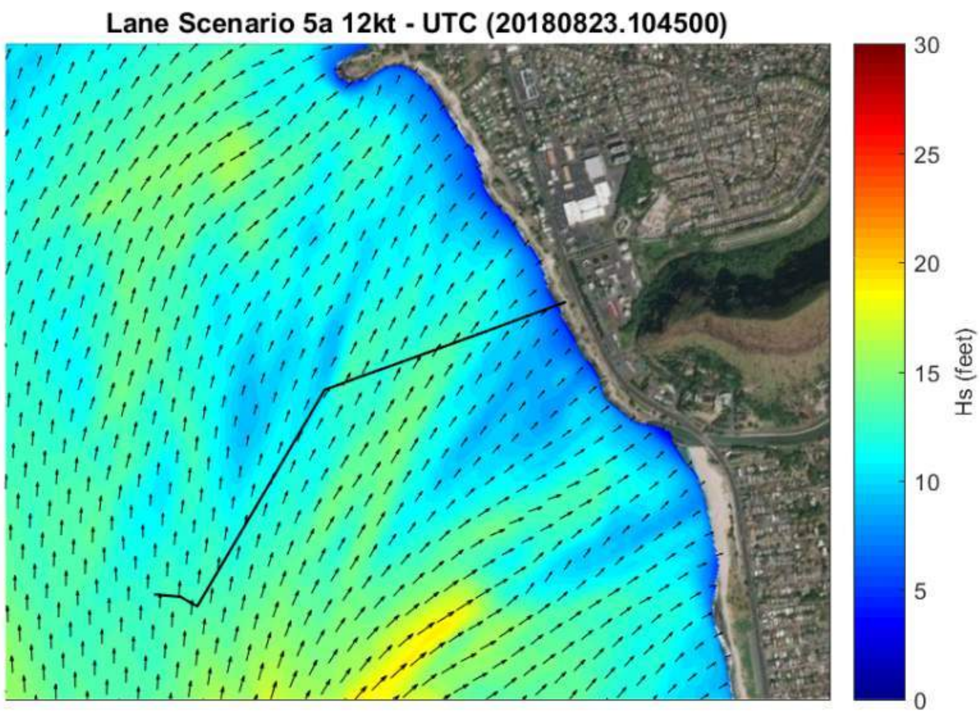


Figure 6-34. Lane Scenario 5a_12kt modeled wave heights in the vicinity of the outfall

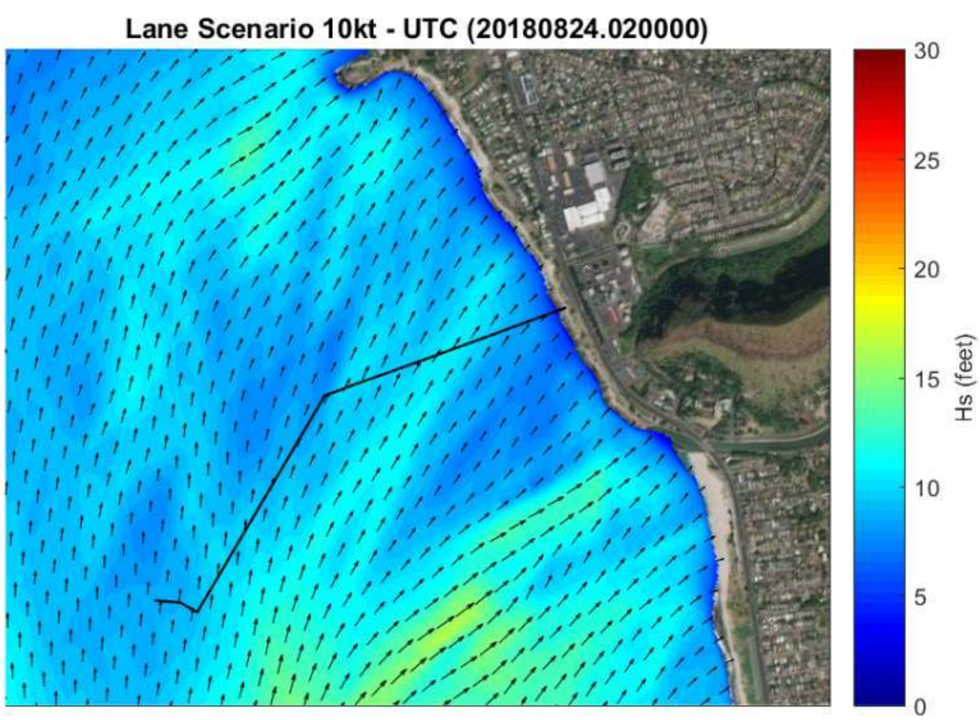


Figure 6-35. Lane Scenario 10kt modeled wave heights in the vicinity of the outfall

6.4.3.2 Nearshore Scenario Hurricane Nearshore Circulation

Simultaneously with the wave computations, the coupled flow model (Delft3D-FLOW) used wave parameters – wave height (H_s), wave period (T_p), and wave direction (D_p) - over the computational domain for each time step. The flow model then computed depth-averaged wave generated current speed and direction for the same computational domain. The flow data was in turn passed back to the wave model for calculation of the effects of the currents on the waves themselves. The utility of a coupled model is the ability to resolve the effects of interrelated phenomena.

Figure 6-36 through Figure 6-39 present representative results of the circulation models, with current magnitude scaled by color contours, and current direction indicated by the vector arrows. Numerical results from the coupled circulation model showed that for most scenarios, maximum flow tended to occur over various regions of the outfall between station 10+00 and the junction box. For scenarios *2ab_12kt*, *5a_12kt*, and *10kt* the currents are predominately in the longshore direction and tend to move from south to north. For scenario *3ab_12kt* the current pattern is more sporadic but still generates longshore currents moving from north to south. In all cases the current pattern is essentially perpendicular to the outfall alignment inshore, which would tend to maximize hydrodynamic forces on the structure. The maximum water velocities were found to occur in scenario 3ab_12kt (Figure 6-37), which is consistent with the fact that maximum wave heights also occur in this case.

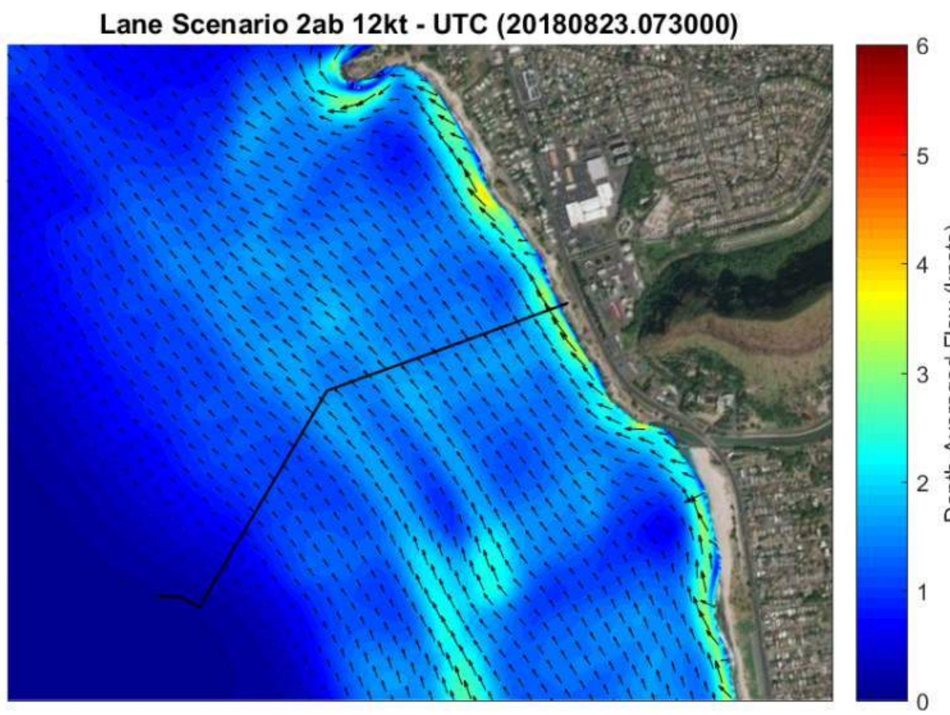


Figure 6-36. Lane Scenario 2ab_12kt modeled wave-generated currents in the vicinity of the outfall

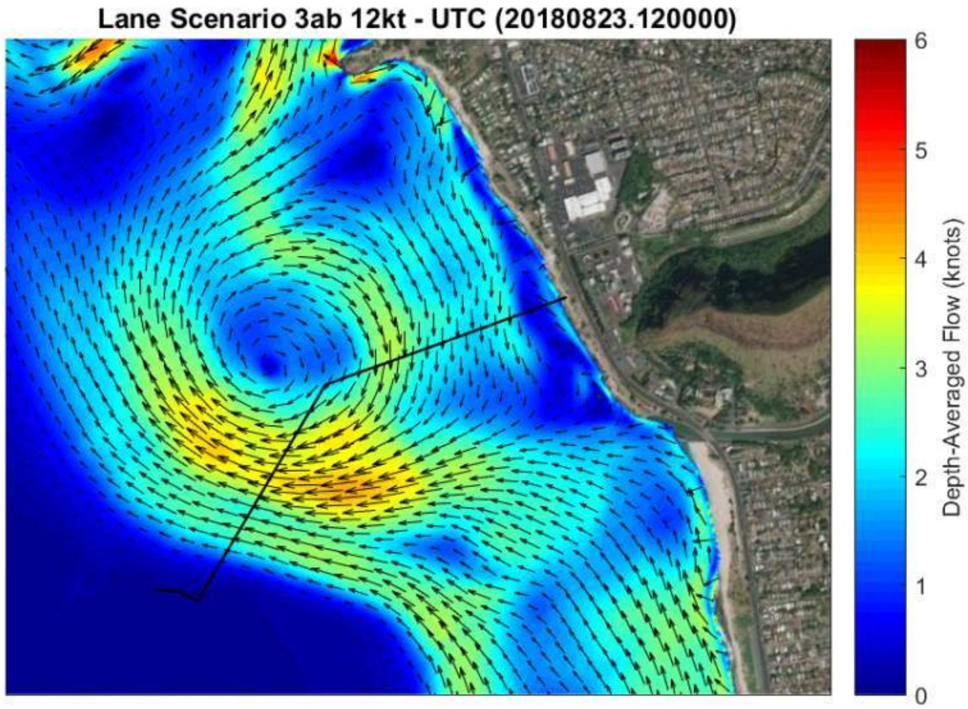


Figure 6-37. Lane Scenario 3ab_12kt modeled wave-generated currents in the vicinity of the outfall

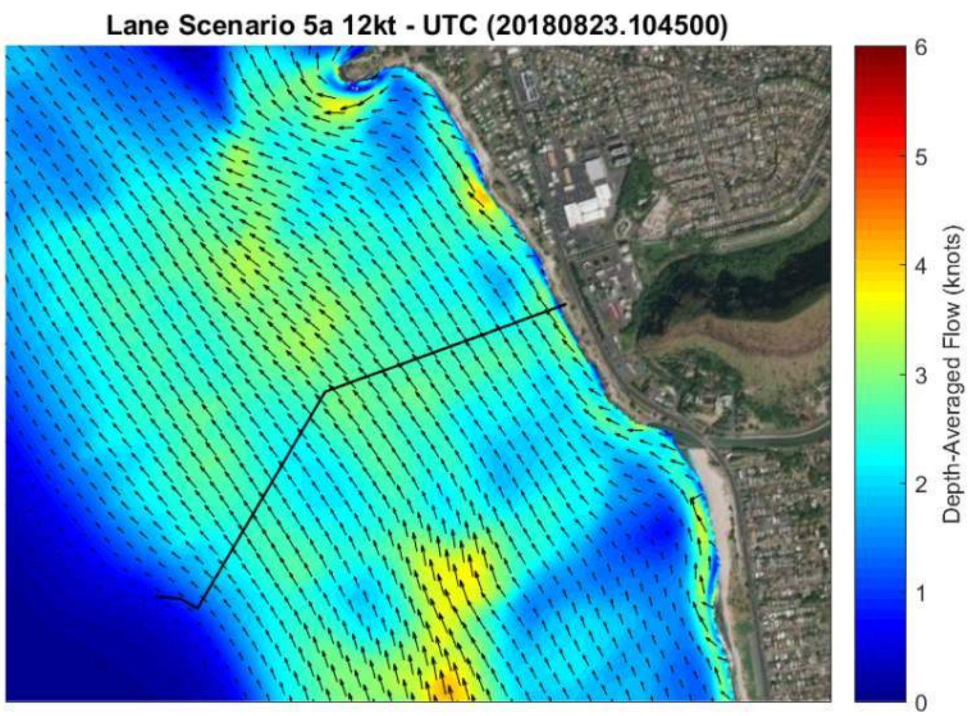


Figure 6-38. Lane Scenario 5a_12kt modeled wave-generated currents in the vicinity of the outfall

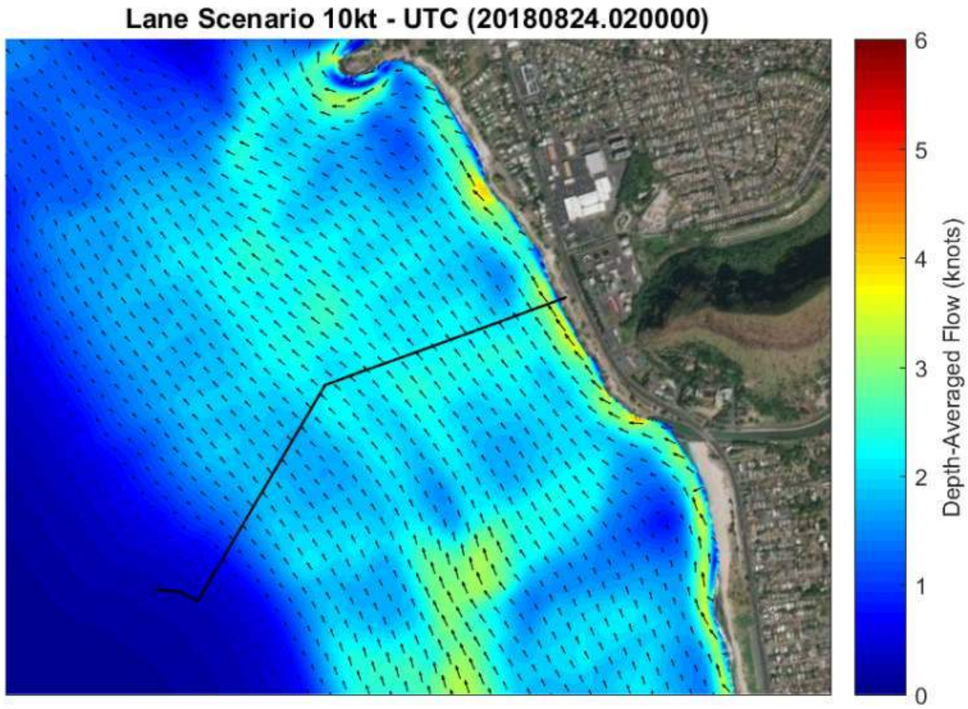


Figure 6-39. Lane Scenario 10kt modeled wave-generated currents in the vicinity of the outfall

6.4.3.3 Maximum Wave Generated Currents and Wave Heights

Plots of maximum current speed and significant wave height at these locations as a function of time of the scenario hurricane passage are presented in Figure 6-40 through Figure 6-43. For scenarios 2ab_12kt and 10kt the maximum current velocity and maximum significant wave height do not coincide at the same instant in time. The maximum flow characteristics for these scenarios were chosen at the time when the instantaneous velocity is maximum. The maximum instantaneous velocity (depth-averaged flow plus the orbital velocity) was found to occur when the depth-averaged velocity is maximum. In addition to the significant wave height, the maximum wave height was calculated as the smaller of 2 times the significant wave height (statistical maximum based on the Rayleigh distribution) or 0.78 times the water depth (depth-limited wave height).

A summary of maximum depth-averaged current speeds along with corresponding significant wave height and maximum wave height reported at six locations along the original 36-inch outfall are presented in Table 6-6. The locations selected correspond to areas of pipeline that are ballasted or have some other feature of interest, and include the special wye structure, and stations 26+00, 25+00, 23+00, 21+00, 10+00. Of note in the table is the trend of decreasing wave height with decreasing station number, which is expected since maximum possible wave height is depth limited by breaking and generally follows the rule:

$$H_{breaking} = 0.78 \text{ x depth}$$

Therefore, the highest wave heights are expected at the deepest part of the outfall. However, we are most interested in the areas of outfall most at risk, which translates to interest in the deepest ballasted portions of outfall.

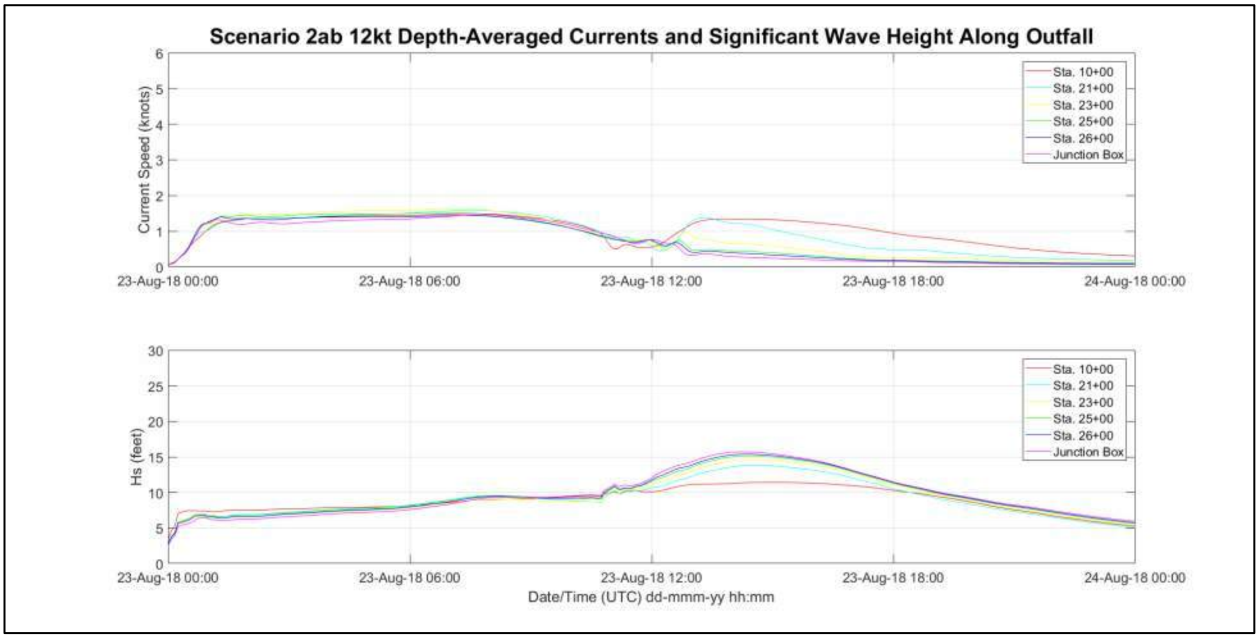


Figure 6-40. Scenario *2ab_12kt* modeled current speed and significant wave height over the simulation time frame

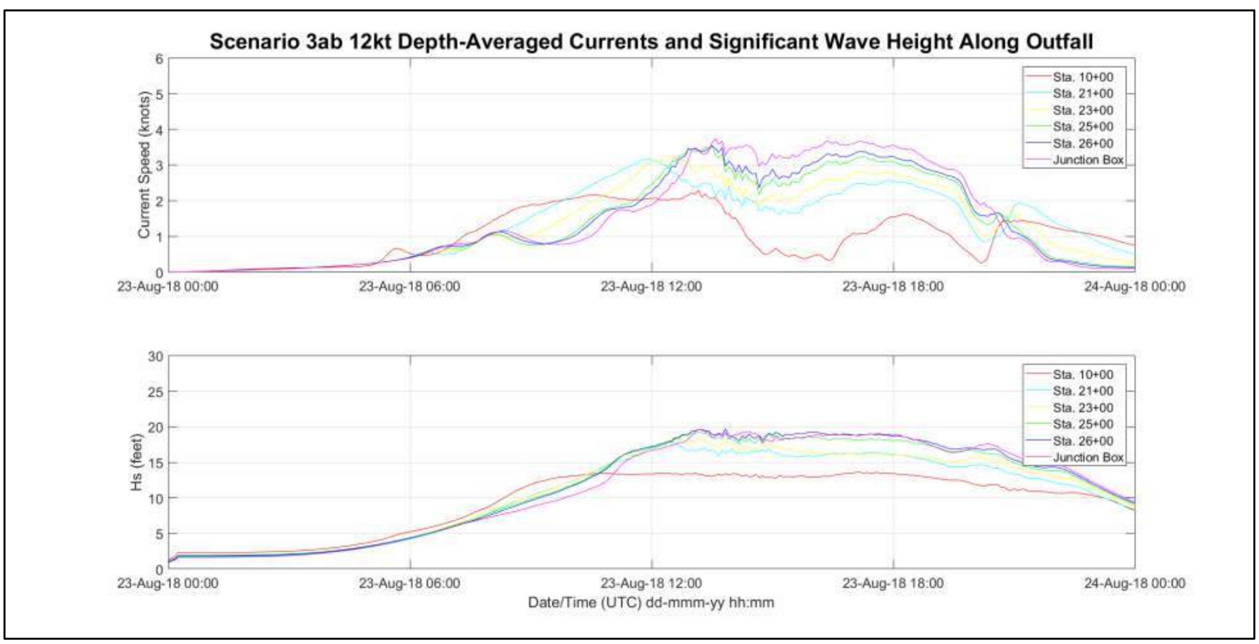


Figure 6-41. Scenario *3ab_12kt* modeled current speed and significant wave height over the simulation time frame

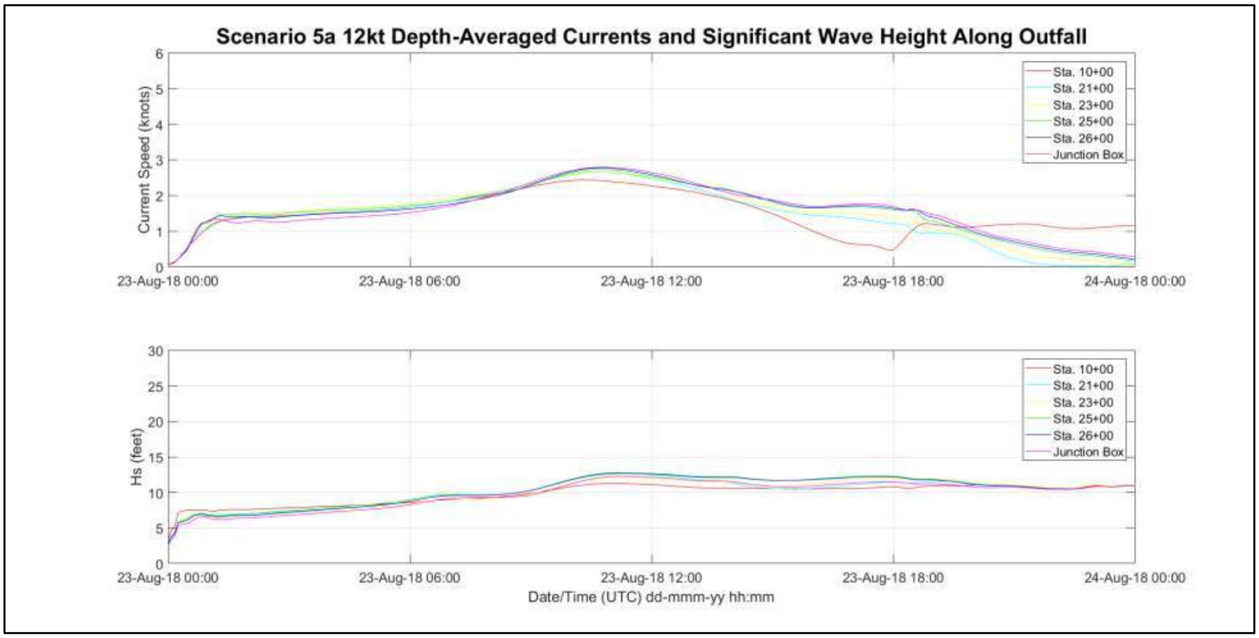


Figure 6-42. Scenario *5a_12kt* modeled current speed and significant wave height over the simulation time frame

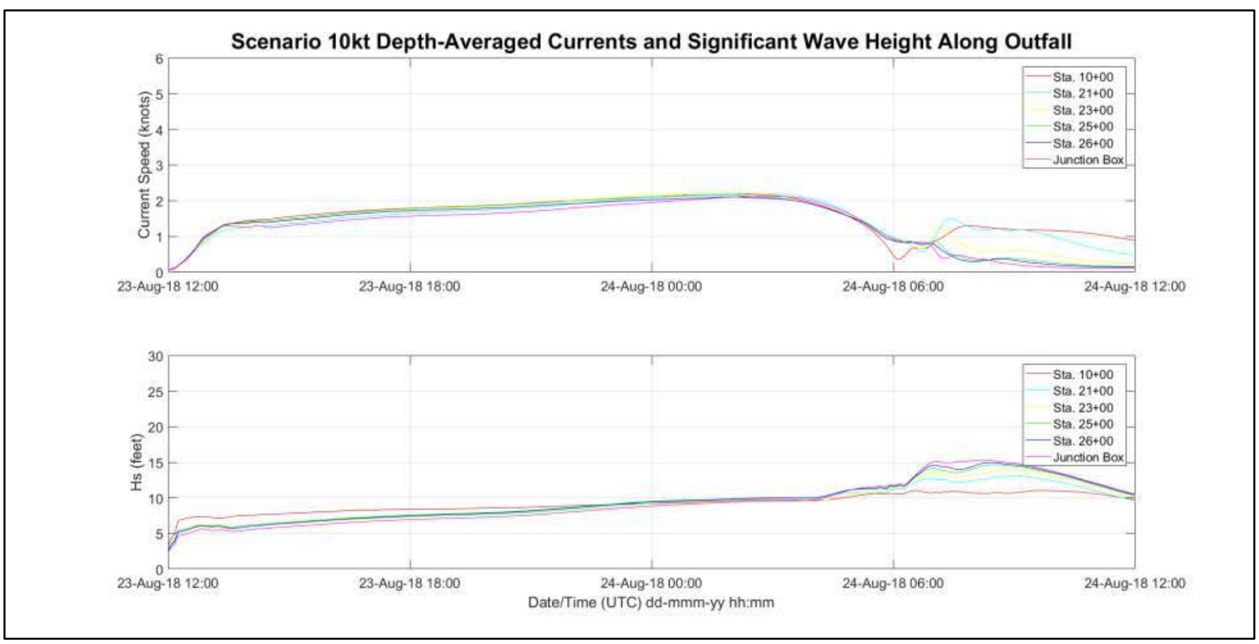


Figure 6-43. Scenario *10kt* modeled current speed and significant wave height over the simulation time frame

Table 6-6. Summary of wave and circulation model results

Scenario	Station	Water Depth (ft)	Current Speed (knots)	Hs (ft)	Hmax (ft)
2ab 12kt	10+00	19.7	1.5	8.8	15.4
2ab 12kt	21+00	27.4	1.6	9.3	18.6
2ab 12kt	23+00	28.3	1.6	8.7	17.3
2ab 12kt	25+00	28.3	1.5	9.1	18.3
2ab 12kt	26+00	28.8	1.4	9.1	18.3
2ab 12kt	Junction Box	30.3	1.5	9.1	18.2
3ab 12kt	10+00	20.5	2.7	12.5	16.0
3ab 12kt	21+00	27.2	3.2	16.2	21.2
3ab 12kt	23+00	28.1	3.4	18.3	21.9
3ab 12kt	25+00	28.1	3.7	17.4	21.9
3ab 12kt	26+00	28.6	3.8	18.9	22.3
3ab 12kt	Junction Box	29.9	4.4	17.0	23.3
5a 12kt	10+00	19.9	2.4	11.2	15.5
5a 12kt	21+00	27.5	2.7	12.4	21.4
5a 12kt	23+00	28.4	2.7	11.9	22.1
5a 12kt	25+00	28.4	2.7	12.5	22.1
5a 12kt	26+00	28.9	2.8	12.6	22.5
5a 12kt	Junction Box	30.3	2.8	12.1	23.7
10kt	10+00	19.8	2.2	9.7	15.4
10kt	21+00	27.4	2.2	9.8	19.7
10kt	23+00	28.3	2.3	9.3	18.7
10kt	25+00	28.3	2.2	10.0	20.0
10kt	26+00	28.9	2.1	10.0	20.0
10kt	Junction Box	30.3	2.1	9.6	19.2

6.4.3.4 Selection of Analysis Criteria for CFD Modeling

Based on the results shown in Table 6-6, the highest *maximum* wave heights are reported in the location of the special wye structure (i.e., junction box), however, the outfall at this location is fully trenched with only the top surface of the junction box being exposed. Station 26+00 has the highest maximum wave heights for any ballasted portion of the outfall. The scenario results reported at this location will therefore be used to develop the hydrodynamic force modeling in the following section.

6.5 Hydrodynamic Force Modeling

Estimated combined maximum hydraulic and hydrodynamic forces acting on the outfall structure due to scenario hurricane conditions were analyzed numerically using a fully three-dimensional transient RANS (Reynolds-averaged Navier–Stokes equations) solver for incompressible, turbulent flow known as *waveFoam*, a component solver of the *OpenFOAM* CFD Toolbox. The primary purpose of the modeling was to calculate the resultant forces on the structure for the scenario conditions presented in Sections 3 and 4.

6.5.1 CFD Model Domain

OpenFOAM solvers require the computational domain to be in three dimensions. In order to accurately develop 3D domains, a robust surface and solid modeling CAD application was required to prepare the physical boundaries of the models. A combination of *Grass GIS* and *Rhinoceros for Mac* were used to prepare the bathymetry and outfall structures for use in the meshing and refinement process. Figure 6-44 illustrates the selection of model domain location for the analysis, showing the base bathymetry and physical features present in the simulation. Final domain dimensions were 400 ft (122 m) and 246 ft (75 m) on a side horizontally, centered on station 26+00, and approximately 77 ft (23.5 m) in the vertical direction for the model.

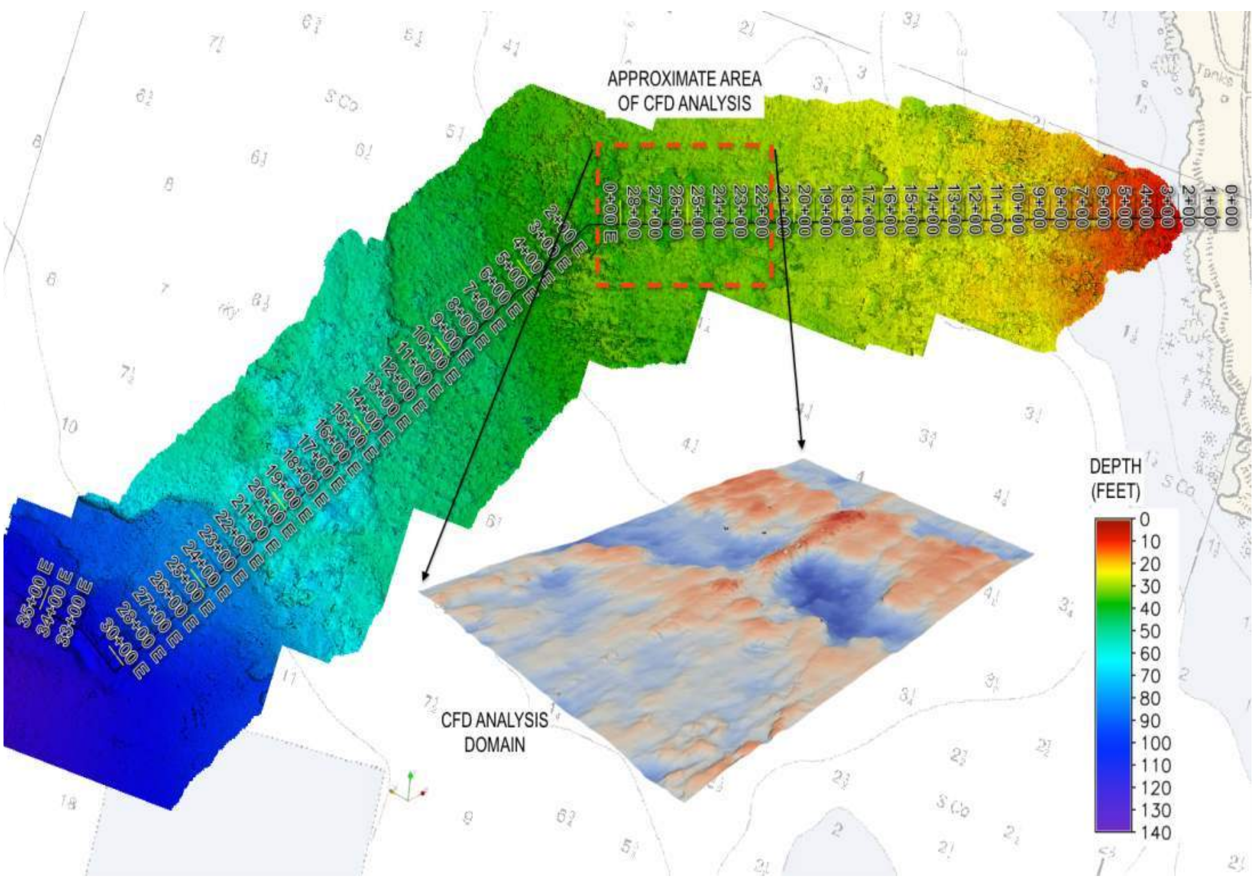


Figure 6-44. Illustration of CFD model domain boundary, shown overlaid on latest multibeam bathymetry (SEI, 2018).

6.5.2 Boundary and Initial Conditions

Following extraction of physical boundaries from the bathymetric digital terrain model, the computational surfaces (also referred to as patches) were assigned boundary conditions appropriate for a transient solution for two-phase (i.e., two fluids: air and water) incompressible, turbulent flow. In this case, the governing equations are mass continuity for incompressible flow;

$$\nabla \cdot U = 0$$

and, the steady flow momentum equation;

$$\frac{\delta \rho U}{\delta t} + \nabla \cdot (\rho U U) - \nabla \cdot \mu \nabla U - \rho g = -\nabla p - F_s$$

where, F_s is the surface tension force which takes place only at the free surfaces. Typical boundary conditions (BC's) selected for use in the analysis are illustrated in Figure 6-45. In general, the BC's consisted of a wave velocity boundary at the inlet using a cnoidal 1st order wave theory, a pressure boundary condition at the outlet, wall boundaries for the sea floor and outfall structure surfaces, an 'inlet/outlet' pressure boundary for the atmosphere, and inlet/outlet boundaries for the north and south sides, and with a numerical relaxation zone applied to the outlet to compensate for wave absorption and reflection.

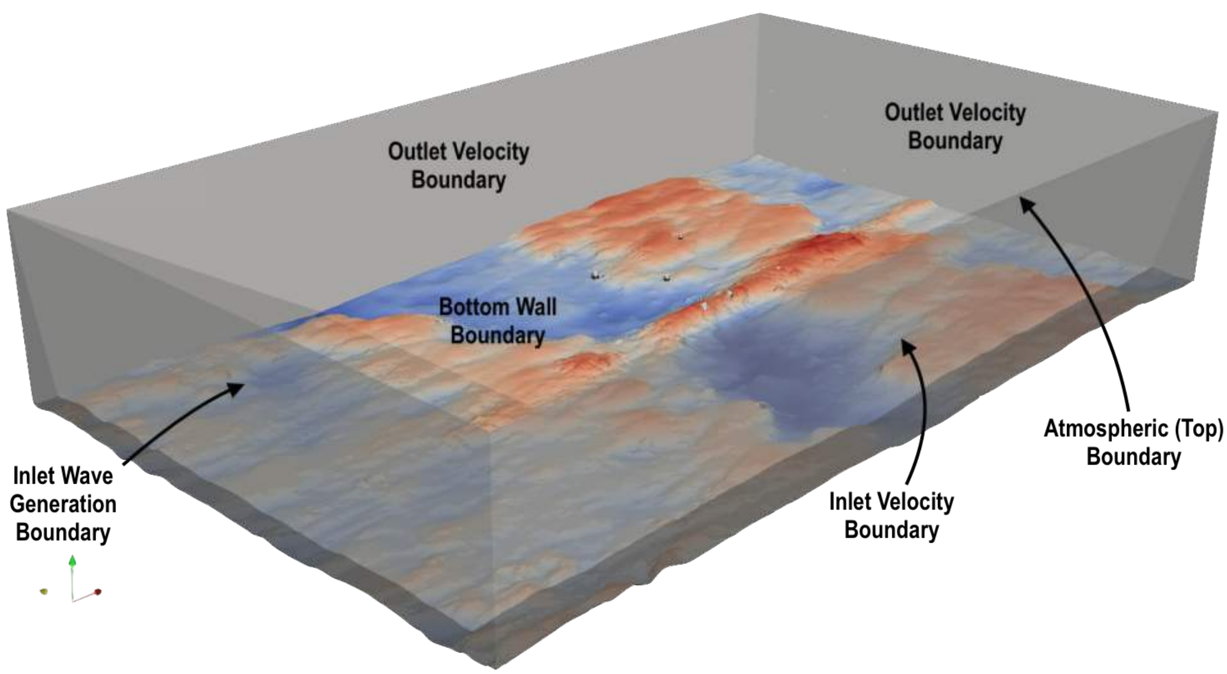


Figure 6-45. Boundary conditions assignment for model.

6.5.3 Mesh Creation

In CFD terminology, a mesh is an arbitrary collection of polyhedral (many sided) cells in three dimensions, bounded by arbitrary polygonal faces—with no restriction on the number of faces or their alignment, allowing much flexibility in creating and manipulating the mesh. *OpenFOAM* terms this type of structure a *polyMesh* (see Figure 6-46), and it is an integral part of the numerical solution and must satisfy certain criteria to ensure a valid, accurate, solution.

The meshing process for the Waianae Ocean Outfall model started with a base mesh created by the *OpenFOAM* utility *blockMesh*, which created a block of simple hexahedral cells to serve as the initial internal domain, and was the basis for further refinement at a following stage. In this study, the base mesh was created with an approximate nominal cell dimension of 6.5 ft (2 m) and a total cell count of 20,000 hexahedra.

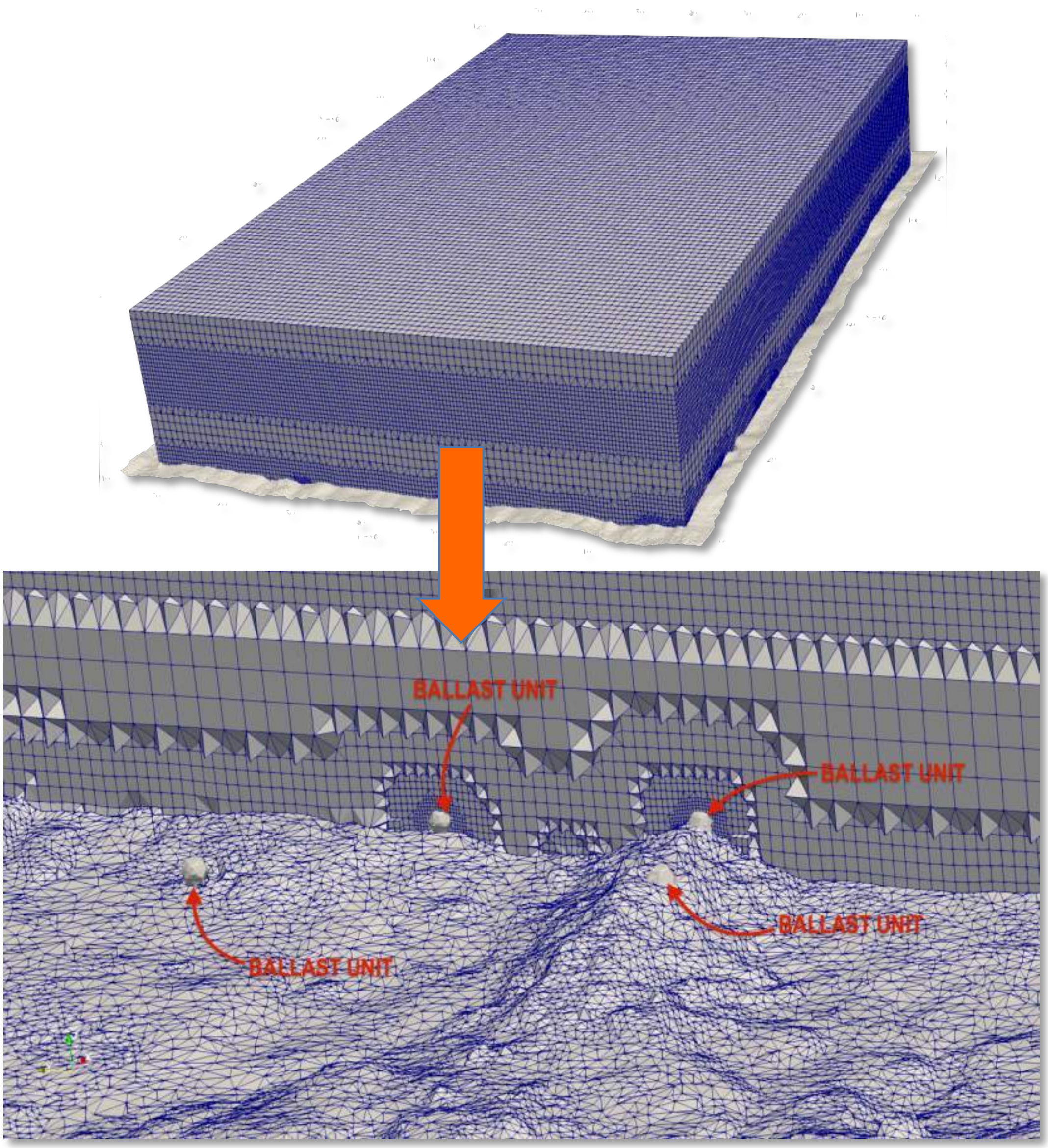


Figure 6-46. Cutaway view of meshed domain for the ballast pile, developed using *snappyHexMesh*. Mesh refinement layering visible on vertical sliced surface, revealing interior cells.

Incorporation of the bottom topography, outfall ballast units, and further refinement of the mesh in specified areas of interest, was accomplished using *snappyHexMesh*—a robust meshing utility provided with *OpenFOAM*. Additional refinement along the seafloor, free surface, and ballast surfaces was required in order to adequately resolve the velocity field and capture the potentially complex flow that could occur over the ballast pile or other significant bottom irregularities. Cells were refined as a function of distance from the bottom or distance from the outfall surface, where the more proximal cells were to the refinement surfaces, the more highly detailed they became. The maximum level of mesh refinement (level 3) resulted in minimum nominal cell sizes of approximately 3 inches (8 cm) on a side, and a total cell count of over 712,000 hexahedra and tetrahedral cells for the entire domain. The cell refinement process was completed through a series of bisection operations, and as such was exponential in cell production; for comparison, a level 1 refinement splits a level 0 (base level) cell into 8 cells, while a level 4 results in 4,096 descendent cells. An example of final mesh structure for the ballast pile near Station 26+00 is presented in Figure 6-46, where a portion of the internal mesh is peeled back to reveal the underlying seafloor boundary surface mesh. The finer boundary layer cells are visible near the intersection with the bottom (darker band).

Six ballast stone reference units were introduced into the model in order to investigate forces acting on individual units of the ballast pile. To account for the natural variability in stone shapes, it was decided to use a 10-sided polyhedron, also called a dodecahedron (see Figure 6-47), to serve as a uniform approximation, providing an approximately spherical shape while also providing some hard edges and flat surfaces. Three stone sizes were used for these investigatory ballast units in the modeling, based on size ranges found from the inspection, including 2, 3.0 and 3.5-foot nominal diameter units. Key physical details of the ballast reference units are summarized in Table 6-7. Specific gravity of basaltic rock assumed to be 2.9 (density of 188 lbf/ft^3).

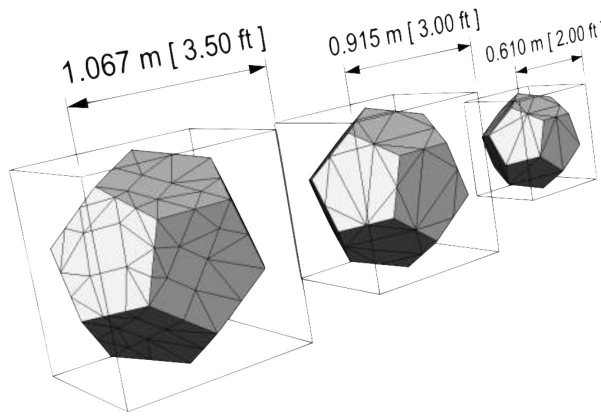


Figure 6-47. Dodecahedron (10-sided) investigatory ballast reference units, prior to meshing.

Mesh quality is critical for CFD analyses and requires special care and attention to detail for accurate models. As such, the meshing phase takes additional time to ensure adequate quality control. OpenFOAM's CFD utilities include the mesh inspection routine *checkMesh*, which allows the user to verify important mesh characteristics such as minimum and maximum cell sizes, total number and types of cells in the mesh, non-orthogonality and skewness. However, the meshing phase was only required to be completed once and was reusable for multiple scenarios of wave and current conditions. The final mesh used in this study passed all required mesh quality tests.

Table 6-7. Summary of investigatory reference stone unit sizes

Stone Unit ID	Nominal Dia.		Volume		Buoyancy		Weight		Wt. in Water	
	(m)	(ft)	(m^3)	(ft^3)	(N)	(lbf)	(N)	(lbf)	(N)	(lbf)
1a	0.61	2.0	0.096	3.4	968	218	2,840	639	1,872	421
1b	0.61	2.0	0.096	3.4	968	218	2,840	639	1,872	421
2a	0.91	3.0	0.325	11.5	3,269	735	9,586	2,155	6,318	1,420
2b	0.91	3.0	0.325	11.5	3,269	735	9,586	2,155	6,318	1,420
3a	1.07	3.5	0.515	18.2	5,190	1,167	15,223	3,422	10,032	2,255
3b	1.07	3.5	0.515	18.2	5,190	1,167	15,223	3,422	10,032	2,255

6.5.4 Model Execution

Due to the relatively large overall mesh size and high cell count, it was necessary to decompose the model domain for use in parallel computing in order to avoid unacceptably long computation times. In this case, the model was decomposed into 80 subdomains (40 in the x-direction, 2 in the y-direction, and one in the z-direction), each subdomain allocated to one processor, with a total of 80 processors assigned to each model run. Run times averaged 1-2 days per scenario, not including mesh creation and model setup time. The previous meshing procedure was also performed using parallel computing with domain decomposition and required approximately 24 hours to complete. For all cases, the hierarchical method was used for parallel decomposition of the domain.

The *waveFoam* solver (Jacobsen, 2012) is a modification based on *OpenFOAM*'s multiphase incompressible solver, *interFoam*. The breaking wave problem is a transient flow solution of two fluids separated by a sharp interface, or free surface. The two-phase algorithm in *interFoam* is based on the volume of fluids (VOF) method in which a specie transport equation is used to determine the relative volume fraction of the two phases, or phase fraction alpha (α), in each computational cell. Physical properties are calculated as weighted averages based on this fraction.

For the transient *OpenFOAM* solver *interFoam* (and thus *waveFoam*), accuracy of a simulation solution was measured in part by monitoring residuals, as opposed to convergence, the latter of which is only meaningful for steady-state solutions. In this study, model solution "convergence" was assessed by monitoring the *initial pressure residual* values at each iteration (solution step), where the residuals were essentially a measure of the error in the solution; whereby the smaller the residual, the more accurate the solution. These values, in addition to the Courant number (and interface Courant number), were also used to assess stability of the solution. As defined in the source code for the program, the residual is evaluated by substituting the current solution into the pressure equation and taking the normalized magnitude of the difference between the left and right sides of the equation.

6.5.5 Hydrodynamic Simulation Results

Hydrodynamic forces computed from the numerical models were obtained by integration of the total dynamic pressure forces (viscous forces are negligible at this scale) over the entire surface of the body (e.g., ballast unit), and resolving those forces into the two principle components of horizontal (drag) and vertical (lift) forces on the body.

To investigate forces acting on the ballast pile, several "reference units" of ballast stone of the size ranges observed in the most recent inspection report (SEI, 2018) were included in the simulation and placed along the peak of the ballast pile, with approximately 50% of the profile exposed above the top of pile to simulate the partial exposure of actual ballast material. Additional ballast units were placed directly on the seafloor adjacent to the outfall to assess stability on fully-exposed or isolated stones for comparison. Relative locations of the reference stone units employed in the model are illustrated in Figure 6-48, which shows half of the units embedded to a depth of approximately half their diameter near the peak of the ballast pile (1a, 2a, and 3a) and the remaining units placed directly on the seafloor adjacent to the outfall with no embedment (1b, 2b, and 3b). Forces were then integrated over the reference ballast units in the vertical direction for lift and the horizontal direction for drag.

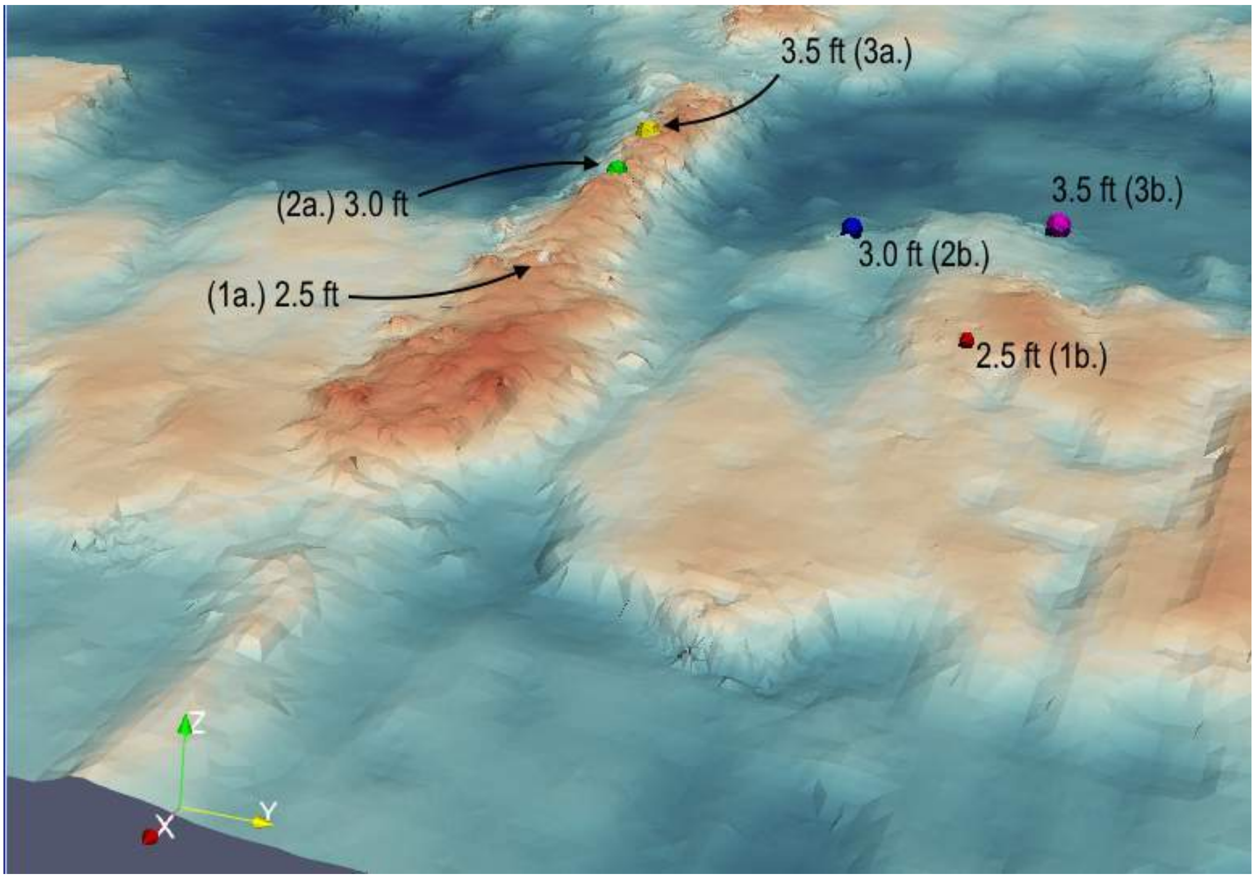


Figure 6-48. Placement of ballast reference units used in model to investigate dynamic forces.

It was noted from the nearshore wave and circulation modeling completed in Section 6.4.3, that the highest maximum wave heights for any ballasted portion of the outfall were found in the vicinity of station 26+00. Because the transient velocity field under a wave crest can be significantly greater than the background steady currents, the wave-induced water velocities are considered governing in terms of model conditions. Therefore, the four hurricane scenario results, reported at this location, will be used to develop the associated four hydrodynamic force models. A summary of the required input conditions used in the CFD analysis is provided in Table 6-8. Wave directions at this location were in actuality slightly varied, but assumed as shore-normal for modeling simplicity, and has negligible effects on the results.

Table 6-8. Summary of model runs and storm conditions used.

Case Number	Hurricane Scenario	Max Wave Ht (m)	(ft)	Peak Period (s)	Longshore Current (m/s)	(ft/s)
1	5a_12kt	6.9	22.5	14.5	1.4	4.7
2	2ab_12kt	5.6	18.3	11.4	0.7	2.4
3	3ab_12kt	6.8	22.3	14.9	2.0	6.5
4	10kt	6.1	20.0	14.3	1.1	3.6

6.5.6 Forces on the Ballast Pile

Forces on the ballast pile were approximated by the addition of reference ballast units, as described previously in Section 6.5.3. The force calculation library used in OpenFOAM allows the measurement of loads on a body as pressure-based, viscous-based, and porous-based forces reported with respect to the body's primary Euler Angles, which in this case are oriented with the Cartesian coordinate system where both the x and y-axes lie on the horizontal, and the z-axis is vertical in the direction of gravity. At the scale of this modeling investigation, both viscous and porous forces are negligible and are omitted from this discussion, whereas pressure forces are dominant.

6.5.6.1 Lift Forces

Total lift forces on the reference units were calculated by integrating the scalar dynamic pressure over the body's surfaces in the vertical direction, with hydrostatic pressure removed. Time series plots of lift force are presented in Figure 6-49 through Figure 6-52, which are combined plots for all reference ballast units, plotted for each hurricane scenario. The submerged weight for each ballast unit size (based on nominal density for basalt = 188 lbf/ft^3 [29.5 kN/m^3]) is shown on the plots for reference in red.

Figure 6-49. Plot of lift force (+ up) on reference ballast units, Case 1. (*5a_12kt*)

In these plots, the ballast units are organized by size with the 2-ft stones represented by hairline, the 3-ft stones by single-point line thickness, and the 3.5-ft stones by heavy line. Solid lines represent those stones embedded in the ballast pile, while dashed lines represent those placed in isolation on the surrounding seafloor, as illustrated in Figure 6-48. The model duration is shown in seconds on the abscissa, where each case can be seen starting at still water (i.e., zero dynamic forces due to no water movement). As wave generation begins, forces from the first wave's passage can be seen at between 10 to 20 s duration, and then repeating four to five cycles, depending on the wave period for each specific case. Positive values indicate a net upward lifting force, while negative values are a downward force, reported in Newtons. To convert force into pounds, a multiplier of 0.224809 is needed.

Figure 6-50. Plot of lift force (+ up) on reference ballast units, Case 2. (*2ab_12kt*)

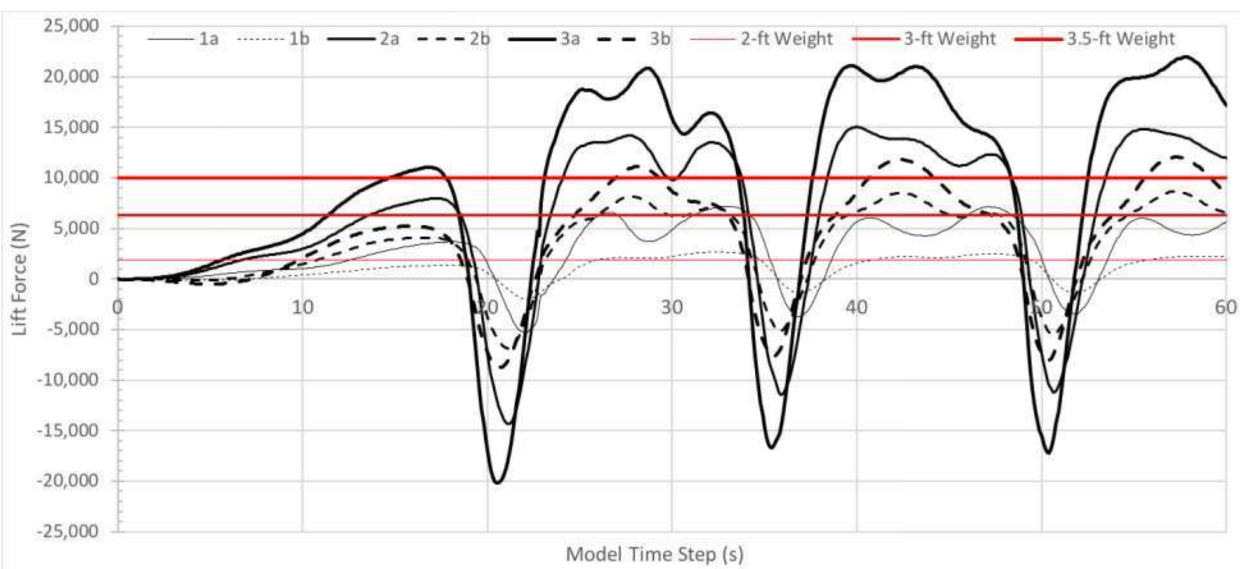


Figure 6-51. Plot of lift force (+ up) on reference ballast units, Case 3. (*3ab_12kt*)

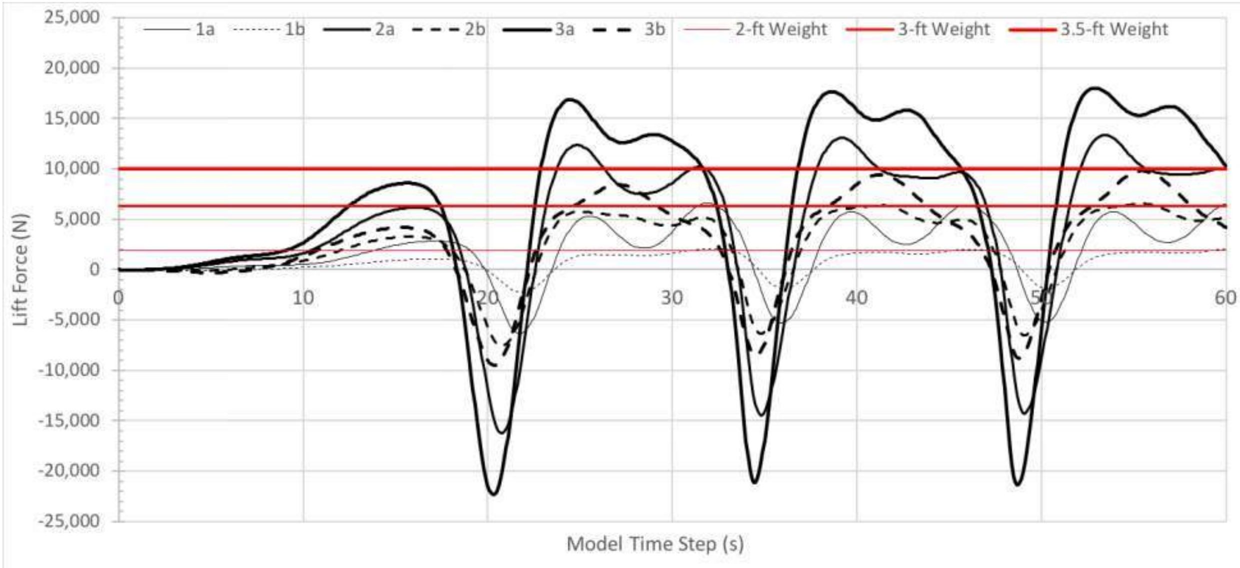


Figure 6-52. Plot of lift force (+ up) on reference ballast units, Case 4. (*10kt*)

Points on any of the black curves where the lift force for a particular stone size has exceeded its associated submerged weight (red line) indicate onset of conditions of potential instability for that unit. Note that only lines of the same thickness as shown in the legend should be compared—for example, the red hairline is the submerged weight for the black hairline curves representing forces on the 2-ft stone, and the red heavy line is the submerged weight for the black heavy curves representing forces on the 3.5-ft stone. A tabularized summary of the maximum lift force value (in Newtons) observed for each ballast unit per scenario is provided in Table 6-9.

A similar table using the same values—with the submerged weight subtracted out—is provided in Table 6-10 as a *net* force, with positive values indicating the amount of lift force in excess of the unit's weight, and negative values representing the amount of force the weight outweighs the lift force. In other words, negative values indicate stability while positive values indicate potential instability. Model results have indicated that maximum lift occurring under wave passage exceeded ballast unit submerged weight in most cases, and averaged approximately 8 to 10 seconds in duration for time of exceedance. Exceptions occurred only for the isolated units, and only for the 2-ft and 3.5-ft sizes in scenario *2ab_12kt* and 2-ft size in scenario *10kt*.

Additionally, it is noted that the half-embedded stones (1a, 2a, and 3a) are experiencing much higher lift forces compared to the equivalent solitary stones (1b, 2b, and 3b) that lay completely exposed on the seafloor. This may seem counter-intuitive at first glance, however there is in fact a rational explanation for this occurrence. In order to explain, it is first necessary to identify the mechanism responsible for generating lift on a solid body submerged in a moving fluid. Specifically, that mechanism is the differential pressure distribution acting over the solid body's entire surface, where the actual pressure distribution is directly related to the velocity field of the fluid as it flows around the body. In essence, this is Bernoulli's principle for incompressible fluids (which also forms the basis of the well-known lift and drag equations), where the faster a fluid is moving, the lower the corresponding pressure in that fluid at that location. Take for example the foiled section of an airplane wing: the cambered top surface of the wing, with its convex curving form, forces the fluid (air or water) to accelerate and flow faster over the top surface compared to the flat bottom surface of the wing where fluid velocity is slower. The higher velocity along the top of the wing generates a low pressure field (negative pressure) on its surface, while the lower velocity on the bottom surface generates a higher pressure (positive pressure) in its surface. Integrating the pressures over the wing (Σ Force = Σ (Pressure$_n$ · Area$_n$)) results in a negative (suction) pressure pulling up on the top surface, and at the same time positive pressure pushing up on the bottom surface of the wing; the end effect is a net vertical force acting upward on the wing section, which is known as lift.

With respect to the outfall, consider the ballast stone as a very poorly-shaped wing: (a) with the stone embedded halfway into the ballast pile, the water flowing along the top of the pile must speed up as it flows and accelerates around the protruding top of the stone, developing negative (suction) pressures on its top surface as it does, while the bottom half of the stone is obscured from flow within the pile and only affected by the positive hydrostatic pressure acting on its bottom surface, thus creating a significant pressure differential similar to the previous wing example, with a net upward lift force; whereas, (b) solitary stones which are completely exposed on the seafloor allow unencumbered flow around nearly the entire surface of the stone (except for its contact points with the bottom), which generates a more symmetrical distribution of vertical pressure forces that when integrated, largely cancel out, and therefore significantly less total lift force is developed on the stone.

Table 6-9. Summary of maximum lift forces observed per modeled scenario

Unit ID	Nom. Dia. (ft)	Max Lift (N) 1. *5a_12kt*	2. *2ab_12kt*	3. *3ab_12kt*	4. *10kt*
1a	2	6,646	5,918	7,172	6,603
1b	2	2,255	1,766	2,648	2,082
2a	3	13,542	14,924	15,019	13,345
2b	3	7,306	6,945	8,657	6,550
3a	3.5	19,087	21,659	21,933	18,010
3b	3.5	10,737	9,100	12,051	9,796

Table 6-10. Summary of maximum net force observed per modeled scenario

Unit ID	Nom. Dia. (ft)	Max Net Force (N) 1. *5a_12kt*	2. *2ab_12kt*	3. *3ab_12kt*	4. *10kt*
1a	2	4,774	4,047	5,300	4,731
1b	2	383	-106	776	211
2a	3	7,224	8,606	8,702	7,027
2b	3	988	627	2,339	232
3a	3.5	9,055	11,627	11,900	7,977
3b	3.5	704	-933	2,018	-236

6.5.6.2 Drag Forces

Total drag forces were calculated in a similar manner as lift forces, by integrating dynamic pressure over the body's surface, this time in the horizontal plane along the inshore/offshore axis (the x-axis in this case). A summary of maximum observed drag force per ballast unit, per hurricane scenario, is provided in Table

6-11. Plots of drag force per ballast unit over the model simulation duration, for each scenario, are presented in Figure 6-53 through Figure 6-56, utilizing the same line type representations as the lift force plots.

Although significant, the drag forces are considered a secondary factor since the stone units comprising the ballast pile shield one another from lateral loading within the pile. As a result, horizontal drag forces on units within the ballast pile armor layer will be neglected. For units that have been isolated from the

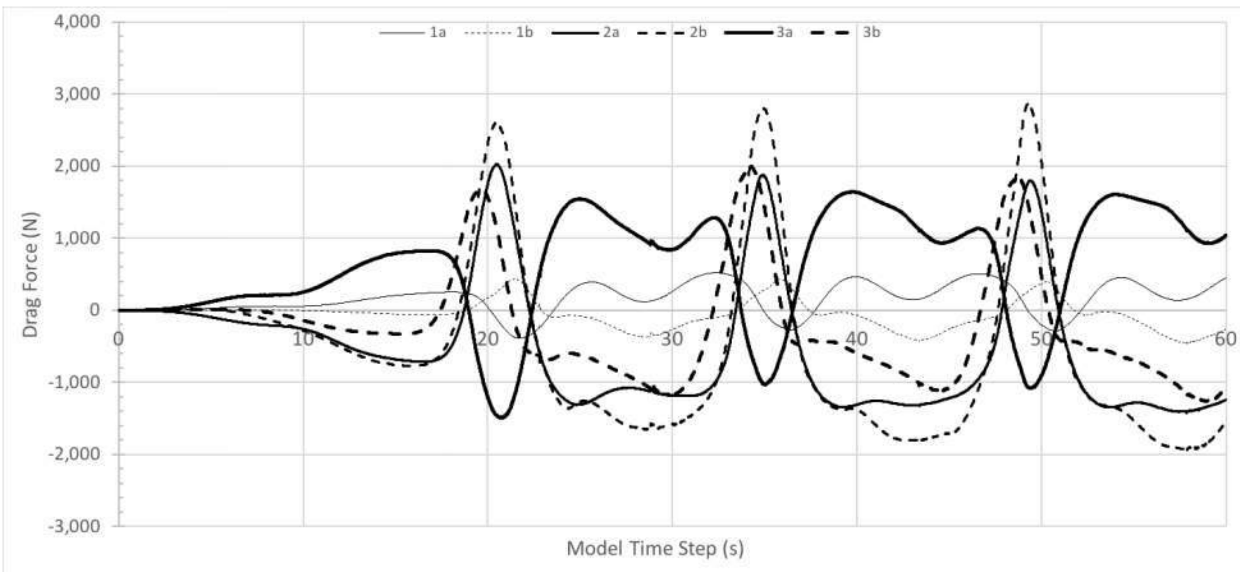


Figure 6-53. Plot of drag force on reference ballast units, Case 1. (*5a_12kt*)

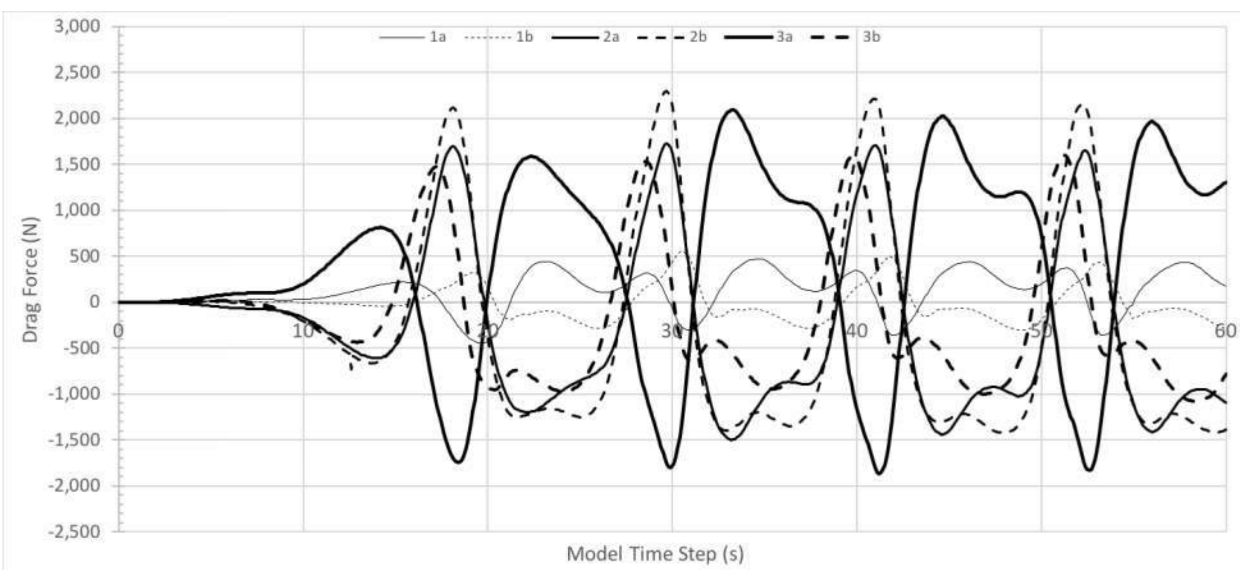


Figure 6-54. Plot of drag force on reference ballast units, Case 2. (*2ab_12kt*)

pile and sit in solitary on the seafloor, horizontal drag forces on their fully exposed surfaces will subject them to possible overturning and movement—however, once isolated and solitary they are no longer part of the structure and provide no additional stability to it, and therefore will also be neglected.

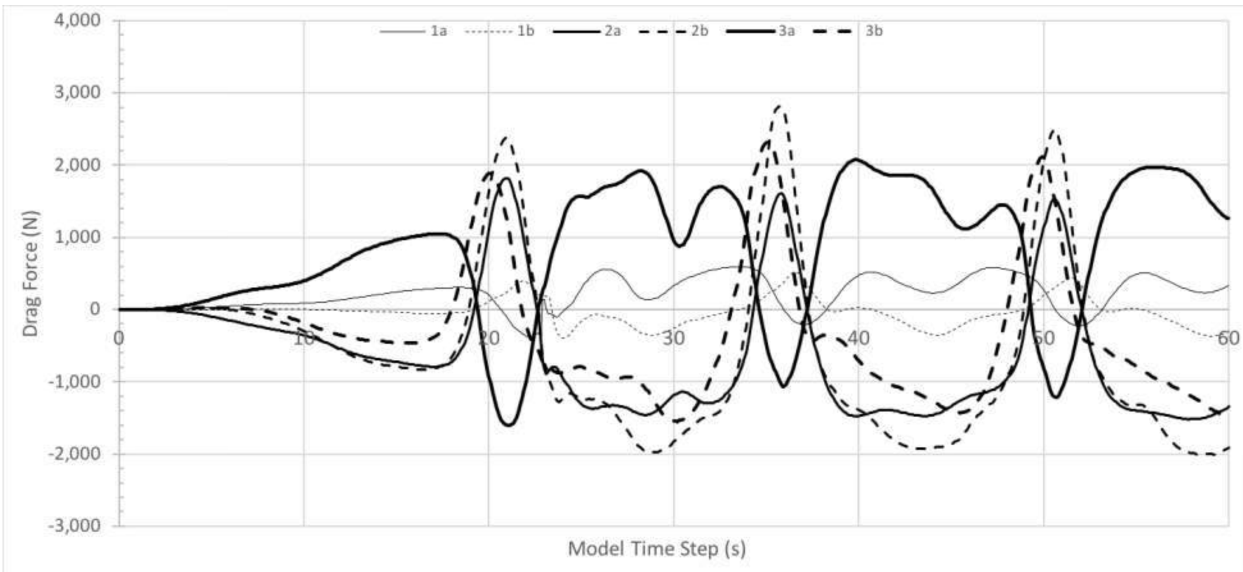


Figure 6-55. Plot of drag force on reference ballast units, Case 3. (*3ab_12kt*)

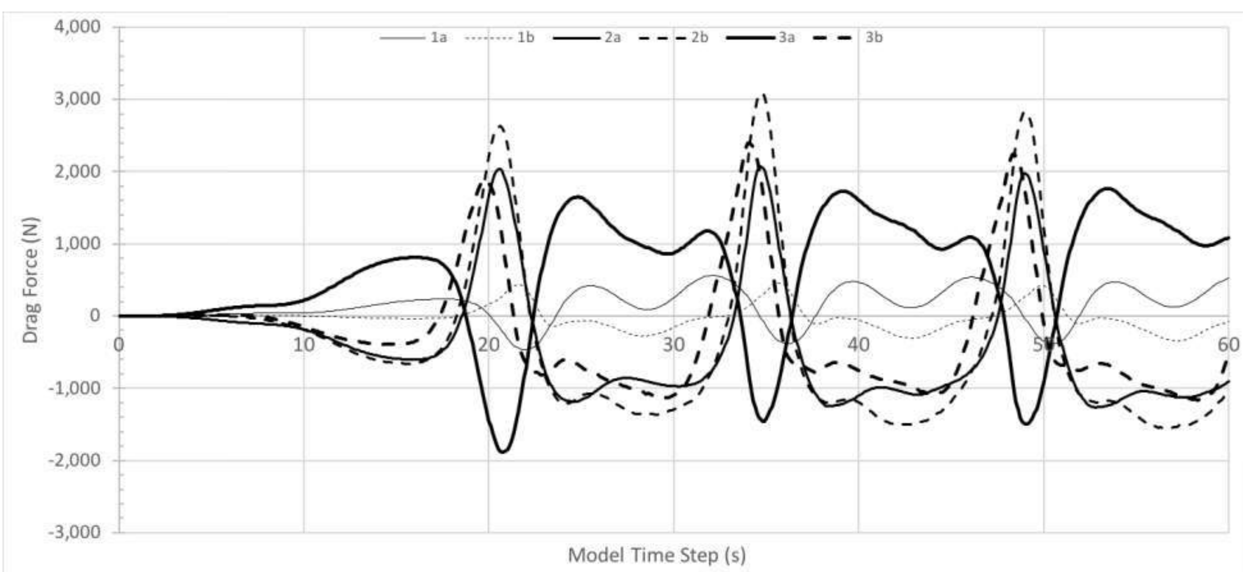


Figure 6-56. Plot of drag force on reference ballast units, Case 4. (*10kt*)

Table 6-11. Summary of maximum drag forces observed per modeled scenario

Unit ID	Nom. Dia. (ft)	Max Drag (N)			
		1. *5a_12kt*	2. *2ab_12kt*	3. *3ab_12kt*	4. *10kt*
1a	2	522	473	593	561
1b	2	435	552	513	457
2a	3	2,029	1,726	1,822	2,071
2b	3	2,875	2,295	2,808	3,086
3a	3.5	1,646	2,092	2,074	1,764
3b	3.5	1,997	1,595	2,321	2,394

6.5.6.3 Near-bottom Water Velocities

Time series data for near-bottom water velocities (reported as magnitudes, $|u|$) observed in the scenario models was extracted at two locations, representing conditions at the ballast pile peak, and conditions on relatively flat and open natural seafloor, in the vicinities of ballast units *2a* and *2b*, respectively (refer to Figure 6-48 for locations). Maximum near-bottom velocities occurring for each hurricane scenario are summarized in Table 6-12 below. Data in the table indicate that maximum near-bottom velocities range from a low of 2.40 m/s (7.9 ft/s) found in scenario *2ab_12kt* to a high of 3.32 m/s (10.9 ft/s) seen in scenario *3ab_12kt*, as measured at the ballast peak location. With respect to the adjacent exposed seafloor location, maximum near-bottom velocities were observed to range from a low of 1.95 m/s (6.4 ft/s) which occurred in scenario *2ab_12kt*, to a high of 2.67 m/s (8.8 ft/s) in scenario *3ab_12kt*.

A quick comparison using a method developed by the Waterways Experiment Station (USACE, 1958) that relates the weight and diameter of a stone to the velocity required for initiation of motion by overturning, for both embedded stone (Equation 5.1) and non-embedded stone (Equation 5.2), reveals that water velocities of 19.9, 24.4, and 26.3 ft/s (6.1, 7.4, and 8.0 m/s) are required for incipient motion of stone sizes 2, 3, and 3.5 ft, respectively for units embedded within in a riprap armor layer such as the ballast pile (see Table 6-13). These threshold velocities are nearly double the maximum velocities found in the CFD model for the location near the ballast pile peak, and further imply that horizontal drag forces on units within the structure are not a controlling factor.

$$V_S = 0.075\rho_s g\sqrt{d} \qquad \text{Equation 5.1}$$

$$V_S = 0.0536\rho_s g\sqrt{d} \qquad \text{Equation 5.2}$$

where:

ρ = seawater density (1.99 slug/ft^3) constant

d = nominal stone diameter (ft)

γ_s = stone specific weight (188 lbf/ ft^3) constant

Table 6-12. Summary of maximum near-bottom water velocities

Location	Max Water Velocity (magnitude)							
	1. *5a_12kt*		2. *2ab_12kt*		3. *3ab_12kt*		4. *10kt*	
	(m/s)	(ft/s)	(m/s)	(ft/s)	(m/s)	(ft/s)	(m/s)	(ft/s)
Top of ballast pile	3.07	10.1	2.40	7.9	3.32	10.9	3.24	10.6
Adjacent seafloor	2.14	7.0	1.95	6.4	2.67	8.8	2.44	8.0

Table 6-13. Critical velocities from USACE incipient motion equation

Diameter (ft)	**Weight** (lbf)	**Critical Velocity** (ft/s)		**Critical Velocity** (m/s)	
		embedded	non-embedded	embedded	non-embedded
2.0	544	19.90	14.26	6.1	4.3
3.0	1837	24.37	17.46	7.4	5.3
3.5	2917	26.32	18.86	8.0	5.7

Time series plots of the near-bottom velocities, per scenario for the entire model duration, are presented in Figure 6-57 for the ballast peak location, and Figure 6-58 for the adjacent open seafloor location. Data at the ballast peak location in Figure 6-57 show that peak velocity conditions are very comparable between scenarios *5a_12kt* and *10kt*, ranging from 2.85 to 3.25 m/s (9.4 – 10.7 ft/s), and similar to scenario *3a_12kt* which is sometimes slightly higher or lower at the peaks. Scenario *2ab_12kt* peak conditions are significantly lower at 2.1 to 2.4 m/s (6.9 – 7.9 ft/s), however the peaks occur more often due to the significantly shorter period of the swell for this scenario—11.4 s versus 14.3 to 14.9 s for the others (refer to Table 6-8).

Peak velocities at the adjacent exposed seafloor location are generally lower as shown in Figure 6-58, likely due to its greater depth in the water column, but also potentially due to bottom boundary layer effects induced by bottom friction from the rough, uneven seafloor. Similar to the top of ballast location, peak velocity conditions are very comparable between scenarios *5a_12kt* and *10kt*, ranging from 2.00 to 2.10 m/s (6.6 – 6.9 ft/s), while scenario *3a_12kt* is clearly higher at the peaks, ranging from 2.25 to 2.50 m/s (7.4 – 8.2 ft/s). Scenario *2ab_12kt* was found to be generally lower with peak velocities of 1.40 to 1.95 m/s (4.6 – 6.4 ft/s).

To better illustrate the velocity profile under a passing wave, a visualization of the data during the process of wave breaking over the area of interest is provided in Figure 6-59 (scenario *2ab_12kt* in this example), where a portion of the sea-surface is removed to reveal the seafloor and ballast pile, with reference ballast units visible in the foreground. A vertical slice through the velocity field under the wave—aligned with the outfall—is shown colored by velocity magnitude, ranging from >11 m/s in red, to near zero in blue. The distinctly enhanced velocity structure under the wave crest is evident by the profile shown in the figure.

A closer view of the passing velocity field structure is shown in Figure 6-60 (scenario *2ab_12kt*), centered on the locations of the reference ballast units. The exponential decay in velocity with depth is discernable in the image, with the colorized cross-section illustrating the parabolic boundaries of the velocity profile. A close inspection of the image in the vicinity of the largest (3.5-ft) ballast unit on the ballast pile reveals a shadowing area (lower velocities in blue) immediately behind the unit as water rushes towards shore (to left in the image).

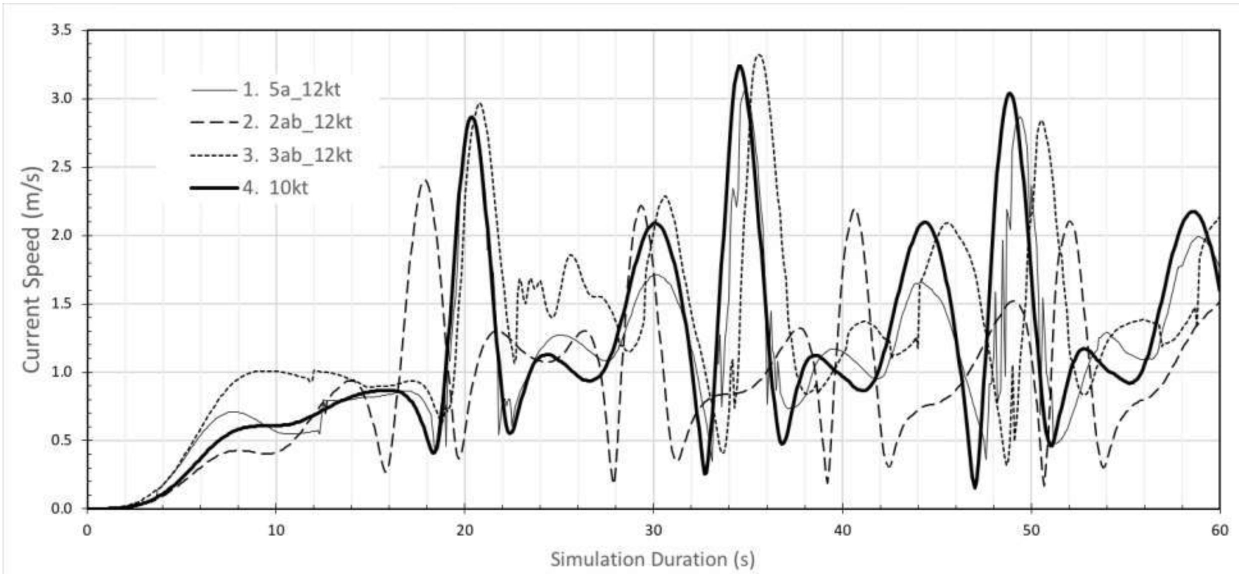


Figure 6-57. Plot of near-bottom water velocities (magnitude) approximately 6 ft (2 m) above ballast pile peak near station 26+00, in the vicinity of ballast unit *2a*

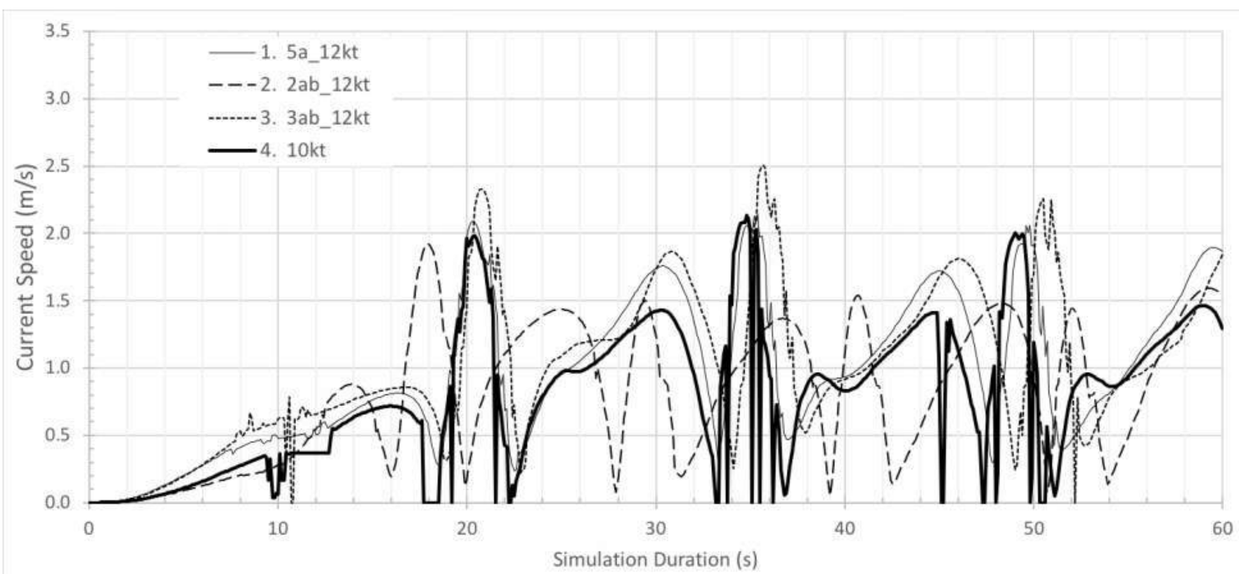


Figure 6-58. Plot of near-bottom water velocities (magnitude) approximately 6 ft (2 m) above adjacent seafloor near station 26+00, in the vicinity of ballast unit *2b*

The image in Figure 6-61 is an extreme close-up of reference ballast unit *2b* (refer to Figure 6-48 for location) during wave passage in scenario *3ab_12kt*, clearly illustrating the flow pattern over the obstacle. A clear shadow zone exists in the lee of the direction of flow (left side of ballast unit) where velocities drop from a high of over 3 m/s (over 10 ft/s) to near-zero in its wake. Differentials in velocity such as this are what drive the associated pressure differences on the surface of the unit, which in turn directly result in lift and drag forces on the unit.

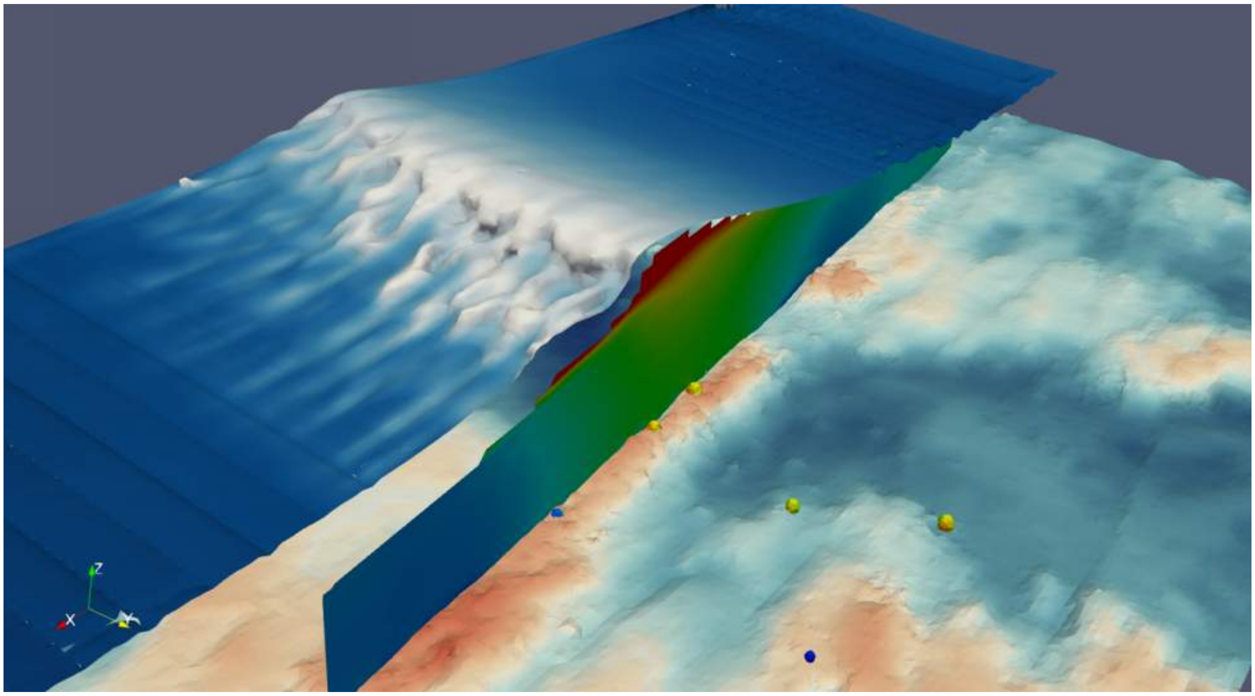


Figure 6-59. Vertical wave velocity profile along ballast pile, with breaking wave free-surface peeled back to reveal seafloor and reference ballast units (scenario *2ab_12kt*).

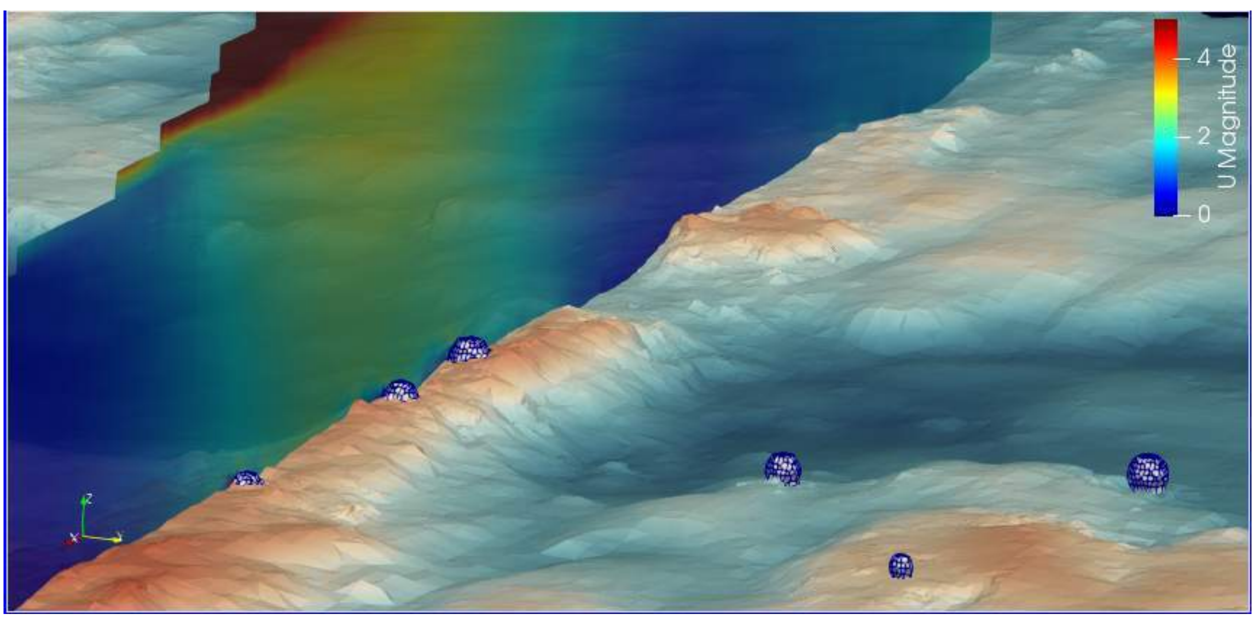


Figure 6-60. Close-up of ballast pile with vertical wave velocity profile, reference ballast units visible with blue surface mesh lines (scenario *2ab_12kt*).

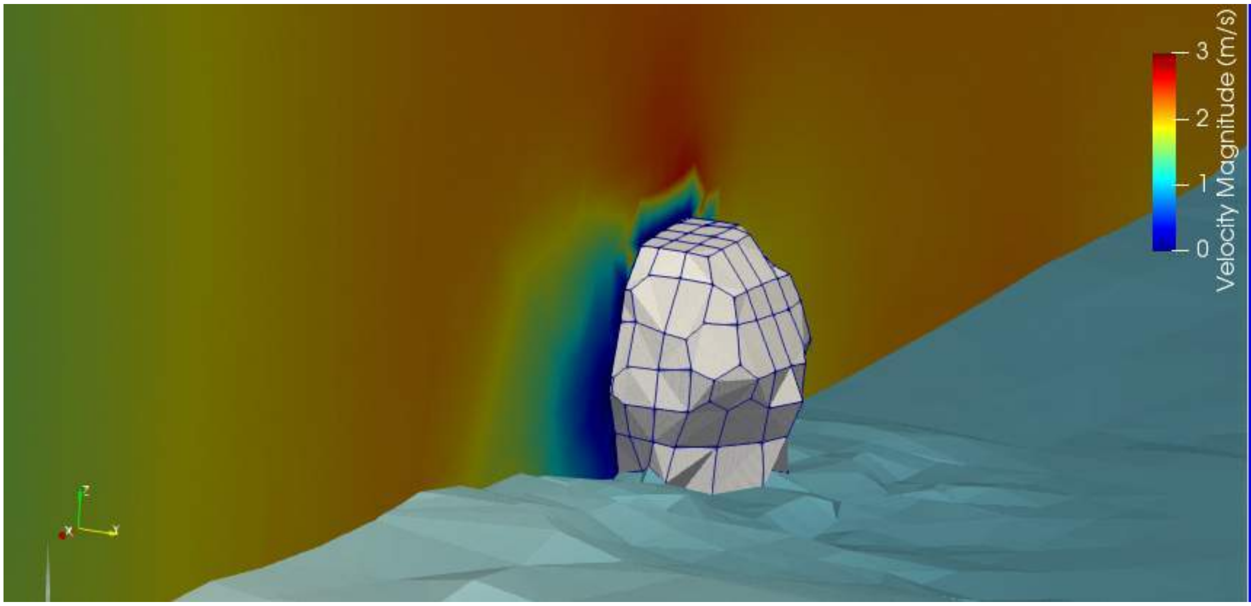


Figure 6-61. A vertical slice through the velocity field for the *3ab_12kt* scenario, illustrating development of a boundary layer around the ballast unit 2b, which is typical. Note the increased water velocity just over the top of the ballast.

6.6 Discussion & Stability Estimation

6.6.1 Trenched and Capped Sections

For a majority of the outfall's length, including the entire 42-inch extension and diffuser section, the pipe is secured deeply within a trench excavated from the reef, with the top-of-pipe typically 2 ft below the pre-existing seafloor elevation, and additionally capped with a concrete jacket, and in some locations further covered with a 1-ft layer of compacted fill, as shown in excerpts from the outfall extension as-built plans provided in Figure 6-62 and Figure 6-63. For these highly immobilized and secured areas of pipeline, where the structure profile does not significantly project above the level of the surrounding seafloor, the outfall is considered inherently safe due to the construction method, and is not analytically considered in this stability analysis. It is noted however, that seismic events and tsunami are not considered herein.

6.6.2 Trench and Ballasted Sections

During construction of the original 36-inch outfall, partial failure or fracturing of one or both walls of the reef trench were observed for limited lengths in some locations. To further secure the pipe in these partially-failed trench wall areas, which ranged in length from 25 to 240 ft, the outfall pipeline was ballasted with armor stone as depicted in Figure 6-64, excerpted from the original as-built plans; the location and extent of each ballasted section is summarized in Table 4-1. During construction of the 42-inch outfall extension (1982-86), additional stone was used to fortify the ballast pile in these areas (see Figure 6-65, typical section). Provided as-built plans indicated that "Class 2" stone was called for in this re-ballasting measure, however, specifications defining the stone size gradation for Class 2 were not given and are currently undetermined. SEI engineering divers took numerous stone size measurements along the ballasted sections during the 2018 visual inspection and found armor stone ranging in size from 10 to 42 inches (SEI, 2018).

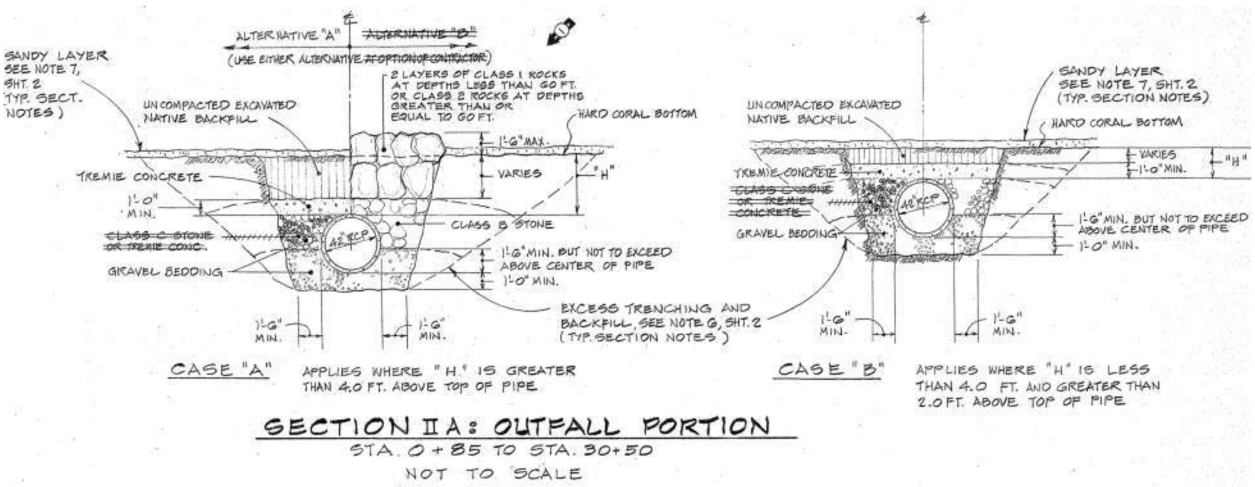


Figure 6-62. Typical section of trenched outfall configuration, from 1986-dated as-built plans for 42-inch extension

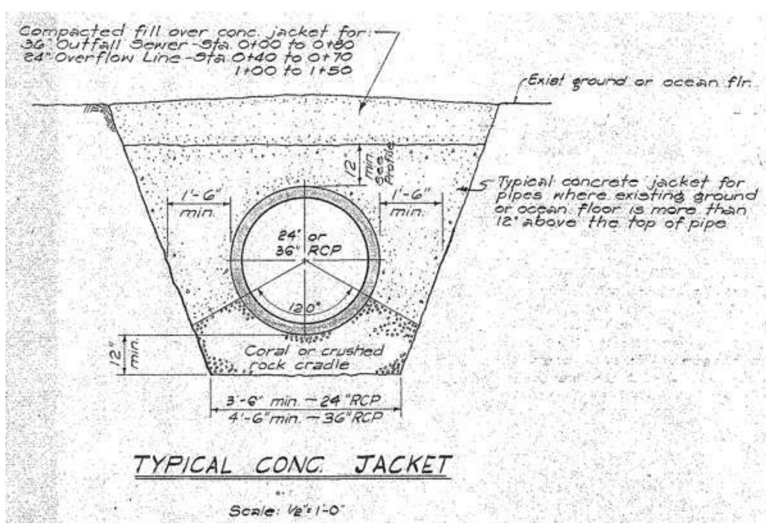


Figure 6-63. Typical section of original trenched outfall configuration from 1966-dated as-built plans for 36-inch pipe.

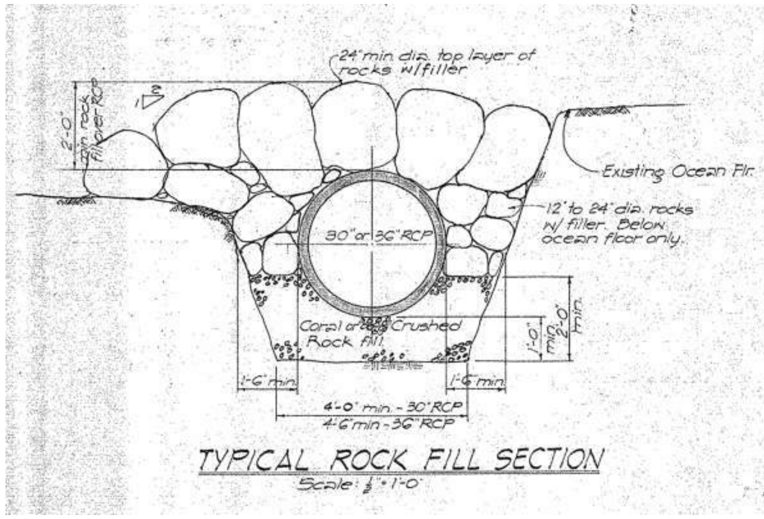


Figure 6-64. Typical section of original 1966 ballasted outfall configuration.

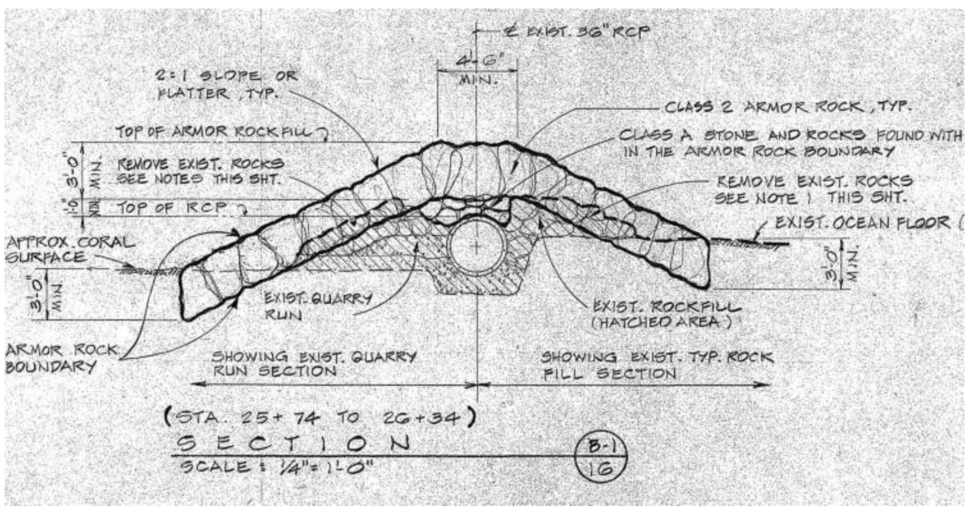


Figure 6-65. Typical section of ballasted sections from 1986 extension and repair.

Table 6-14. Ballasted sections of Waianae Ocean Outfall

ID	Depth ft	Start station	End station	Length ft
1	17	06+60	07+00	40
2	19.5	08+40	08+65	25
3	21	09+75	10+82	107
4	23	14+60	15+05	45
5	25	16+50	16+80	30
6	29	20+50	22+90	240
7	29.5	23+90	24+60	70
8	30	25+45	26+30	85
9	31	27+70	28+00	30
Total length of ballasted pipe				**672**

Estimating structural stability along the rocked (ballasted) portion of the outfall is a complex problem, due in part to the porosity of the ballast pile, the irregularity of the individual ballast units, and irregularity in the shape of the ballast pile itself. Numerical analysis of the hydrodynamic forces acting along this section was completed using a combination of the recently collected multibeam survey data and embedment of several idealized ballast stones consisting of dodecahedron (a ten-sided solid composed of equilateral hexagonal faces) ballast units placed along the peak of the ballast pile, with additional units to the side as isolated stones, as illustrated in Figure 6-48. The zone used for the analysis is in the vicinity of Station 26+00, which is just inshore of Manhole 4 on the original 36-inch pipeline, as shown in Figure 4-1 and Figure 6-48. This area was chosen as it represents the ballasted portion of outfall that is exposed to the largest wave heights.

6.6.2.1 Empirical Comparisons of Stability

To increase confidence in model results an alternative empirical method to assess armor stone stability was applied based on flow shear stress and Shield's formula (Grace, 1978), which utilizes a friction factor obtained through boundary value equations derived from rough turbulent pipe flow. The empirical results for this method were found to compare well for both steady state and oscillating flow experiments. Grace's equation for median stone size (D_{50}) was developed by inserting the pipe flow friction factor equation into the Shield's equation, resulting in the formula:

$$D_{50} = \frac{0.125\left[2\log_{10}\frac{h}{D_{50}}+2.11\right]^{-\frac{1}{2}}\cdot\rho U_{max}^2}{(\gamma_s-\gamma)(0.06)}, \qquad \text{Equation 6.1}$$

where:

- h = water depth (33.6 ft) constant
- ρ = seawater density (1.99 slug/ft^3) constant
- γ = seawater specific weight (64.1 lbf/ ft^3) constant
- γ_s = stone specific weight (188 lbf/ ft^3) constant
- U_{max} = maximum water velocity

By setting the maximum water velocity (U_{max}) in Equation 6.1 to the *top of ballast pile* values provided in Table 6-12 above, it is now possible to solve iteratively for D_{50} for each case. The results of this process are given in Table 6-15 below, which summarizes the minimum required stone size per scenario storm, along with the resulting factor of safety (FS) for the three reference ballast unit sizes, where FS is defined as the given unit diameter divided by the calculated minimum required diameter. A FS value less than 1 is clearly unstable for the given conditions, however, to be conservative any FS less than 1.25 should be considered as potentially unstable. Using that criterion, two out of the total 12 combinations in Table 6-15 are found to be unstable (italicized), while the remaining units are considered stable (bold). Grace's method suggests that the outfall would sustain minimal to no damage for scenarios *5a_12kt* and *2ab_12kt*, while for the remaining storms ballast under 2-ft nominal diameter would appear undersized and potentially be subject to displacement.

Table 6-15. Minimum required stone size by Grace method, with reference unit safety factors

Case Number	Hurricane Scenario	U_{max}		Required Dia.		Safety Factor (by diameter)		
		m/s	ft/s	m	ft	2.0 ft	3.0 ft	3.5 ft
1	*5a_12kt*	3.1	10.07	0.472	1.55	**1.29**	**1.94**	**2.26**
2	*2ab_12kt*	2.4	7.87	0.274	0.90	**2.22**	**3.33**	**3.89**
3	*3ab_12kt*	3.3	10.89	0.564	1.85	*1.08*	**1.62**	**1.89**
4	*10kt*	3.2	10.63	0.533	1.75	*1.14*	**1.71**	**2.00**

A second empirical approach (Melby, et al, 1997) developed for the estimation of the incipient motion of breakwater armor units is also a useful comparison. The ballast pile sections for Waianae may be considered similar in construction and porosity to a rubble mound breakwater, for which Melby performed his analysis. Melby found through measurement and experimentation the following relation between vertical critical velocity and nominal stone diameter:

$$\frac{v_c^2}{D_n g (S_r - 1)} = 1.3 \qquad \text{Equation 6.2}$$

Where v_c is critical velocity, D_n is nominal stone diameter, and S_r is specific gravity of the stone, which was assumed to average 2.9. Based on Equation 6.2 and the given reference ballast unit sizes, and assuming the given scenario maximum velocity magnitudes are equivalent to the vertical critical velocity, the subsequent minimum required stone sizes are calculated and summarized in Table 6-16, along with associated FS for the three reference unit sizes. It is interesting to note from the results that when using Melby's method, all ballast reference unit sizes were found stable for all scenario conditions.

Also of note, a conclusion of the Melby study was that it found the only displacement mechanism observed for rounded stones (somewhat typical of the ballast at Waianae) that were sufficiently embedded in the armor layer was uplift under a steep wave face. Melby states the observations indicated that a fluid velocity or acceleration in the vertical direction was normally required to initiate armor motion for hidden or embedded armor units. The typical ballast unit along the Waianae ocean outfall is embedded in the ballast pile similar to an armor layer of a breakwater, and would likely have a similar failure mode. Using this assumption, the drag forces from the numerical model would have less meaning than the lift forces, since it was found that vertical motion, the pulling of units out of the slope or flank, that was the controlling factor.

Table 6-16. Minimum required stone size by Melby method, with reference unit safety factors

Case Number	Hurricane Scenario	U		Required Dia.		Safety Factor (by diameter)		
		m/s	ft/s	m	ft	2.0 ft	3.0 ft	3.5 ft
1	*5a_12kt*	3.1	10.07	0.58	1.12	**1.8**	**2.7**	**3.1**
2	*2ab_12kt*	2.4	7.87	0.34	0.69	**2.9**	**4.4**	**5.1**
3	*3ab_12kt*	3.3	10.89	0.70	1.31	**1.5**	**2.3**	**2.7**
4	*10kt*	3.2	10.63	0.67	1.25	**1.6**	**2.4**	**2.8**

6.6.2.2 CFD Force-based Stability

The CFD-derived lift forces in Table 6-9 can be evaluated by dividing the lift forces by the submerged weight of that particular unit, therefore obtaining a table of lift factors (F_L / W) for each unit size and scenario. Results are presented in Table 6-17 for the units embedded in the ballast pile only. With lift factors of 1.8 to 3.8, the CFD model results suggest that all ballast of 3.5-ft diameter or smaller would be subject to possible displacement during all of the scenario hurricanes. Drag data are omitted because it is assumed that the ballast units are sufficiently embedded in the armor layer of the ballast pile that adjacent units would prevent any lateral displacements.

Table 6-17. Summary of maximum lift factors observed per modeled scenario

Unit ID	**Nom. Dia.** (ft)	**Max Lift Factor** 1. *5a_12kt*	2. *2ab_12kt*	3. *3ab_12kt*	4. *10kt*
1a	2.0	3.55	3.16	3.83	3.53
2a	3.0	2.14	2.36	2.38	2.11
3a	3.5	1.90	2.16	2.19	1.80

6.6.3 Stability Synopsis

In this study, the direct approach of four scenario hurricanes to the southwest side of the island of Oahu were used to generate reasonably expected extreme wave conditions in the vicinity of the Waianae ocean outfall. Conservative assumptions were used in a series of numerical wave models to generate a set of worst-case conditions. The numerically developed maximum depth-averaged currents and collocated maximum wave heights were taken as the basis for CFD models that accurately simulated the transient, oscillating fluid flow over the deepest ballasted portion of the outfall at an average depth of approximately 34 ft (10.4 m). The CFD models allowed direct calculation of hydrodynamic (drag and lift) forces on the outfall ballast pile through use of computational patches on several individual *reference* ballast units (see Figure 6-48) by integration of the scalar dynamic pressure over their surfaces, and resolved into lift and drag components.

Additionally, two empirical methods were considered to provide a comparison with the CFD-based results, adapted from Grace (1978) and Melby (1997). A stability matrix was then developed with the results of each method for each of the scenario hurricanes and is provided in Table 6-18 below. The stability criterion for the table is that the minimum stone size of 2-ft must be stable for the given conditions for the given method, otherwise it is considered unstable—meaning that armor stones comprising the ballast pile of 2-ft diameter or smaller are potentially at risk of displacement. The stability matrix in Table 6-18 indicates that the scenario with the smallest maximum wave heights (*2ab_12kt*) would result in a stable ballast pile according to both empirical methods, yet the CFD results imply that sufficient lift forces would be developed under wave passage that stone displacement was a possibility. For the remaining scenarios—all with maximum wave heights exceeding six meters—only the Melby method indicates stability for stone sizes of 2-ft or larger. However, the Melby method is for a surface-piercing revetment in very shallow water, and it may not provide the best comparison for a completely submerged riprap structure in relatively deep water.

Table 6-18. Summary of stability assessment by method (S = stable, U = unstable)

Run No.	Scenario	U_{max}		H_{max}		Stability Assessment Method								
						Grace			Melby			CFD		
		ft/s	m/s	ft	m	2'	3'	3.5'	2'	3'	3.5'	2'	3'	3.5'
1	*5a_12kt*	10.1	3.07	22.5	6.9	S	S	S	S	S	S	U	U	U
2	*2ab_12kt*	7.9	2.40	18.3	5.6	S	S	S	S	S	S	U	U	U
3	*3ab_12kt*	10.9	3.32	22.3	6.8	U	S	S	S	S	S	U	U	U
4	*10kt*	10.6	3.24	20.0	6.1	U	S	S	S	S	S	U	U	U

The oscillatory nature of waves and tides means that the peak maximum forces from these conditions are transitory. The combined instantaneous water velocity that is experienced by a specific point on the outfall is a dynamic mix of tidal currents, wave orbital motion, and wave generated currents, and when they happen to align in the same direction at a specific location, may be thought of as being summed linearly as a worst-case condition at that instant. With the currents and wave velocities entered into the model as independent motions, component velocities are not likely to remain aligned for sustained periods. Over time however, the effects may be significant, and will be amplified with event duration.

Damage to the ballast pile sections could occur due to displacement or loss of units from the structure crest, or more seriously from the structure flank or near the base of the pile. Loss or displacement from the base or flank could potential destabilize remaining upslope units. While results indicate that ballast units may potentially move as a result of some maximum velocities, it does not imply that entire sections of ballast will be stripped off. Rather, it is indicative of a gradual attrition of ballast from the pipe and given the ample supply of reserve ballast in the pile, the structure would likely be able to withstand significant amounts of damage before the pipe becomes gravely threatened. Additionally, the interlocking effect of adjacent ballast units, combined with the moving and transitory nature of maximum water velocities, means that it is likely a limited number of units will be affected by maximum conditions at any one time; and the neighboring ballast units under lower velocities may help retain or immobilize the units under greatest strain.

One more important consideration is that due to the transient and unpredictable nature of hurricanes, return period wave heights are typically only estimated for seasonal wave events like winter north swells, summer south swells, trade wind swells, and so on, which occur every year at some predictable rate without fail. However, hurricanes can be prolific in some years, and nearly non-existent in others—making their wave height prediction by statistical analysis problematic. In ocean engineering, a return period design wave height is typically used in the design process, which uses a statistical distribution such as the Weibull or Gumbel distribution to predict a desired return period wave height based on past statistics. The plot presented in Figure 6-66 is an example, showing the Weibull distribution for a location on the offshore boundary of the Waianae nearshore wave and circulation model. It can be seen from this plot, and the associated data in Table 6-19, which lists both the statistical return period waves and actual and modeled hurricane wave heights, that the hurricane wave heights, with the exception of scenario *2ab_12kt*, exceed the 100-yr wave height. Interestingly, the 50-yr wave height (which is often taken as the design wave height) is lower than all actual and scenario hurricane wave heights. If the outfall were designed to a similar 50-yr criterion, this would explain why the ballast appears undersized (unstable) for all modeled scenarios based on the CFD model.

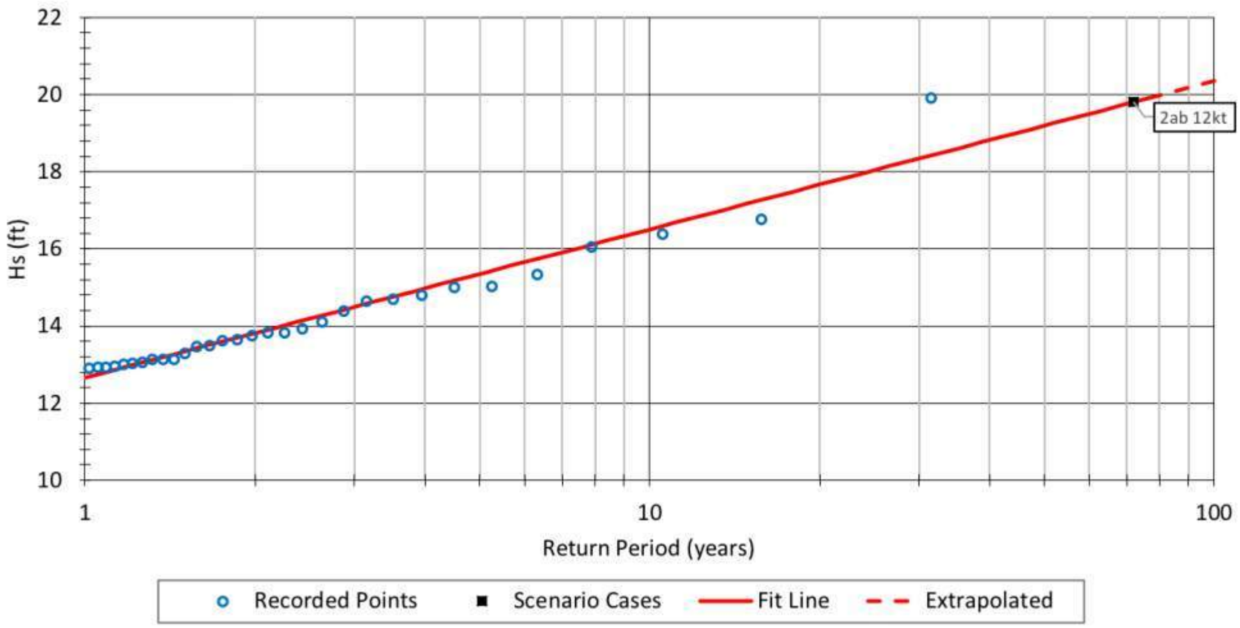


Figure 6-66. Plot of return period wave heights at nearshore model's deep-water boundary using Weibull distribution.

Table 6-19. Table of Weibull-distribution return period wave events at nearshore model boundary, with hurricanes included (in *italics*)

Event	H_s		H_{max}		Return Period
	(ft)	(m)	(ft)	(m)	(years)
1-yr Wave	12.7	3.9	25.3	7.7	1
2-yr Wave	13.8	4.2	27.6	8.4	2
5-yr Wave	15.3	4.7	30.7	9.4	5
10-yr Wave	16.5	5.0	33.0	10.1	10
25-yr Wave	18.0	5.5	36.1	11.0	25
50-yr Wave	19.2	5.9	38.4	11.7	50
2ab_12kt	19.8	6.0	39.6	12.1	N/A
100-yr Wave	20.4	6.2	40.7	12.4	100
Iniki	22.8	7.0	45.7	13.9	N/A
10kt	23.2	7.1	46.4	14.1	N/A
Iwa	24.8	7.5	49.5	15.1	N/A
5a_12kt	33.0	10.1	66.0	20.1	N/A
3ab_12kt	38.0	11.6	76.0	23.2	N/A

Lastly, it was noted during the 2018 visual inspection of Waianae ocean outfall that undersized ballast—visually estimated at 1-ft diameter or smaller—was observed in accumulations scattered off to the side of the ballast pile in some areas. Additionally, it was also noted that the outfall re-ballasting effort conducted as part of the outfall extension project initiated at the end of 1982 (completed in 1986), was commenced shortly after the passage of Hurricane Iwa. It is possible, perhaps likely, that the stray ballast observed during the recent inspection was a result of damage inflicted by Iwa, and that the re-ballasting construction effort completed in 1986 was a direct result of that damage. No records are available to confirm this assertion however.

6.6.4 Summary

In summary, the following comments and recommendations are made based on the results of this outfall stability study:

- Return period wave heights for the Waianae area, along with the range of stone sizes found during inspection, suggest that the outfall ballast sections may potentially have been designed to a nominal 50-yr wave height, and will likely remain stable for seasonably high surf episodes with wave heights equivalent to or less than that.
- Model results suggest that damage to ballasted sections of the outfall may result from the direct strike of a hurricane.
- Trenched and concrete-capped sections of the outfall, including the entire extension and diffuser leg, are considered well protected.
- Since the analysis shows that damage may occur to the ballast pile from individual stone loss, it is recommended that an emergency visual inspection of the entire outfall be conducted following the direct or near-direct hit of any significant tropical storm to Oahu.
- It is also recommended that a high-resolution multibeam survey of the outfall corridor be conducted after such an event, in order to quantify large scale changes to the ballast pile and surrounding seafloor.
- Ballast attrition volumes may be estimated relatively accurately by comparing the proposed emergency post-storm survey with the high-resolution baseline survey conducted by SEI in 2017.

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7. SUMMARY & RECOMMENDATIONS

7.1 High Resolution Bathymetric Survey Summary

The multibeam survey results clearly resolved the outfall in its various forms along much of the outfall corridor, and particularly where the trench cut appears to slice through the surrounding seafloor (which is characteristically irregular, hard bottom substrate). Visual analysis of the processed bathymetry data suggests that the seafloor adjacent to the outfall appears to be stable with no indications of significant erosion, active fissures, scour, or other destabilizing processes identifiable in the corridor that may threaten the outfall.

Additionally, the survey data will serve as a valuable baseline for which future surveys may be compared to, allowing direct assessment of seafloor stability within the corridor as well as outfall displacements or ballast attrition. A complete set of the annotated sun-illuminated hill-shade digital terrain models of corridor bathymetry are presented in Appendix B. Another version of the same map set with annotations overlaid for reference is provided in Appendix C.

7.2 Exterior Inspection and Cathodic Protection Summary

A visual exterior inspection was conducted for all exposed portions of Waianae Ocean Outfall. Inspectors noted that overall, the outfall appeared to be in good operational condition. The seafloor adjacent to the pipe was observed to be hard substrate, with no evidence of active erosion or scour, forming a stable foundation to support the pipe throughout the outfall corridor.

A limited area of cracking in the concrete cap (spanning less than 10 feet in length) was found near the start of the new 42-inch line, however, the damage appeared limited and the mass of the cap appeared to still sufficiently protect the pipe buried within the underlying trench. Otherwise, where visible, the concrete cap/jacket was found undamaged or degraded along the length of the outfall.

Ballasted sections of the outfall were typically in good condition, matched as-built construction plans relatively well, appeared stable, and currently providing ample protection and reserve material for the pipeline in those areas. In summary, the entire length of submerged outfall appears to be well protected—either fully trenched and jacketed in concrete, or partially trenched and covered in an engineered ballast pile, with no part of the actual reinforced concrete pipe joints visible at any location. All diffusers were functioning as designed, and no leaks were detected elsewhere.

The four concrete and stainless steel manholes on the newer 42-inch extension were in excellent condition with no signs of damage, corrosion, or leakage. The cast iron manhole assemblies on the older 36-inch pipeline all exhibited signs of advanced corrosion, with the manhole covers in particular, likely to be compromised from loss of effective material thickness.

The stopgate and special wye structures were found to be in good condition with no signs of leakage or degradation. The stainless steel slot covers and underlying rubber gaskets on the special wye structure were observed to be in good condition, with no evidence of corrosion on the covers and the rubber gasket material still pliable and forming a tight seal with no leakage.

7.3 Shoreline Assessment Summary

Comparison of present-day and historical aerial imagery for the Waianae coastline has revealed that a short section of shoreline on the south flank of the outfall has eroded substantially since the time of outfall construction in the mid-1960s. Measurements from the photographic analysis estimate that the shoreline location on the south side of the pipe has receded approximately 30 feet or more since construction, while the shoreline on the north side has remained relatively static.

Visual inspection of the outfall's shoreline landing site confirmed the shoreline erosion, as well as the loss of a portion of the south trench wall. Closer inspection of this area also revealed a section of pipeline that was completely undermined and unsupported for a span of approximately 20 feet. Erosion and subsequent trench wall failure have exposed this intertidal section of pipe to direct wave action, sediment movement, and potential impact hazards from nearby large stones or boulders displaced during periods of high surf. A temporary repair to brace and protect the unsupported span was completed in June 2018.

7.4 Stability Analysis Summary

Conservative assumptions were used in a series of numerical wave models to generate a set of worst-case conditions based on NOAA-developed scenario hurricane trajectories. Resulting wave heights and currents were used to drive detailed near-field three-dimensional computational fluid dynamics (CFD) wave models which directly calculated hydrodynamic forces on the outfall ballast. In addition to the numerical method, two empirical methods were used to compare with the CFD-based forces. Final results suggested that ballasted sections of the outfall were susceptible to damage at such extreme conditions. For the highly immobilized and hardened areas of pipeline, where the outfall is fully trenched and capped with a concrete jacket, the outfall was considered inherently safe due to the method of construction.

Damage during such extreme conditions would likely be a gradual attrition of ballast from the pipe, which would increase in severity with an increase in event duration. Ballast piles are typically designed with a certain amount of reserve ballast in the pile, available to respond and readjust when lower units are removed, and therefore the structure would likely be able to withstand significant amounts of damage before the pipe becomes gravely threatened.

All but one of the scenario hurricane wave heights exceeded the statistical 100-yr return period wave height for Waianae shoreline exposures, while the 50-yr wave height (a value often used for design) is lower than all actual hurricane and scenario hurricane wave heights, suggesting that if the outfall were designed to a similar 50-yr criterion, this would explain why the ballast appeared undersized (unstable) for all modeled scenarios based on the CFD model.

7.5 Recommendations

The following recommendations are provided to maintain the structural integrity and environmentally safe operation of the Waianae Ocean Outfall:

A. Cap existing cast iron Manholes 2 through 4 on the original 36-inch pipeline. Advanced and ongoing corrosion may eventually lead to failure of the manhole covers or risers and potentially result in unexpected effluent discharge due to leakage. As installed, the pre-cast concrete cap should extend sufficiently below existing grade to encapsulate the entire riser, while the void space between the cap and manhole should be filled with grout to displace all air or water. Permits anticipated to be required for the proposed work are as follows:

1) Section 10 (Rivers and Harbors Act Permit) and Section 404 (Clean Water Act Permit)

2) Section 401 (Clean Water Act, Water Quality Certification)

B. Begin the planning and design effort for a permanent repair concept which not only protects the pipe at the emergency repair area, but also stabilizes and armors the nearby adjacent rock formations and shoreline upon which the pipeline is founded. Permits anticipated to be required for the proposed shoreline armoring are as follows:

1) SMA/SSV (Special Management Area Use Permit and Shoreline Setback Variance)

2) CDUP (Conservation District Use Permit)

3) Section 10 (Rivers and Harbors Act Permit) and Section 404 (Clean Water Act Permit)

4) Section 401 (Clean Water Act, Water Quality Certification)

5) CZM (Coastal Zone Management Consistency Determination)

C. Implement a preventative maintenance plan to inspect the outfall biyearly, or following episodic extreme conditions such as a significant seismic event, tsunami, or large storm system impacting the site, in order to identify new threats, damage, or potential for failure before it occurs. In particular, the following are recommended:

1) Conduct a high-resolution multibeam survey of the outfall corridor be conducted after such an event, in order to quantify large scale changes to the ballast pile and surrounding seafloor.

2) Continue to monitor the site of broken concrete jacket/cap near the start of the 42-inch extension for any signs of movement of the fractured cap pieces or erosion of the material beneath the cap. Also continue to monitor the low spot in ballast pile observed near station 23+50.

3) Since the analysis shows that damage may occur to the ballast pile from gradual stone loss, it is recommended that an emergency visual inspection of the entire outfall be conducted following the direct or near-direct hit of any significant tropical storm to Oahu.

4) Periodically monitor the above water portion of the outfall for signs of movement, displacement, or erosion of the supportive rock mass. Additionally, monitor the temporary repairs for stability until the permanent repair solution is in place, with a particular focus on signs of degradation of the concrete.

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APPENDIX A

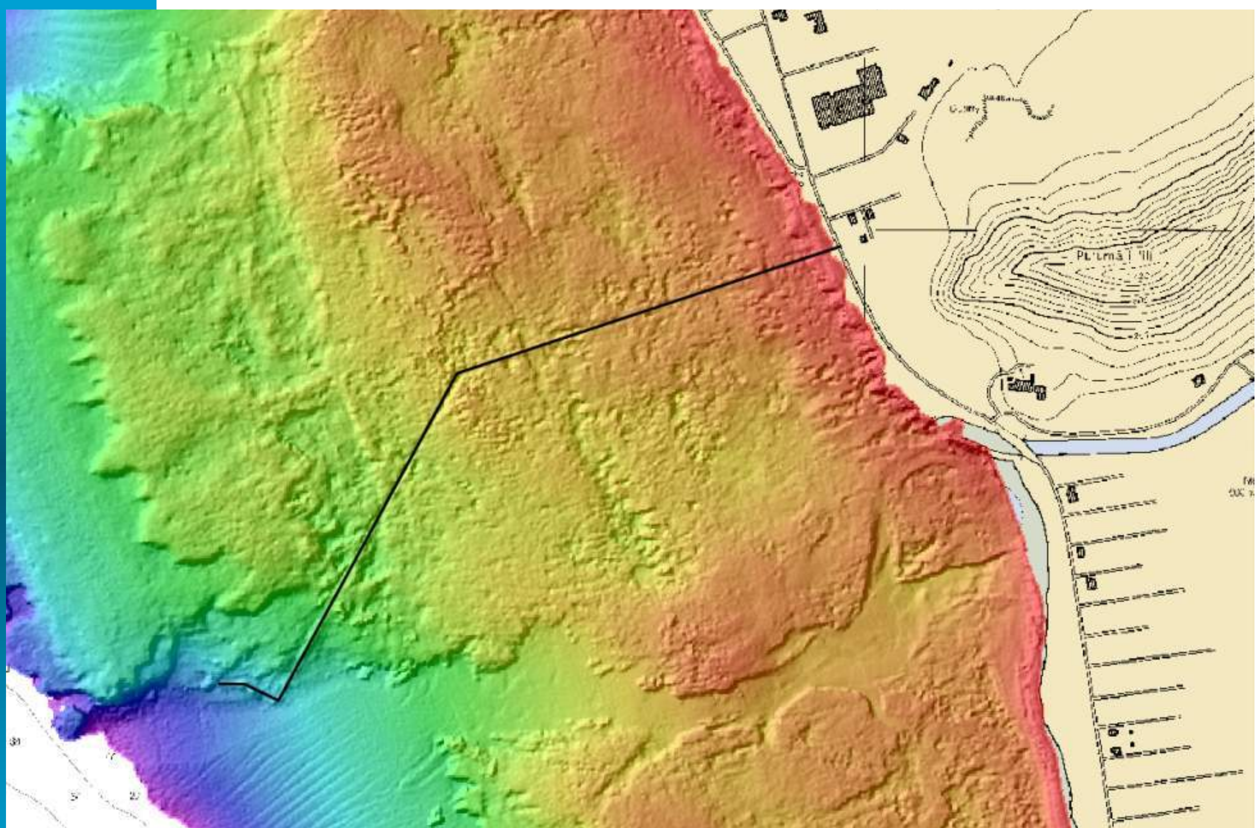
WAIANAE OCEAN OUTFALL INSPECTION ACTIVITIES – WORK PLAN

FINAL

Work Plan:
Waianae WWTP Ocean Outfall Inspection and Condition Assessment Program

Waianae, Oahu, Hawaii

March 2016



Prepared for:

SSFM International

Prepared by:

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Makai Research Pier
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SEI N^{o.} 25487

EXECUTIVE SUMMARY

The Waianae Waste Water Treatment Plant (WWTP) serves as the primary sewage reception, treatment and disposal facility for a large portion of West Oahu. The facility utilizes an ocean outfall structure for transferring treated effluent from the treatment plant to offshore waters for disposal. The Waianae WWTP's 36 inch diameter ocean outfall was initially constructed in 1965 to a depth of 24 ft, and later extended to a depth of 105 ft with a 42 inch pipe in 1987. The pipeline extension was installed on a gravel bed within a trench excavated from the reef, backfilled with stone, and capped with tremie concrete, or ballasted with rock. The new offshore diffuser leg was equipped with 42 top mounted, 3 inch diameter diffuser ports.

Routine environmental water quality inspections conducted in early 1996 noted leaking effluent emanating from the junction box, which forms the transition from the original 36 inch pipe with the 42 inch extension. A repair of the leak was completed in March of 1996.

This work plan has been developed to provide a comprehensive engineering inspection methodology for assessment of the existing condition of the outfall structure and adjacent seafloor corridor. Due to the lack of any documented annual, regular, or any other type of physical or engineering inspections having been conducted of the outfall since it's construction, this work plan has been structured to present a wide array of inspection components and techniques in order to aid in evaluating the pipe's current condition, and to make informed estimates of it's remaining service life.

Recommended inspection tasks in this work plan include the following:

- High resolution multibeam bathymetric survey of the pipeline and surrounding seafloor ($77,670);
- External visual inspection of the entire outfall including diffuser port maintenance ($64,050);
- Dye injection leak testing ($40,130);
- Cathodic protection and corrosion assessment ($4,300);
- Concrete core extraction and testing ($65,720);
- Stability analysis modeling ($85,660); and,
- Service life modeling ($8,070).

Optional inspection tasks, which may be recommended at a later time based on findings gathered during the initial inspection work, are as follows:

- Side scan sonar survey of the outfall corridor ($21,910);
- Laser scanning point cloud survey of specific damage areas (cost TBD); and,
- Internal inspection of the pipe barrel ($200,000).

None of the recommended inspection activities presented in this work plan are expected to have significant impacts on normal plant operations.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. BACKGROUND

The Waianae Waste Water Treatment Plant (WWTP) is located approximately 1.5 miles south of Waianae Small Boat Harbor, on the western shoreline of the island of Oahu, in the State of Hawaii. The facility's relative location is illustrated in Figure 1-1. The treatment plant utilizes an ocean outfall structure for transferring treated effluent from the facility to offshore waters for disposal, where it is introduced at depth by an array of diffusers for dilution and dispersal by natural oceanographic processes.

The Waianae WWTP's ocean outfall was initially constructed in 1965 with a 3,133 ft (955 m) length of reinforced concrete pipe (RCP) with a diameter of 36 inches (914 mm), and terminated with a 230 ft (70 m) long, southward angled diffuser leg at a depth of approximately 24 ft (7 m). The diffuser leg was equipped with one 6 inch (152 mm) diameter diffuser and seven 8 inch (203 mm) diameter diffusers mounted along the top of the pipe at 18 ft (5.5 m) spacing. During construction of the original outfall, a 24 inch (610 mm) diameter RCP bypass line was also installed, which runs roughly parallel to the main line for a length of approximately 265 ft (81 m) starting from just landward of the shoreline. The bypass line is normally closed, and accessed through a wye ("Y") structure located near Station 00+00 of the main outfall, where is controlled with a plug valve located in a valve box located above the high water mark. The bypass line terminates just seaward of the reef line near sea level, north of the primary outfall. Images of the outfall daylighting at its shoreline emergence (along with the bypass line) taken during a recent site visit are shown in Figure 1-2 and Figure 1-3. These photographs are illustrative of the trenching and grout capping process used during construction for most of the nearshore portion of the outfall. Areas of eroded soft sedimentary rock or limestone have left the grout cap fully exposed in some places, as shown in Figure 1-2.

Approximately two decades after initial construction, an extension was added to the original outfall. The extension project was completed in 1986, and shifted the diffuser field out to an approximate depth of 105 ft (32 m). The 42 inch (1,067 mm) diameter extension consisted of an additional 3,051 ft (930 m), for a total length of 6,184 ft (1,884 m), terminating with a 530 ft (162 m) long diffuser section. The pipeline extension was installed on a gravel bed, within a trench excavated from the reef. Following installation, the trenched pipeline was backfilled with stone and capped with tremie concrete, or ballasted with rock.

The new diffuser leg consists of 42 top-mounted diffuser ports equipped with 3 inch (122 mm) diameter elbow risers with a riser height of approximately 1 ft (0.3 m) and spaced at a 12 ft (3.7 m) on-center interval. The diffuser leg terminates with a concrete stopgate structure. According to as-built construction plans, 21 of the diffuser ports were installed with blanking plates, meaning they were effectively closed. The remaining 21 ports were installed in an 'open' configuration, allowing flow.

In 1996, routine environmental inspections noted a leak emanating from the junction box (wye structure) which forms the transition from the original 36 inch pipe with the 42 inch extension. A repair of the leak was completed in March of 1996. Engineering plans or other details describing the repair work were not available at the time of this report.

A plan view of the outfall's currently documented configuration is presented in Figure 1-4. A profile view of the outfall centerline is illustrated in Figure 1-5. Both figures were taken from the 1983 as-built construction plan set.

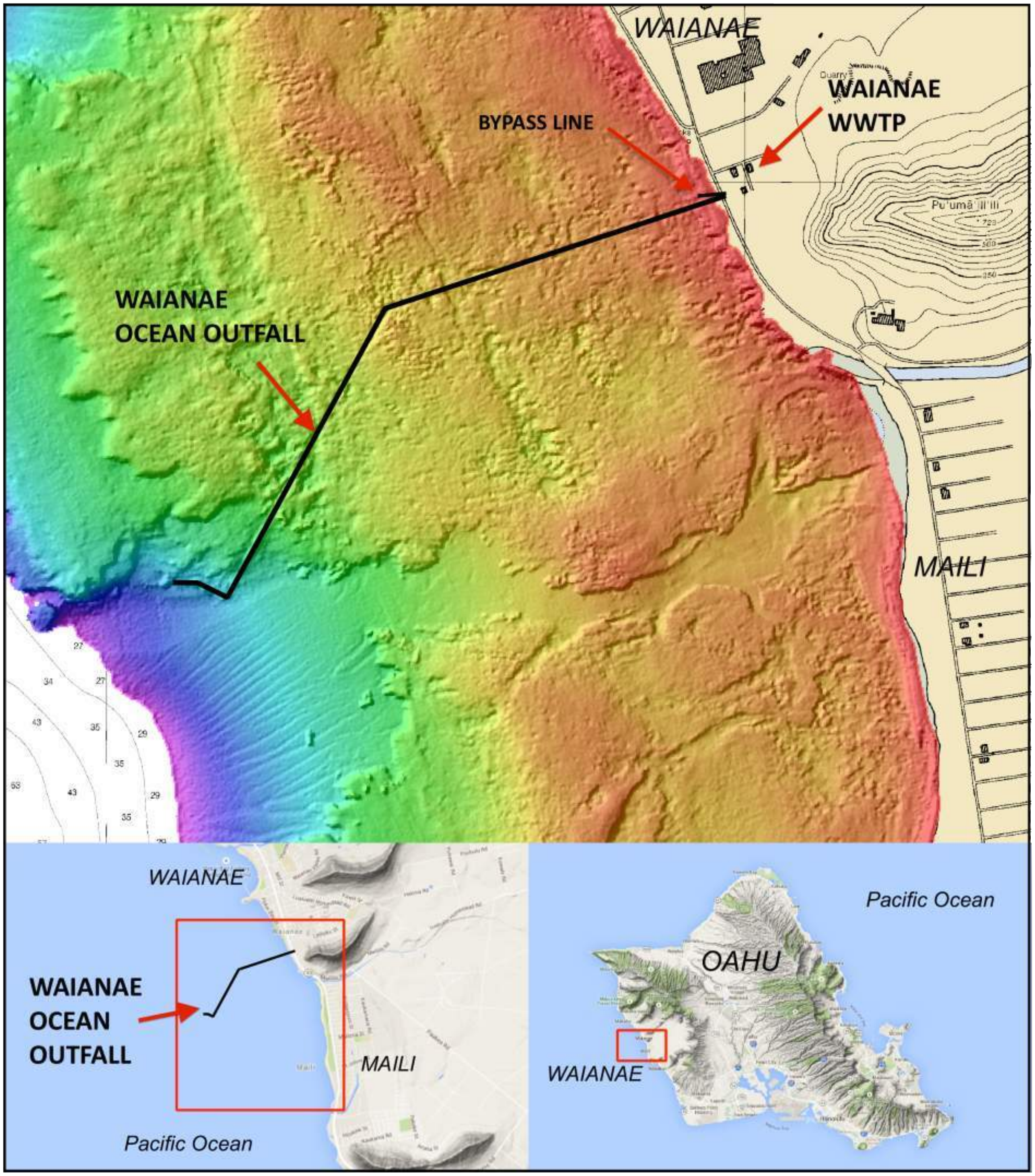

Figure 1-1. Waianae WWTP location map, with color-shaded bathymetric DTM. (Bathymetry source: SHOALS LiDAR bathymetry). Depth color scale: Red = 0 ft, Cyan = 100 ft.

Figure 1-2. Outfall bypass line and junction/valve box.

Figure 1-3. Outfall shoreline emergence with junction/valve box.

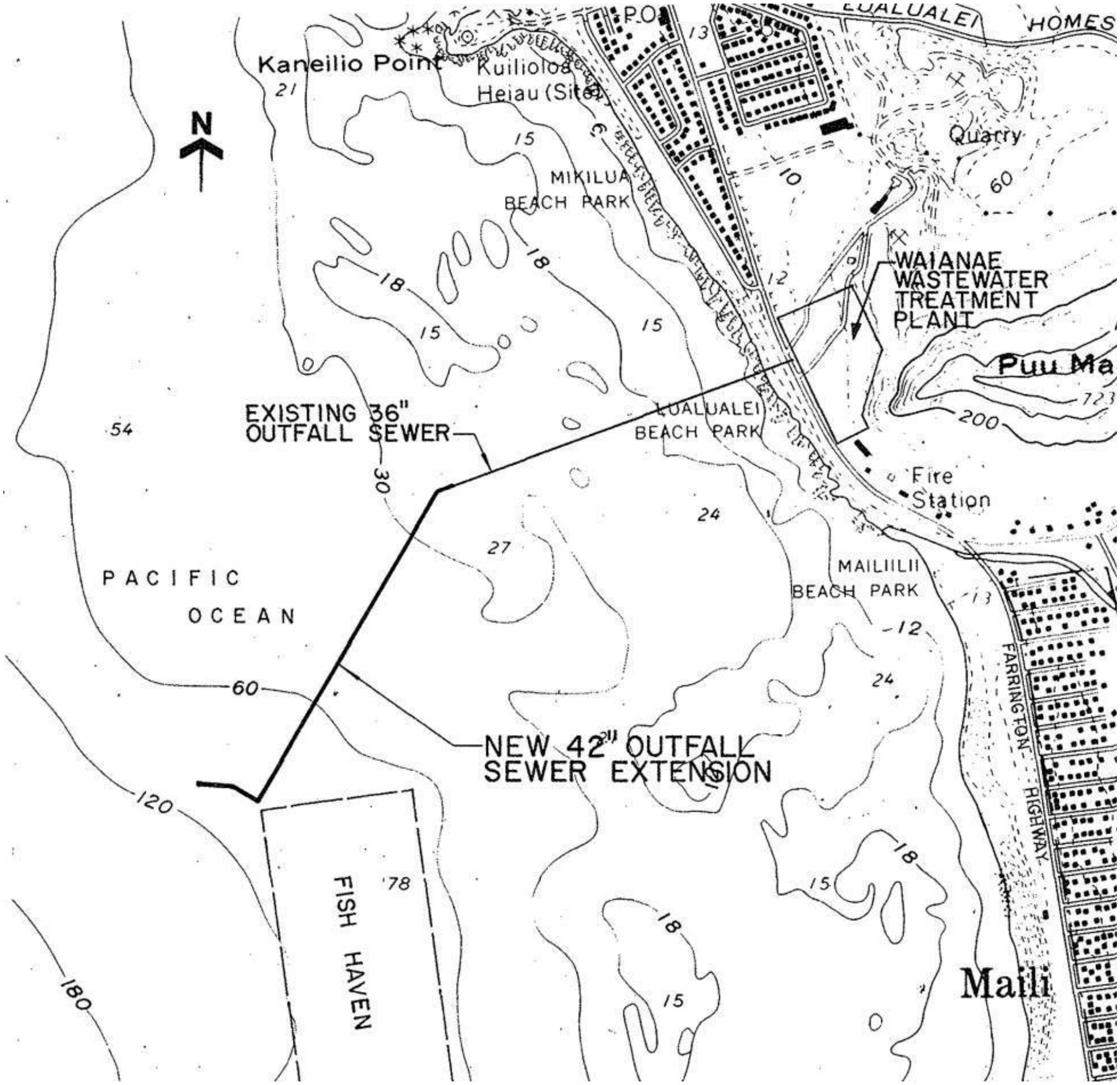

Figure 1-4. Waianae WWTP ocean outfall plan view, extracted from the as-built construction drawings.

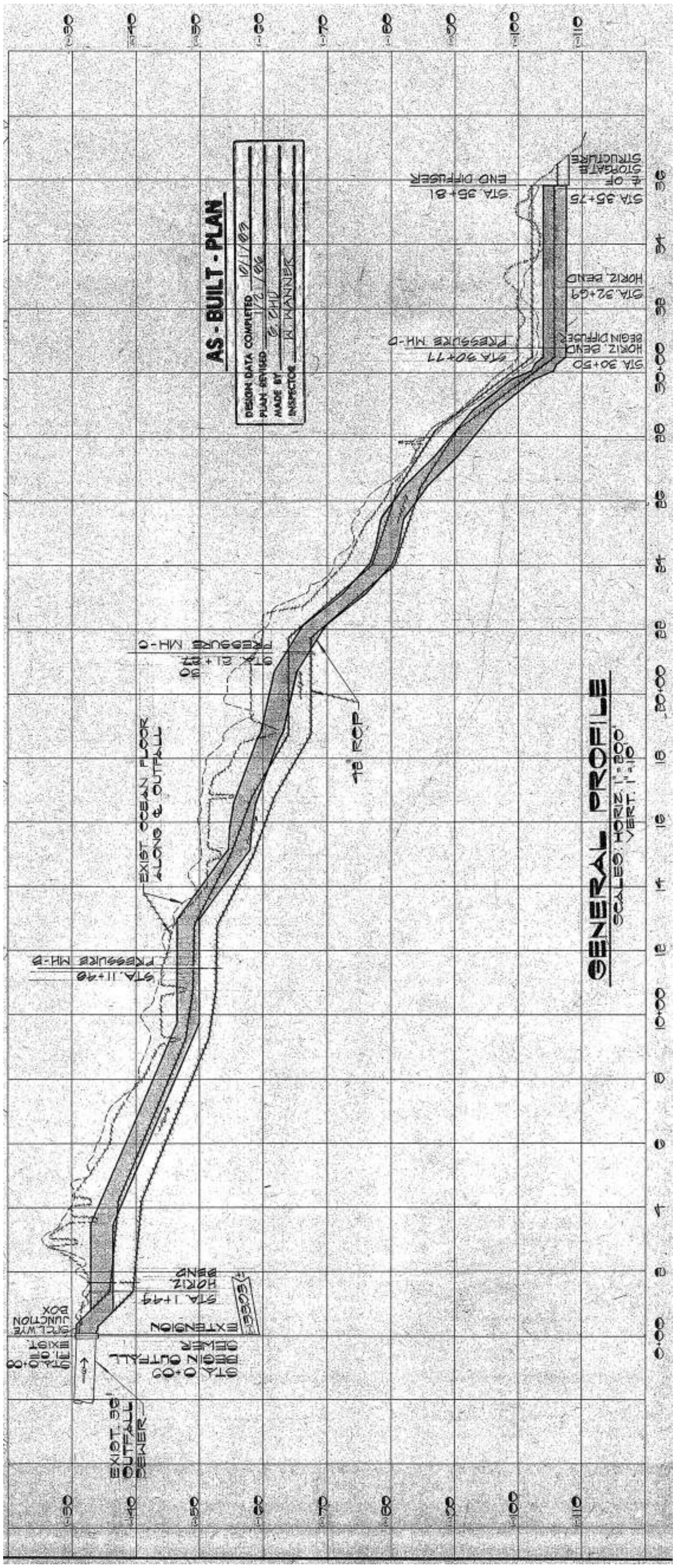

Figure 1-5. Waianae WWTP ocean outfall profile view of extension, extracted from the as-built construction drawings.

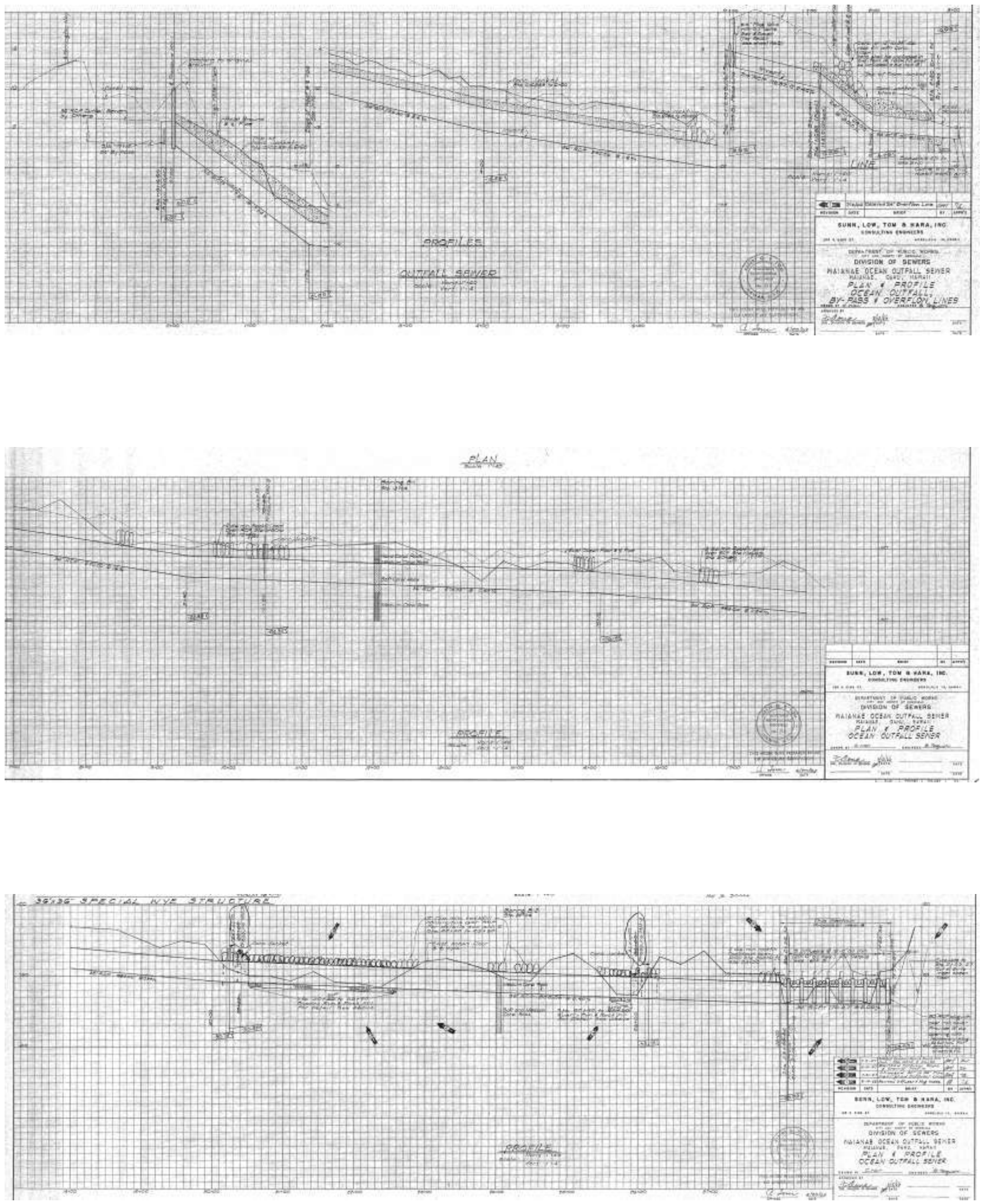

Figure 1-6. Waianae WWTP ocean outfall profile view of original pipeline, extracted from the as-built construction drawings.

2. PROJECT OVERVIEW

2.1 Purpose

SSFM International, Inc. has been contracted by the City and County of Honolulu to conduct planning and design services for the Waianae Wastewater Treatment Plant (WWTP) Outfall Improvements and Rehabilitation Project. Sea Engineering, Inc. (SEI) has been selected by SSFM to assist with the inspection and condition assessment of the ocean outfall.

The purpose of the work plan is to develop and document a procedure and associated costs to inspect and assess the current condition of the ocean outfall, and to provide appropriate recommendations on improvements if necessary.

This document presents the proposed work plan, and serves as the initial task of the larger project, which consists of the performance of the task items developed herein. The objectives of the work plan are to obtain available background information on the outfall's current condition; to develop a plan for inspecting and assessing the existing condition of the outfall based on various inspection methods; to evaluate outfall stability during extreme conditions such as during a hurricane; to provide costs for each of the work plan elements; and to provide recommendations for repair work if necessary.

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3. MAINTENANCE AND INSPECTION METHODS AT OTHER OUTFALLS

Background information was collected on other existing outfalls to gain perspective from alternate inspection programs, as well as maintenance issues and problems encountered that may be relevant to Waianae WWTP's ocean outfall. A summary of information on selected existing outfalls is presented in the subsections below. The synopsis includes date brought into service, location, operational parameters, inspection methods, and documented significant findings.

Inspection and assessment activities conducted for these outfalls included diver and remotely operated vehicle (ROV) visual overview inspections, multibeam and sidescan sonar surveys, internal inspection by divers and ROV, concrete coring of pipe barrel, dye tests, cross-section measurements of ballast pile and inspections with submersibles. The general observations of these inspections included deficient rock ballasting, leaks at joints and manholes, clogged diffuser ports, and corrosion of exposed metallic components and interior rebar.

3.1.1 Sand Island Ocean Outfall, Honolulu, Hawaii

Entered service:	1976
Description:	Outfall material -- RCP Anchoring -- Combination of trenching and ballast Designed max flow rate -- 202 MGD Average flow rate -- 70 MGD Outfall length -- 2.28 mi Diffuser type -- single leg (near parallel to shore) Diffuser length -- 3,398 ft Max diffuser depth -- 240 ft
Inspection Methods:	Visual inspection of outfall ballast pile to 100 ft depth using divers Visual inspection of the deep exposed outfall and diffuser leg using submersible High resolution multibeam survey of outfall corridor ROV inspections completed by C & C annually
Significant Findings:	Some blocked diffuser ports Flap gate at end structure found partially opened

3.1.2 Hilo Ocean Outfall, Big Island, Hawaii

Entered service:	1965 (extended 1987)
Description:	Outfall material -- RCP Anchoring -- Combination of ballast and trenching Outfall length – 4,468 ft Diffuser length -- 210 ft Max diffuser depth -- 90 ft

Inspection Methods: Visual inspection of outfall using divers
Diver cross sections
Hydrographic surveys

Significant Findings: Scour of supportive bed
Some small leaks noted
Various repairs completed in 1989

3.1.3 Honouliuli ('Barbers Point') Ocean Outfall, Oahu, Hawaii

Entered service: 1982

Description: Outfall material -- RCP
Anchoring -- Combination of ballast and trenching
Outfall length -- 2.0 mi
Diffuser length -- 1,777 ft
Max diffuser depth -- 205 ft

Inspection Methods: Visual inspection of outfall using divers
Submersible used for visual inspection at depths greater than 120 ft
Diver cross sections
Hydrographic surveys
ROV external inspection of entire ocean outfall
ROV internal inspection of entire ocean outfall, equipped with profiling sonar

Significant Findings: Significant ballast attrition attributed to large wave forces resulting from hurricanes Iniki and Iwa. Subsequent stability modeling revealed undersized ballast. Repairs for re-rocking the outfall were designed and completed based on stability modeling results.

3.1.4 Hyperion Ocean Outfall, Los Angeles, California

Entered service: 1960

Description: Outfall material -- RCP
Anchoring -- Ballast
Designed max flow rate -- 720 MGD
Outfall length -- 5 mi
Diffuser type -- dual diffuser legs, using a 'Y' configuration
Diffuser length -- 4,000 ft, each leg
Max diffuser depth -- approximately 200 ft

Inspection Methods: Visual inspection using ROV annually
Multibeam survey of outfall corridor
Internal inspection of first 2,500 ft by divers
Pipe coring
Scanning sonar survey of pipe interior along diffuser sections

Significant Findings: Ballast rock deficiencies noted
Signs of corrosion visible from pipe interior

3.1.5 Orange County Ocean Outfall, Huntington Beach, California

Entered service: 1971

Description: Outfall material -- RCP
Anchoring -- Ballast
Designed max flow rate -- 480 MGD
Outfall length -- 5.2 mi
Diffuser type -- single diffuser leg, shore-parallel
Diffuser length -- 5,940 ft
Max diffuser depth -- 200 ft

Inspection Methods: Visual inspection of outfall ballast pile to 65 ft depth using divers
Visual inspection of the deep outfall and diffuser leg using submersible
Single beam hydrographic survey of outfall corridor
Inshore ballast pile cross section measurements by divers
Diffuser port cleaning using probe on submersible

Significant Findings: Concrete degradation noted on exposed RCP joints in areas
Signs of corrosion visible from pipe interior
Some diffuser ports found obstructed

3.1.6 Point Loma Ocean Outfall, San Diego, California

Entered service: 1963

Description: Outfall material -- RCP
Anchoring -- Ballast
Average flow rate -- 180 MGD
Outfall length -- 4.5 mi
Diffuser type -- dual diffuser legs, using a ‘Y’ configuration
Max diffuser depth -- 330 ft

Inspection Methods: Annual visual inspection of outfall ballast pile to 100 ft depth using divers
Annual visual inspection of the deep outfall and diffuser legs using ROV
Single beam hydrographic survey of outfall corridor
Visual inspection of pipeline interior from WWTP to 2,000 ft, using divers

Significant Findings: Pipeline rupture due to buoyant forces/air entrapment (approx. 40 ft depth)
Signs of corrosion and concrete degradation visible in the first 2,000 ft of pipe interior

3.1.7 San Elijo Ocean Outfall, Cardiff, California

Entered service: 1965 (extended in 1974)

Description: Outfall material -- RCP
Anchoring -- Ballast and pile supported
Outfall length -- 1.5 mi
Diffuser length -- 1,176 ft
Diffuser type -- single diffuser leg, perpendicular to shore
Max diffuser depth -- 150 ft

Inspection Methods: Annual visual inspection of outfall ballast pile to 100 ft depth using divers
Visual inspection of the deep outfall and diffuser leg using ROV
Single beam hydrographic survey of outfall corridor
Multibeam survey of outfall corridor
Visual inspection of portholes and inshore pile supports
Cathodic protection inspection of pile supports and porthole covers
Ballast pile cross section measurements by divers
Kelp clearing
Concrete coring

Significant Findings: Some areas of seafloor instability, sand scouring along ballast pile toe
Minor ballast movement
Sacrificial anodes replaced on some pile supports

3.1.8 La Salina Ocean Outfall, Oceanside, California

Entered service: 1975

Description:
Outfall material -- Steel pipe with cement jacket
Cathodic protection -- Impressed current CP system
Anchoring -- Ballast
Outfall length -- 1.7 mi
Typical discharge rate -- 13 MGD
Diffuser length -- 230 ft
Diffuser type -- single diffuser leg, perpendicular to shore
Max diffuser depth -- 100 ft

Inspection Methods:
Visual inspection of entire outfall using divers
Single beam hydrographic survey of outfall corridor
Multibeam survey of outfall corridor
Visual inspection of manholes
Cathodic protection inspection
Ballast pile cross section measurements by divers
Clearing of obstructed diffuser ports by divers

Significant Findings:
Some areas of seafloor instability, sand scouring along ballast pile toe
Some plugged diffuser ports

3.1.9 Encina Ocean Outfall, Oceanside, California

Entered service: 1965 (extended 1974)

Description:
Outfall material -- RCP
Anchoring -- Ballast
Outfall length -- 1.5 mi
Diffuser length -- 800 ft
Diffuser type -- single diffuser leg, perpendicular to shoreline
Max diffuser depth -- 170 ft

Inspection Methods:
Annual visual inspection of outfall ballast pile to 100 ft depth using divers
Visual inspection of the deep outfall and diffuser leg using ROV
Single beam hydrographic survey of outfall corridor
Multibeam survey of outfall corridor
Visual inspection of manhole caps
Cathodic protection inspection of slot covers
Ballast pile cross section measurements by divers
Kelp clearing
Concrete coring

Significant Findings: Some areas of seafloor instability, sand scouring along ballast pile toe
Some plugged diffuser ports
Manhole cover leakage due to corrosion, manholes later capped and grouted

3.1.10 Goleta Ocean Outfall, Santa Barbara, California

Entered service: 1965

Description:
Outfall material -- RCP
Anchoring -- Ballast
Outfall length -- 1.9 mi
Typical discharge rate -- 4.2 MGD
Diffuser type -- single diffuser
Max diffuser depth -- 100 ft

Inspection Methods: Annual visual inspection of outfall using divers

Significant Findings: None available

3.1.11 Santa Cruz Ocean Outfall, Santa Cruz, California

Entered service: 1989

Description:
Outfall material -- RCP
Anchoring -- Ballast
Outfall length -- 2.3 mi
Typical discharge rate -- 10.5 MGD
Diffuser type -- single diffuser leg
Max diffuser depth -- 110 ft

Inspection Methods:
Visual inspection of outfall using divers
Dye testing

Significant Findings:
Leak observed at 70 ft depth
Some plugged diffuser ports

3.1.12 Monterey Regional Ocean Outfall, Santa Cruz, California

Entered service:	1982
Description:	Outfall material -- RCP Anchoring -- Ballast Outfall length -- 2.1 mi Diffuser length -- 1,371 ft Max diffuser depth -- 107 ft
Inspection Methods:	Visual inspection of outfall using divers Dye testing Hydrographic surveys
Significant Findings:	Loss of ballast Cracking of RCP nearshore from seismic movements

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4. OUTFALL INSPECTION AND CONDITION ASSESSMENT METHODOLOGIES

Suitable strategies for an inspection program for Waianae WWTP's ocean outfall will require completion of a number of tasks in order to develop a comprehensive understanding of the outfall's current condition and estimated future stability. In general, the outfall inspection and condition assessment can be categorized into four primary phases, as follows:

1. <u>Outfall corridor mapping</u>: Outfall corridor mapping involves conducting a bathymetric survey along the entire outfall pipeline and typically includes a 500 - 1000 ft swath of natural seafloor to either side of the pipe. The initial survey provides accurate positioning of outfall structures and establishes a baseline for future monitoring. Subsequent surveys are used to assess general physical condition by comparison with prior surveys. Significant ballast movement or pipe displacements would be revealed during the comparison analysis. Changes or instabilities in the adjacent seafloor due to scouring, erosion or other processes would also be highlighted.
2. <u>Outfall pipeline inspection</u>: Inspection work typically involves visual inspection and documentation of exposed portions of the ocean outfall. Inspection of the outfall exterior will provide a good indication of the pipeline's current state based on the appearance of exposed RCP surfaces, detection of significant ballast pile movement or instability, and cracking or other deficiencies of the grout cap where present. Additionally, visual inspection will identify abnormal areas of the seafloor along the outfall flank where erosion or scour may be actively undermining the pipe. Visual inspections will also confirm diffuser activity, at which point any diffuser ports that are found blocked will be manually cleared. Interior inspections will require specialized tools such as a pipeline pig or remotely operated vehicle (ROV) that is introduced into the pipe from the treatment plant, and then travels within the flowing effluent. Due to lack of visibility within the effluent stream, the ROV or pig would be equipped with ultrasonic sensors or profiling sonar for detecting major leaks or damage. This mode of inspection is challenging for outfalls however, due to the non-reversing nature of the effluent flow, and the extremely limited visibility inside the pipe. Equipment recovery would be difficult; recovery of a pig would require lifting of the concrete stopgate at the end of the diffuser leg, while recovery of the ROV requires pulling the ROV and cable back up the pipe to the shoreline access location.
3. <u>Quantitative and qualitative measurement programs</u>: Corrosion is a common concern for marine infrastructure, and assessing its threat is commonly incorporated in ocean outfall inspection plans. During visual inspection, a quantitative corrosion evaluation will be conducted for all exposed metallic elements including manhole covers, diffuser risers, stopgate lifting eyes, or any other metallic hardware, by obtaining *in situ* measurements of their galvanic voltage potentials using a reference electrode. Dye testing, a qualitative observation, will provide an initial and cost effective means of identifying leaks in the pipeline, and thus potentially significant problem areas. Selective coring of the reinforced concrete pipeline where it is exposed, will provide extremely valuable information on the current condition of the RCP through destructive testing in a laboratory, yielding data on compressive strength, chloride penetration relating to corrosion risk, and petrographic analysis relating to chemical attack of the concrete. The

core data may additionally be used at a later point for remaining service life modeling based on time to corrosion initiation.

4. Service Life Estimation and Outfall Stability: As the final phase of outfall condition assessment, this stage utilizes the data gathered during the field efforts of (1.) through (3.) above to develop numerical estimations of two key processes which have the potential to significantly affect the outfall negatively.

   First, a numerical simulation of chloride intrusion into the concrete using the STADIUM model will be conducted by a qualified laboratory for estimation of time-to-corrosion (TTC) of the reinforcing rebar. This is also referred to as an estimate for remaining service life for the RCP pipeline due to the process of spalling, where once the rebar begins to corrode and expand, the concrete is no longer in compression and begins to crack and fail mechanically. The TTC modeling involves numerical simulations that predict future chloride ingress and concrete degradation of the outfall pipeline, from which an estimation can be made of time to corrosion initiation of the steel reinforcement within the RCP, and thus expected remaining service life.

   A second numerical method will be used for estimating the physical stability of the outfall structure. The stability analysis involves a fusion of integrated wind, wave, and circulation modeling to drive a high resolution computational fluid dynamics (CFD) hydrodynamic model of lift and drag forces imparted on the pipe and ballast.

5. SPECIFIC WORK PLAN ELEMENTS

In general, outfall inspections have not required permitting from any regulatory agency. More specifically, none of the following tasks have required permitting in our experience. Therefore, permitting is not considered an element of the work plan. However, the dye testing task should involve notification to the U.S. Coast Guard prior to operations in order to avoid the potential for mistaking of the tracer dye with an emergency distress signal by observers. The durations for all tasks noted in this section are the total times to complete the tasks and generally include: task planning, mobilization, field data collection or other field operation, demobilization, data analysis, and report writing.

5.1 Outfall Corridor Mapping

5.1.1 High Resolution Multibeam Hydrographic Survey (Task A1)

A high resolution multibeam survey of the outfall and surrounding corridor is recommended as the first task to be performed for the program. The survey will provide an accurate map of the outfall's existing configuration, and will be used to construct a detailed digital terrain model of the outfall pipeline and surrounding seafloor, providing a vital first insight to its current condition, as well as usage for targeting areas of interest during planned visual inspection work.

Multibeam echosounder survey (MBES) systems utilize an array of multiple, narrow, acoustic beams to measure water depths across a wide swath of seafloor, ranging from 90 to 160 degrees depending on the model. MBES systems are capable of precise, high resolution measurement of depth and backscatter intensity, and have become a valued and reliable tool for seafloor surveying and underwater infrastructure inspections.

A high resolution multibeam survey of the Waianae Ocean Outfall will provide fundamentally important information, such as: continuous and highly accurate map of the entire outfall structure extents, including surrounding natural bathymetry; overview of general condition of the pipe, ballast pile or trench system protecting the pipe; measure of the level of sediment (if present) surrounding the outfall and diffuser leg; and general condition of the seafloor in the vicinity of the outfall. The multibeam survey will provide a critical baseline for future surveys to be compared with, allowing identification of areas of ballast movement or attrition, erosion of the supporting seafloor, or structural displacements.

For optimum results, a high resolution multibeam survey requires the following elements: stable survey vessel or other survey platform; modern state-of-the-art MBES system; high precision inertial navigation system (INS); accurate, sub-meter positioning system (i.e., real-time kinematics 'RTK' GPS); continuous measurements of sound velocity for the water column; data acquisition software on a high performance field computer, and data processing and calibration software. The survey area will cover the entire extents of the ocean outfall and surrounding corridor, as navigable by the survey vessel.

The survey vessel planned for this effort is the *S/V Huki Pono,* a 43-ft fiberglass hull constructed in 1985 by Delta Marine, Inc. The vessel is owned and operated by SEI, and is USCG certified for 30 passengers and two crew with berthing space for six persons. It is powered by twin 320-hp Caterpillar diesel engines, with a cruising range of 300 nautical miles.

During survey operations, the multibeam system will be used in two ways: range measurements from the MBES will provide accurate bathymetric data (depths) for the project site, while measurement of the backscatter intensity will provide an acoustic image of seafloor composition, with hard objects such as rocks and reef causing more intense backscatter, and soft materials such as sand causing less intense reflections. The tools and equipment required for the MBES survey are discussed in detail below:

Sonar Head: The system proposed for use in this work is the high resolution R2Sonic 2024 (or equivalent), which emits 256 beams in up to a 160° swath width at an operating frequency of 200-400 kHz. This high frequency system utilizes a 0.5° x 0.5° beam width resulting in up to 1.25 cm depth resolution. The sonar system will be pole mounted over the side in a vertical configuration, with the center (nadir) beam oriented directly down. The mounting system will be rigidly affixed to the ship's hull to prevent any independent motions that could degrade data quality.

Positioning: Precise positioning of the vessel and sonar head is essential for achieving accurate survey results. RTK GPS is presently the most accurate method of satellite-based positioning. RTK is a system in which GPS signal corrections are transmitted in real-time from a static reference receiver, referred to as a base station, at a known location, to one or more remote roving receivers. The RTK system proposed for use is a Leica GS/CS15 (or equivalent). The system requires a base station that is set up on a known benchmark with known horizontal and vertical coordinates referenced to project control points. During survey operations, the base station will be located at an appropriate location onshore, while the rover is placed on the survey vessel for primary positioning. Using RTK based GPS along with an inertial navigation system, positioning accuracies are sub-meter and can increase to centimeter level.

In contrast to the alternative of survey-grade differential GPS (DGPS) receivers, RTK GPS provides accurate (centimeter level) vertical (elevation) values, and therefore acquires usable measurements of water level above the WGS84 reference ellipsoid. As a result, it is a straight forward process to then calculate and correct for the tidal heights using the collected elevation data, based on a known benchmark tying local tidal datum to the reference ellipsoid.

Inertial Navigation System: During hydrographic survey operations, particularly in open coastal waters, vessel motions can be substantial and will have significant negative effects on the sonar data unless properly compensated for. An inertial navigation system (INS) is a system of devices that combines an inertial measurement unit (IMU) with heading and position measurements, to provide an extremely accurate measure of the vessel's attitude (pitch, roll, heave, etc.) in order to correctly position each of the 256 beams produced by the sonar head as the vessel moves in six degrees of freedom on the sea surface. The high resolution nature of this project will require systems such as the Applanix POS MV or the Coda-Octopus F180 (or equivalent) to perform this critical task.

Sound Velocity (SV) Measurements: Because the speed of sound through water varies with density (affected mainly by temperature and salinity), accurate sound velocity measurements are an important component for hydrographic surveys. To obtain a measure of the vertical structure of sound velocity (profiles) in the water column within the project area during survey operations, an Odom Digibar Pro sound velocity probe will be deployed by casting just prior to and immediately following the survey to correct for local conditions. The Digibar probe returns a profile of the sound velocity as it changes with depth in the water column. SV casts will be completed before and after the survey, and at both inshore and offshore locations. Open coastal locations such as Waianae are typically well mixed with little stratification, however if layering in sound velocity is observed, it can be accounted for with the collected SV data.

In addition to the SV casts which measure the vertical structure at discrete points within the survey area, an additional SV probe will be affixed to and integrated into the sonar head for continuous measurement of sound velocity at the sonar transducer. This data is used in real-time by the sonar processing electronics for beam forming and beam steering during active surveying.

Data Acquisition and Processing Software: The multibeam survey data will be acquired on a high-performance field computer using the industry standard hydrographic survey software known as Hypack, and their multibeam add-on called Hysweep. The Hypack/Hysweep software compiles all incoming data streams such as depth, position, heading, pitch, heave, roll, etc., and time-tags the data to millisecond precision as it is recorded. Hypack/Hysweep's multibeam editor is later used during post-processing to clean the data and produce motion, tide, and offset corrected soundings.

Survey methods, procedures, and QA/QC will adhere to guidelines and requirements given in the U.S. Army Corps of Engineers' engineer manual EM 1110-2-1003 (Chapter 11 – Multibeam Surveys for Navigation and Dredging Support Surveys over Hard Bottom), and related standards as described elsewhere in the manual. Quality control procedures include: keeping records of survey documentation such as line logs, device offset sketches and calculations; calibration patch test data including calculated results for offsets of pitch, roll, yaw, and latency; horizontal position accuracy checks; and, vertical control accuracy checks.

The patch test procedure is a standard calibration test used to determine offsets inherent in the installation configuration of the multibeam sonar head, the IMU, and the GPS antennas. The procedure consists of collecting overlapping data over short line segments at various speeds, offsets, directions, and bottom structures. Comparison and analysis of the calibration data within the processing software provides calculation of the following calibration offsets:

Latency: The latency test calculates the time-synchronization differences between the time-tagging of the multibeam soundings with respect to the time-tagging of the position records.

Pitch: The pitch test calculates the offset or angular misalignment between the fore/aft orientation of the MBES sonar head with relation to the IMU.

Roll: The roll test determines the offset or angular misalignment between the port/starboard orientation of the MBES sonar head relative to the IMU.

Yaw: The yaw test determines the offset or angular misalignment between the orientation of the MBES sonar head with respect to the heading sensor.

Deliverables

The high density and precision of multibeam soundings mean that the data can be processed to yield high resolution models of the sea floor and any structures present there. Final products developed from the survey will include point cloud data of the outfall corridor in XYZ format; gridded digital terrain model (DTM) for visual analysis, map products, sun-shaded perspective renderings; contour map in AutoCAD file format, and optionally cross sections at areas of interest.

Cost & Schedule

Estimated Cost: $77,670

Estimated Time to Complete: 90 days

5.1.2 Side Scan Sonar Survey (Task A2)

Side scan sonars are a towed sonar system that use transmitted and reflected acoustic energy to digitize a high resolution acoustic image of the seafloor. A side scan sonar transmits acoustic signals with wide vertical beam widths out to either side of a sonar towfish, which is towed near the seafloor behind the survey vessel. A topside receiver then records the signals that are reflected back from the seafloor to the towfish. The data acquisition computer combines the position data streaming in from the GPS receiver and parses it with the incoming sonar data in real-time to provide geo-rectified acoustic imagery.

In contrast to echosounders, which are employed to obtain accurate depth information, side scan sonars are an *imaging* sonar and use the acoustic signal reflections and shadowing to create a digitized image of the seafloor. Intensity of the backscatter created by the reflected signal is a characteristic property of the seafloor material it is reflecting from. For example, rocky areas, hard reefs, and manmade structures such pipelines produce more intense reflections, while sedimentary bottoms like sand and silt will absorb acoustic energy and be less reflective.

Side scan sonar data is collected in individual strips acquired along straight survey lines. Once the individual survey lines have been post-processed, they are merged and layered into a continuous map or mosaic, the result of which is an acoustic image of entire seafloor in the survey area, indicating bottom composition.

The advantage of a side scan sonar is that the system is towed through the water behind the survey vessel, in close proximity to the seafloor. By being towed, the sonar towfish is much nearer to the seafloor, thereby providing enhanced reflectivity and resolution of features on and around the outfall. A side scan sonar is also relatively cost effective to deploy and operate.

The primary disadvantage of side scan sonar is that the towfish is located some distance behind the vessel and below the water surface, and is therefore difficult to position accurately. The side scan would therefore not be used for depth measurements or accurate positioning of features of the outfall. Instead, it is proposed to utilize the side scan sonar only in addition to the MBES because of the advantage gained by the potentially higher resolution imagery that could be acquired by flying the towfish close to the outfall.

The side scan survey operation will require a suitable vessel, a survey-grade navigation system, and a side scan sonar system. The *S/V Huki Pono*, described above, is recommended for this survey due to it's greater stability, and the availability of an onboard a-frame for towing the sonar. A C-MAX CM2 side scan sonar system (or equivalent) will be utilized for the effort. The CM2 system uses a dual frequency 325/780 kHz signal generator, where the 325 kHz transducer provides a greater swath of imagery and longer ranges, while the 780 kHz transducer provides less range but finer resolution. Because of the inaccuracies of towing a system behind the vessel, the positioning requirements for a side scan survey are not as stringent as for a multibeam survey. In this case, a standard DGPS system which relies on RTCM corrections broadcast by U.S. Coast Guard operated beacons is sufficient for positioning. Hypack will be used for navigation and data acquisition.

The side scan sonar survey is suggested as an optional inspection element to be conducted if results of the multibeam survey indicate that additional information is needed.

Deliverables

The side scan data will be processed to develop an image mosaic, exported in a standard geo-referenced format such as 'GeoTIFF' or similar.

Costs & Schedule

Estimated Cost: $21,910

Estimate Time to Complete: 60 days

5.1.3 Point Cloud Laser Scanning of Damage Areas (Task A3)

In the case that an area of significant damage is identified along the outfall during visual inspections, and a repair must be considered, a new technology known as laser point cloud scanning could be utilized to accurately map the region of damage as a three dimensional model. The 3D scanning technology is derived from rapid prototyping and manufacturing industries such as automotive and aerospace, where mechanical parts are scanned into a CAD/CAM program for manipulation, modification, and assembly modeling.

In the case of an outfall inspection, a specialized underwater version of laser scanner would be required, such as the ULS-500 produced by 2G Robotics. The scanner is deployed by divers on the bottom, where it is placed on a tripod near the damage area. The scanner then sweeps multiple times over the area of interest, developing a dense point cloud representing the feature's surface. The scanner is then moved and redeployed a number of times to obtain points on the feature that were hidden from other setup locations. Sophisticated post-processing software is then used to stitch the individual scans from multiple views to build a continuous and complete coverage in three dimensions of the entire area of interest. This seamless 3D model can then be brought into CAD software for accurate analysis and repair design. An example of the underwater scanner's capabilities is shown in Figure 5-1, which illustrates the very fine detail and resolution possible with such instrumentation.

The point cloud scanning effort is not recommended for the initial general inspection program. However, three dimensional laser scanning should be considered as a separate follow-on option if conditions warrant it. Cost may vary significantly depending on the area and complexity of damage requiring scanning.

Deliverables

Data set will be processed to develop a 3D model, compatible with conventional CAD and 3D computer modeling software (*.stl, *.obj, *.sat, or other common format).

Costs & Schedule

Estimated Cost: TBD (to be determined)

Estimated Time to Complete: TBD

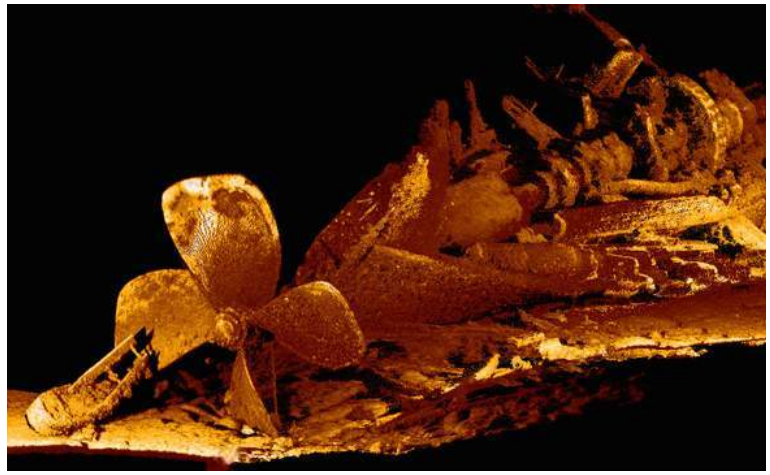

Figure 5-1. Laser scanner point cloud results for a submerged wreck.

5.2 Visual Inspections

5.2.1 Main Outfall Pipe Inspection (Task B1)

An ocean outfall, like any other type of civil infrastructure, requires routine inspection and maintenance to ensure functionality at full capacity throughout its design lifespan. However, being a structure submerged in a corrosive environment along an open coastal shoreline, the combined effects of hydrodynamic forces, foundation movement, corrosion, and scour can have catastrophic effects—even under normal conditions—on an improperly protected ocean outfall. The seasonal occurrence of high surf conditions and the resulting enhancement of hydrodynamic loads on the outfall typically pose the greatest threat to the Waianae Ocean Outfall. However, the episodic occurrence of rare events such as hurricanes, tsunami, and earthquakes can also impart excessive forces on the structure and may have devastating effects or otherwise indirectly lead to failure of the pipe. Regular inspection of the outfall is an important insurance policy by looking for early warning signs of potentially damaging conditions or other threats to the outfall's stability, and therefore allowing reaction time to be able to effect repairs as necessary.

Accurate positioning for diver operations is an important facet of underwater inspection work. Therefore, divers will be equipped with an underwater tracking device known as an ultra-short base line (USBL) tracking system, which uses acoustic signals transmitted from the surface support vessel to calculate range, elevation and azimuth to the diver's transponder. Additionally, temporary pipeline stationing may be demarcated with small markers placed every 100-ft along the outfall. These markers will provide visual pipeline stationing throughout the inspection project.

The diving inspection will include the pipe barrel, trench, grout capping, ballast pile, and adjacent seafloor. General inspection criteria will consist of the following:

- Evidence of spalling of exposed concrete surfaces
- Cracks or other deficiencies in the reinforced concrete
- Joint integrity
- Leaks or evidence of degradation in the pipe barrel
- Potential hazards
- Bio-fouling
- Manhole condition
- Attrition or the loss of efficacy of the trench, grout capping, or ballast material due to physical, biological, or geologic processes
- Scour, loss, or degradation of supportive sediments or limestone bed layer
- Anthropogenic debris

Additionally, inspectors will give particular attention to the condition of the 36 inch wye junction box located roughly 3,000 ft offshore, which forms the beginning of the 42 inch outfall extension. The junction box was repaired in 1996 after leaks were observed emanating from the structure.

5.2.2 Diffuser Leg Inspection (Task B1)

The approximately 500 ft long diffuser section lies in the deepest portion of the outfall corridor, and due to the 'no decompression' limitations on bottom time and required surface intervals for SCUBA divers, this portion of the outfall inspection may take up to an entire day to complete, depending on its condition. During visual inspection of the diffuser leg, engineering divers will assess the current state of the pipe and adjacent seafloor in terms of stability and potential threats to future stability. Open diffuser ports will be inspected for blockages, and manually cleared if necessary, while blanked (closed) diffuser ports will be checked for leakages. All exposed metallic hardware on the diffuser section will be checked for corrosion, including the diffuser port risers, blanking plates, and the stop gate lifting eyes.

5.2.3 By-pass Line and Surf Zone Inspection (Task B1)

The 24 inch by-pass line, which branches off of the primary outfall at the shoreline junction box, cuts through the beach rock shelf roughly parallel to the main barrel and terminates approximately 100 ft offshore. The by-pass line is trenched and grouted in the same manner as the primary 36 inch outfall and protected with a concrete jacket offshore.

Engineering inspectors will conduct the inspection work for the by-pass line along with the shoreline crossing segment of the main 36 inch outfall. This work will require careful planning to guarantee that it is conducted during exceptionally calm conditions, due to the hazardous surf zone and irregular reef scarp present along the shoreline, as well as to ensure sufficient visibility for documentation of underwater conditions. Inspectors will need to traverse the shoreline and surf zone multiple times as inspection activities take them up and down the pipelines. Particular attention will be given to the current state and condition of the grout cap and protective concrete jacketing. Significant cracks, spalls, areas of scour or loss of supportive base, and any other signs of degradation will be noted along with their position on the outfall.

Deliverables:

Deliverables for the exterior visual inspections will be included in a written inspection report and accompanying drawings, sketches, photographic and video documentation taken during the operation. Does not include interior inspection.

Cost & Schedule:

Estimated Cost: $64,050

Estimated Time to Complete: 150 days

5.2.4 Internal Inspection (Task B2)

Due to the inherent dangers involved with working in such a confined space, interior inspection of the outfall would not employ divers but would need to be conducted using a specialized ROV or by *pigging* the pipeline with an inline *pig* device. *Pigs* use the fluid flowing in the pipe to propel them along the pipeline, and in fact, term *pig* comes from the squealing sounds that the early versions of the device made as they traveled down metal oil pipelines. Modern pigs are technologically advanced instruments that house payloads including non-destructive testing (NDT) sensors or low light video equipment.

Pigs are untethered by an umbilical, and because the flow from the WWTP is not reversible, the pig would need to be recovered from the end of the outfall by lifting the stopgate, which is a massive concrete structure of unknown operability. Opening the stopgate, if functional, is expected to be an involved and costly effort requiring surface supplied diving and an on-site decompression chamber because of the depth at this location. These factors make using a pipeline pig for the interior inspection a less feasible option.

An ROV-based inspection would be complex and costly due to the length of the outfall and the amount of umbilical that would be required to transit the entire outfall. However, it is still a viable inspection technique that could be accomplished utilizing a specialty contractor's equipment and services to perform this operation. The ROV would be equipped with specialized low-light video equipment and lighting, as well as an imaging sonar to provide a real-time acoustic image of any obstructions or debris in the pipe.

Limitations of the ROV inspection would include the following: operations would require reduced flow from the plant during inspection; near zero visibility for optical cameras due to the high turbidity and suspended particulates of the effluent stream; and, the scanning sonar would only resolve major structural defects in the pipe wall with minor damage likely obscured by grease and biological buildup on the interior surface.

Due to the high costs, operational difficulties, and uncertainty of results related poor visibility, an internal inspection is not recommended for the initial phase of the outfall inspection and assessment. If significant damage or leaks are detected during the initial inspection phase, however, an interior inspection may be warranted. Therefore, the interior inspection will be considered as a potential follow-on option.

Deliverables:

ROV inspection video, results incorporated into inspection report.

Cost & Schedule:

Estimated Cost: $200,000 (rough order of magnitude cost using ROV)

Estimated Time to Complete: TBD

5.3 Quantitative and Qualitative Measurement Program

5.3.1 Cathodic Protection Inspection (Task C1)

Corrosion is a galvanic process that occurs when two connected dissimilar metals, or different regions of the same metal, are immersed in an electrolyte such as seawater and exhibit a voltage potential difference sufficient to initiate an oxidation reaction. Metals immersed in seawater are susceptible to corrosion, particularly near the surface where the water is highly oxygenated by the mixing effect of wind and waves, while those in deeper waters typically experience relatively less aggressive corrosion due to a lower availability of dissolved oxygen in the water. Even corrosion resistant materials such as stainless steel are susceptible to attack over time. Stainless steel is particularly vulnerable to pitting and crevice corrosion, which are variations of a focused attack on the metal surface caused by localized loss of the protective chromium passive layer on the metal surface.

Inspectors will utilize an underwater potentiometer with a silver/silver-chloride (Ag/AgCl) reference electrode in order to measure *in situ* voltage potentials of all exposed metallic hardware along the outfall. The voltage value of the potential measurements will indicate the current state of the metal surface—whether it is close to corrosion, actively corroding or inert. Typically, sacrificial anodes (zinc for ferric metals) are utilized as a passive cathodic protection measure on submerged steel alloy structures, including stainless steel. Documentation for such features has not been found in the available plans for Waianae's outfall, however if encountered, inspectors will note the location, integrity, voltage potential and estimated amount of anode remaining.

Based on the as-built drawings for the Waianae Ocean Outfall, there are three submerged manholes on the original outfall, with and an additional four more manholes on the extension. The manholes consist of a concrete box riser with a stainless steel manhole cover. Other metallic hardware along the outfall includes the cover plates (slot covers) on the junction box, diffuser port risers, and the stop gate lifting eyes. Any additional exposed hardware encountered during inspection will be noted and assessed in the same manner.

Deliverables:

A table of voltage potential measurements for all exposed hardware will be developed, along with entries for visual description and corrosion state (i.e., active corrosion/inert). The table will also be incorporated in the inspection report.

Cost & Schedule:

Estimated Cost: $4,300

Estimated Time to Complete: Concurrent with visual inspections in Task B1 (Section 5.2)

5.3.2 Concrete Coring (Task C2)

Concrete structures submerged in the marine environment are subject to degradation by multiple modes including chemical attack, corrosion of the internal steel reinforcement due to chloride penetration or cracking, and physical erosion from rocks and debris propelled by waves and currents. Although not commonly thought of as permeable, concrete naturally possesses a degree of permeability which allows for the slow inward migration over time of chlorides present in seawater. Additionally, for ocean outfalls that carry effluent treated with chlorine, the chloride intrusion may also occur from the inside surface of the pipe. Chemical attack of the concrete can also have the effect of changing the chemical composition of the cementitious matrix such as decalcification and formation of magnesium silicate, which combine to weaken the concrete's strength.

With respect to ocean outfalls constructed using RCP joints, inspection and testing of the structural integrity of concrete pipelines subjected to the types of degradation discussed above are often conducted once during their lifetime, roughly at the expected midpoint of their design life, to ascertain the pipe's current structural condition as well as to develop an estimation of remaining service life. Documentation containing information on the design lifespan for the Waianae Ocean Outfall was unavailable for this report. However, for reference the San Elijo Ocean Outfall (constructed in 1965) was cored in 1998 and the Encina Ocean Outfall (constructed in 1965) was cored in 1999, for an age of 33 and 34 years respectively, at the time of core extraction. By comparison, Waianae WWTP's original outfall was also constructed in 1965 and is now 50 years old, and the 1986 extension is now 29 years old.

Selective coring of up to 6 locations along the reinforced concrete pipeline where it is exposed, will provide extremely valuable information on the current condition of the RCP through destructive testing in a laboratory. Testing will yield data on compressive strength, chloride penetration relating to corrosion risk, and petrographic analysis relating to chemical attack of the concrete. As a separate task, the core data may additionally be used at a later point for remaining service life modeling based on time to corrosion initiation. If appropriate locations for coring cannot be located along the pipe due to extensive rock or grout covering, it is not recommended to excavate in order to extract cores due to the risk of causing damage to the pipe during excavation, as well as the high cost of doing so.

Coring of the pipe would be completed by surface supplied air divers using a hydraulic core drill rig equipped with a 2.75 to 4 inch (70 to 102 mm) diameter coring bit. Once extracted, the core holes will immediately be sealed with pre-fabricated titanium expansion plugs. The plug tops will then be encased with Splash Zone epoxy (or equivalent) as a second layer of protection to guard against leakage and vandalism.

All core testing and analysis will be completed by an accredited laboratory qualified to perform such tests. Testing will be completed in accordance with standards set forth by the American Society for Testing and Materials (ASTM).

Deliverables:

Deliverables will include a summary table containing core compression strength, chloride content, and a petrographic analysis, along with the original laboratory report containing the test procedures and results. Results will also be incorporated into the inspection report.

Cost & Schedule:

Estimated Cost: $65,720

Estimate Time to Complete: 210 days

5.3.3 Dye Testing (Task B3)

The Waianae Ocean Outfall is either trenched and grouted or ballasted with stone continuously from the shoreline to the start of the diffuser leg. It is likely that limited portions of the pipe barrel are exposed such as adjacent to the manhole risers and the junction box, however the large majority of the pipe is expected to be concealed from view, making it infeasible to directly inspect the condition of the pipe. A dye test can serve as an efficient, initial means of determining if there are significant problems in the pipe, particularly in those segments that are buried or covered with loose material such as ballast or unconsolidated sediments.

Tracer dyes such as Rhodamine B, Fluorescein or Uranine have regularly been used to detect leaks in subsea pipelines and outfalls. Two outfalls, identified in *Marine Outfall Performance* (Grace, 2005), Macaulay Point and Clover Point, both in Victoria, B.C, are required to carry out dye tests every five years as part of a pipeline monitoring program. The Chinese autonomous region of Hong Kong monitors the performance of 43 ocean outfalls by introducing dye into the effluent and noting color changes in the surface water along the outfalls from the air. Within the United States, two California municipalities, the Goleta Sanitary District and Monterey Regional Water Pollution Control Agency, conduct dye testing for the Santa Cruz Ocean Outfall and Monterey Regional Ocean Outfall, respectively.

There are three methods in which dye is typically identified during an outfall dye test. These include subsurface visual identification, identification from a vessel on the water, or identification from the air. Subsurface identification is completed visually by divers or ROV's while tracking from a vessel is completed visually or with flourometers. Finally, aerial identification is typically completed with the naked eye or with photographic or video equipment. Subsurface identification using divers is proposed for this test because it will provide the most accurate positioning of leaks along the pipe, if they exist. Surface support vessels will also be able to detect surfacing dye. Alternative options for dye tracking are by aircraft such as a helicopter, or by drone piloted from the shoreline.

The procedure for the tracer dye test will have 3 components: dye injection at the plant; underwater monitoring; and sea surface monitoring (if present). The initial phase will be the feeding of tracer dye, which will be injected at the decommissioned chlorine contact chamber, located immediately upstream of the outfall entrance gate as shown in Figure 5-2, where the preferred point of injection is indicated by a red arrow. If this is unsuitable for plant operations, than the shoreline manhole may be used as an alternate location for dye injection. Advance notifications will be made to the appropriate authorities including the M & C Branch and the Water Quality Lab prior to testing as requested. Dye will be introduced into the effluent at a rate of approximately 0.5 pounds per minute. Based on discharge data provided by Waianae WWTP, effluent flow rate averages 3.55 MGD, which approximately equates to a residence or transit time of 130 minutes.

Figure 5-2. Tracer dye injection location, outfall entrance gate (red arrow)

Once the dye introduction process has been initiated, notification will be sent to offshore crews standing by via VHF radio or cellular phone. With flow rates documented to range typically between 2 and 4 MGD, it is estimated that the dye will be transported from the plant to the end of the diffuser leg in a 110 to 210 minute window. Once it has been observed that dye is discharging from the diffusers, divers will enter the water at the stop gate and begin the tracer dye inspection working from deep to shallow in order to maximize bottom time.

Dye will continually be fed into the effluent stream at the specified rate until the dive teams have completed their inspections. Divers will work in pairs and utilize underwater scooters to traverse the approximate 2 mile length of outfall at a speed of approximately 1 knot (0.5 m/s), flying along each side of the pipe simultaneously.

If dye is detected during the inspection, divers will immediately stop travel along the outfall and attempt to identify the exact location of the leak source. The leak location will be documented and photographed by the divers, who will then record its location based on the stationing markers and then deploy a pop-up float so that the surface support vessel can obtain a position fix on the float using DGPS. Following documentation of the leak location, the float will be recovered and the divers will continue inspection operations, repeating this procedure as necessary.

Upon arrival at the shoreline crossing, divers will return to the surface and the topside support crew will notify the shore crew that the dive team has completed their inspection work, at which point the dye supply into the chlorine contact chamber will be halted.

It is not anticipated that the WWTP's flow rate will need to be adjusted during dye release, or any other phase of this operation.

Deliverables:

Deliverables will include video documentation of any leaks, along with a map and coordinates of the leak locations. Results will also be incorporated into the inspection report.

Cost & Schedule:

Estimated Cost: $40,130

Estimate Time to Complete: 180 days

5.4 Outfall Stability and Service Life Estimation

5.4.1 Hydrodynamic Analysis of Outfall Stability (Task D1)

In the years since construction of the Waianae WWTP's original ocean outfall in 1965, two powerful hurricanes, *Iwa* (1982) and *Iniki* (1992), have directly impacted Oahu. Storm waves produced by Hurricane Iwa caused significant damage to the submerged oil pipelines that run from Barbers Point to the Single Point Mooring. A 30-inch concrete jacketed steel pipeline was laterally displaced up to 140 ft (43 m) in water depths of 45 to 60 ft (14 to 18 m) by the hydrodynamic forces applied by wave generated currents. The damage sustained from Hurricane Iwa, and the occurrence of Hurricane Iniki ten years later highlighted the potential risk to submerged pipelines and other seafloor infrastructure from extreme wave events such as those caused by hurricanes.

Tropical storms and hurricanes historically have a low probability of occurrence in the vicinity of the Hawaiian Islands, yet the potential for damage to Hawaii's offshore infrastructure is substantial. Using revised hurricane design criteria, a 1998 study by SEI found that the existing condition of the Honouliuli ocean outfall was not stable, and additional ballast rock was placed along some sections of the pipe. Additionally, global warming and the presence of an extremely strong *El Niño* in 2015 have contributed to a very active tropical storm season for the Central Pacific—further highlighting the potential for increasing direct impacts to Hawaii from hurricanes.

In recent years, methods for hurricane wind field and wave modeling have both greatly improved. Previous methods generated hurricane wind and wave fields as they appeared at one point in time. Modern numerical hurricane models have the ability to track hurricanes over the course of several days and generate a time series of wave spectra. In a recent study for the Tesoro Hawaii Corporation, SEI modeled the close approach of a series of Category 5 hurricanes for up to four days from different approach directions as a worst-case analysis of wave forces on the Tesoro Pipeline fields. The study indicated that longshore currents developed by breaking waves can generate significant hydrodynamic forces on the pipeline in the zone of wave breaking, and that the hurricane approach direction is a critically important factor.

For the proposed analysis, multiple scenario hurricanes with a direct approach to the island of Oahu will be used to generate extreme wave conditions at the site of the Waianae WWTP's ocean outfall. As Oahu has not experienced a hurricane center track landfall crossing in recorded history, each of these scenario hurricanes can be considered an extreme worst case scenario. Numerical modeling of complicated wave transformations, including the effects of shoaling, refraction, and breaking—and the development of wave generated currents including longshore currents—will be utilized to predict the complex circulation patterns and water velocities that occur along the outfall corridor during such extreme events. Based on resultant wave conditions over the outfall, conservative assumptions in linear wave theory will be used to generate maximum instantaneous (worst-case) flow conditions at the depth of the outfall. The instantaneous water particle velocity will be combined with the 'steady state' currents to develop a composite maximum current at the pipeline. Using the composite peak current speed estimations, Computational Fluid Dynamics (CFD) methods will be employed to model in three dimensions the turbulent flow over the outfall at select locations of particular interest, such as within the breaker zone, and where the pipe is exposed along the diffuser leg. The numerical CFD technique allows direct calculation of hydrodynamic forces (i.e., drag and lift) on the outfall based on pressure and viscous effects.

The computational fluid dynamics (CFD) model to be used for this numerical method is called *OpenFOAM®* (Open Field Operation and Manipulation). The CFD toolbox is an open source software package produced by OpenCFD Ltd. It has a large user base across many areas of engineering and science, including both commercial and academic organizations. *OpenFOAM* has an extensive range of features to solve complex fluid flow problems. It includes tools for meshing complex CAD geometries, and for pre- and post-processing. These features allow for the effective modeling of complicated three-dimensional problems such as turbulent flow over a rigid body in an incompressible fluid, in both time-dependent and steady state flow regimes, with or without a free surface.

For the CFD model domain, the high resolution multibeam bathymetry of Task A1 will be used to form the physical bottom boundary for the simulation, with a computational patch applied to the pipe or ballast pile to quantify pressure (form drag) and viscous (friction drag) forces per unit length on the structure. The resultant forces will be resolved into the two principle components: horizontal forces (*drag*) and vertical forces (*lift*). The quasi steady-state Reynolds's Averaged Navier Stokes (RANS) solver from OpenFOAM will be used for the analysis, which is appropriate for steady-state, incompressible, turbulent flow. A turbulent flow model is suggested in this study due to the anticipation that Reynolds Numbers (Re) will likely exceed 10^6 for all scenarios, in an attempt to capture transient forces such as those produced from vortex shedding.

Deliverables:

Deliverables will include a comprehensive technical report presenting the methods, findings and recommendations from the results of the analysis. Multiple visualizations of the data will be provided as video clips, illustrating features like streamlines, vortices, and pressure distribution over the structure.

Costs & Schedule:

Estimated Cost: $85,660

Estimated Time to Complete: 210 days

5.4.2 Service Life Modeling (Task D2)

Based on the results of the core testing analyses, modeling simulations will be performed to predict future chloride ingress and concrete degradation of the RCP joints. Numerical modeling of 'time-to-corrosion-initiation' provides a critical estimation for the onset of corrosion of reinforcing rebar, at which point the RCP joints would begin to fail by cracking and spalling of the covering concrete. The remaining service life estimation procedure will encompass up to three elements, which include: determination of past chloride exposure conditions using the core test data; prediction of future chloride penetration using a numerical model such as STADIUM, and thus development of estimates for time-to-corrosion based on the data; and, brief assessment of maintenance and repair options to identify potential pathways for extending service life, as appropriate.

Remaining service life estimation modeling will be completed by an accredited laboratory qualified to perform such analyses. Testing will be completed in accordance with standards set forth by the ASTM as applicable.

Deliverables:

Deliverables will include a laboratory analysis report, including time-to-corrosion estimation based on the model results.

Costs & Schedule:

Estimated Cost: $8,070

Estimated Time to Complete: Concurrent with concrete core extraction Task C2 (Section 5.3.2)

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6. TABULATED SUMMARY OF WORK PLAN COSTS AND SCHEDULE

In summary, the recommended initial work phase includes the following items:

- High resolution bathymetric survey (MBES) of the outfall corridor using a MBES system
- Visual inspection of the entire length of the outfall
- Leak testing of the pipe barrel using tracer dye
- Corrosion assessment of exposed hardware
- Concrete core extraction and laboratory analysis
- Stability analysis of the outfall structure using advance numerical methods
- Time-to-corrosion (remaining service life) modeling using core data

Optional tasks considered as potential follow-on work that may be valuable at a later point based on findings from the initial program include the following tasks:

- Side scan sonar survey of the outfall corridor
- Point cloud scanning of damage areas for repair design
- Internal inspection of the outfall via ROV

A summary of the recommended and optional tasks, associated cost estimates, and estimated duration of work is presented in Table 6-1 below.

Table 6-1. Work Plan Cost Summary

Task N°.	Recommended Work Plan Component	Est. Cost	Est. Duration
A1	High Resolution Multibeam Survey	$77,670	90 days
B1	Outfall External Inspection & Maintenance	$64,050	150 days
B3	Dye Testing	$40,130	180 days
C1	Cathodic Protection / Corrosion Assessment	$4,300	concurrent with B1
C2	Concrete Core Extraction and Testing	$65,720	210 days
D1	Stability Analysis Modeling	$85,660	210 days
D2	Service Life Modeling	$8,070	concurrent with C2
Total		$345,600	840 days

Option N°.	Optional Follow-on Component	Est. Cost	Est. Duration
A2	Side Scan Sonar Survey	$21,910	60 days
A3	Point Cloud Scanning Survey	TBD†	TBD†
B2	Internal Inspection	$200,000	TBD†
Total	Total for options, excluding point cloud scan	$221,910	120 days

† Scope, level of effort, and duration undefined pending completion of primary inspection tasks.

Estimated total durations shown in Table 6-1 are simply a sum of the individual task durations, and would likely not represent an accurate estimate of time required due to various unpredictable delays which may occur from contractual delays, equipment or crew availabilities, unforeseen technical issues, or poor weather conditions.

All marine field tasks are dependent upon the occurrence of appropriate safe working conditions, often referred to as weather windows. In general, the west side of Oahu is exposed to high surf from both the northwest in the winter and southwest in the summer, in addition to sporadic Kona storms which may occur from fall through spring. However, due to the relatively short periods of time needed for inspection work tasks, sufficient weather windows may be possible at any time throughout the year.

7. IMPACT OF INSPECTION ACTIVITIES ON WWTP OPERATIONS

The recommended inspection activities presented in this work plan are not expected to have any significant impacts on normal plant operations. The only inspection component which could potentially require alternation of normal flow rates is the internal inspection (Task B2), however that task is not recommended at this time.

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8. REFERENCES

City and County of Honolulu, Department of Public Works. *Report on Oceanographic Survey and Study Relative to Sewage Disposal for Waianae, Oahu.* Technical Report. June 1962.

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Grace, R. A. *Marine Outfall Construction*. ASCE Press. 1979.

Grace, R. A. *Marine Outfall Performance*. Journal of Performance of Constructed Facilities. Vol. 19, No. 4, November 2005.

Hirata, E. K. and Associates. *Soils Investigation and Underwater Reconnaissance, Waianae Outfall Sewer Extension, Waianae, Oahu, Hawaii.* Technical Report. October 1982.

Noda, E. K., and Associates. *Nearfield and Farfield Plume Analysis, Waianae Ocean Outfall System*. Technical Report. October, 1997.

Russo, A. R. *Fish Community Structure in the Vicinity of the Waianae Ocean Outfall, Oahu, Hawaii.* Special Report. January 1987.

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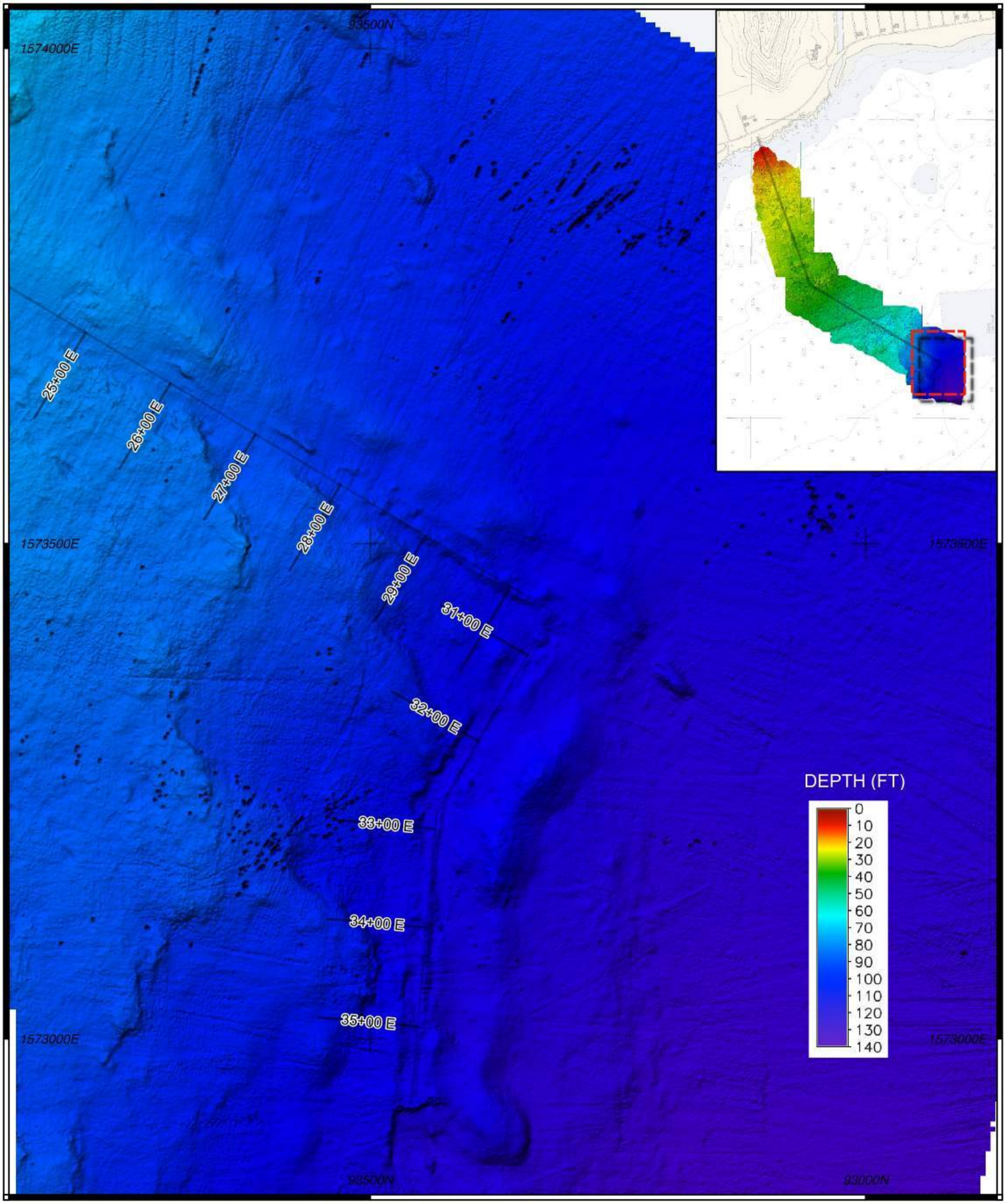
APPENDIX B

MULTIBEAM BATHYMETRY



Sea Engineering, Inc.
Makai Research Pier
Waimanalo, Hawaii 96795
808.259.7966

N

PLATE 1 (DIFFUSER SECTION)
Color-Shaded Bathymetry
Waianae Ocean Outfall, Waianae, Hawaii
SPCS-HI Zone 3, NAD83, feet

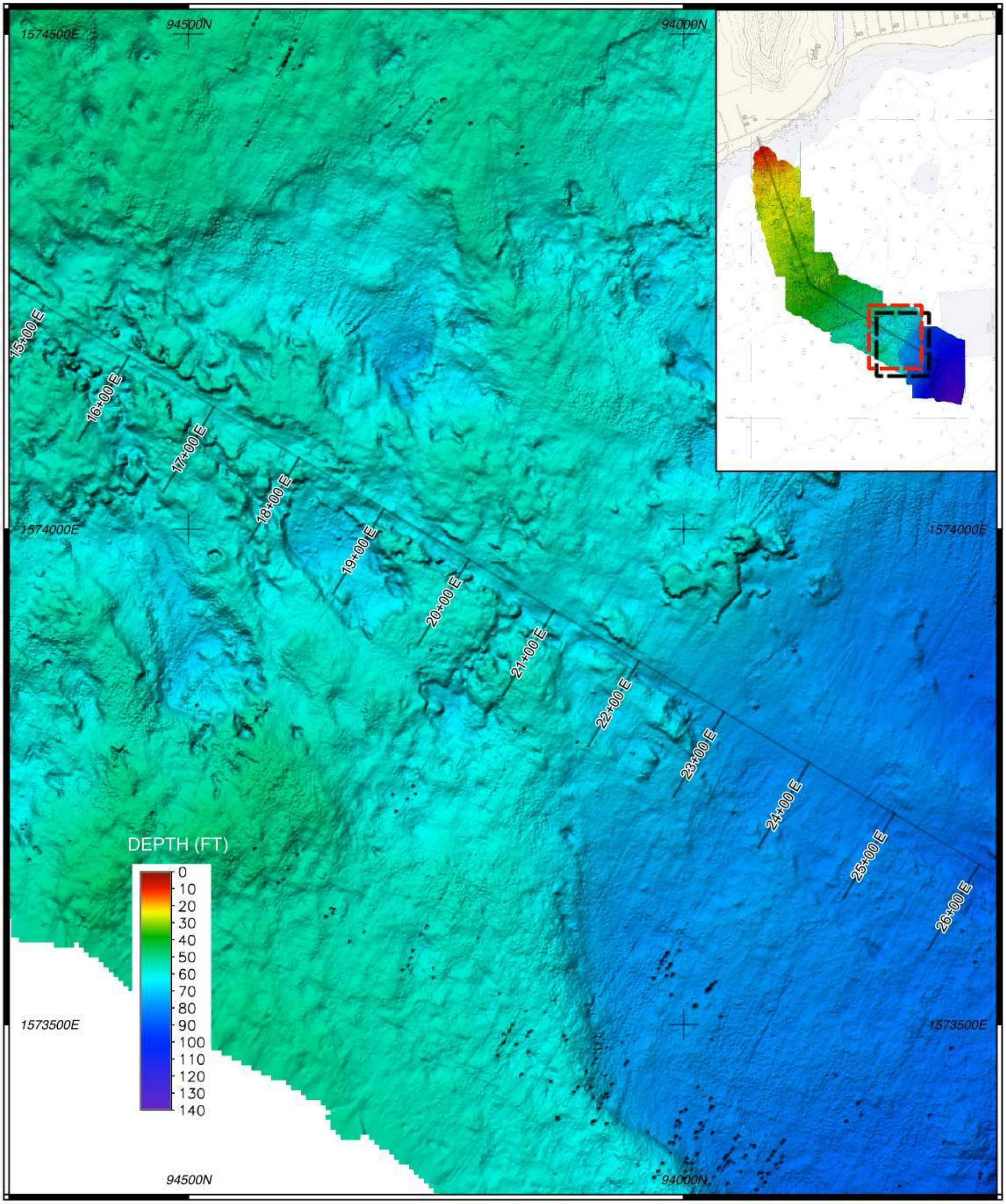


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PLATE 2 (42" OUTFALL EXTENSION)
Color-Shaded Bathymetry
Waianae Ocean Outfall, Waianae, Hawaii
SPCS-HI Zone 3, NAD83, feet

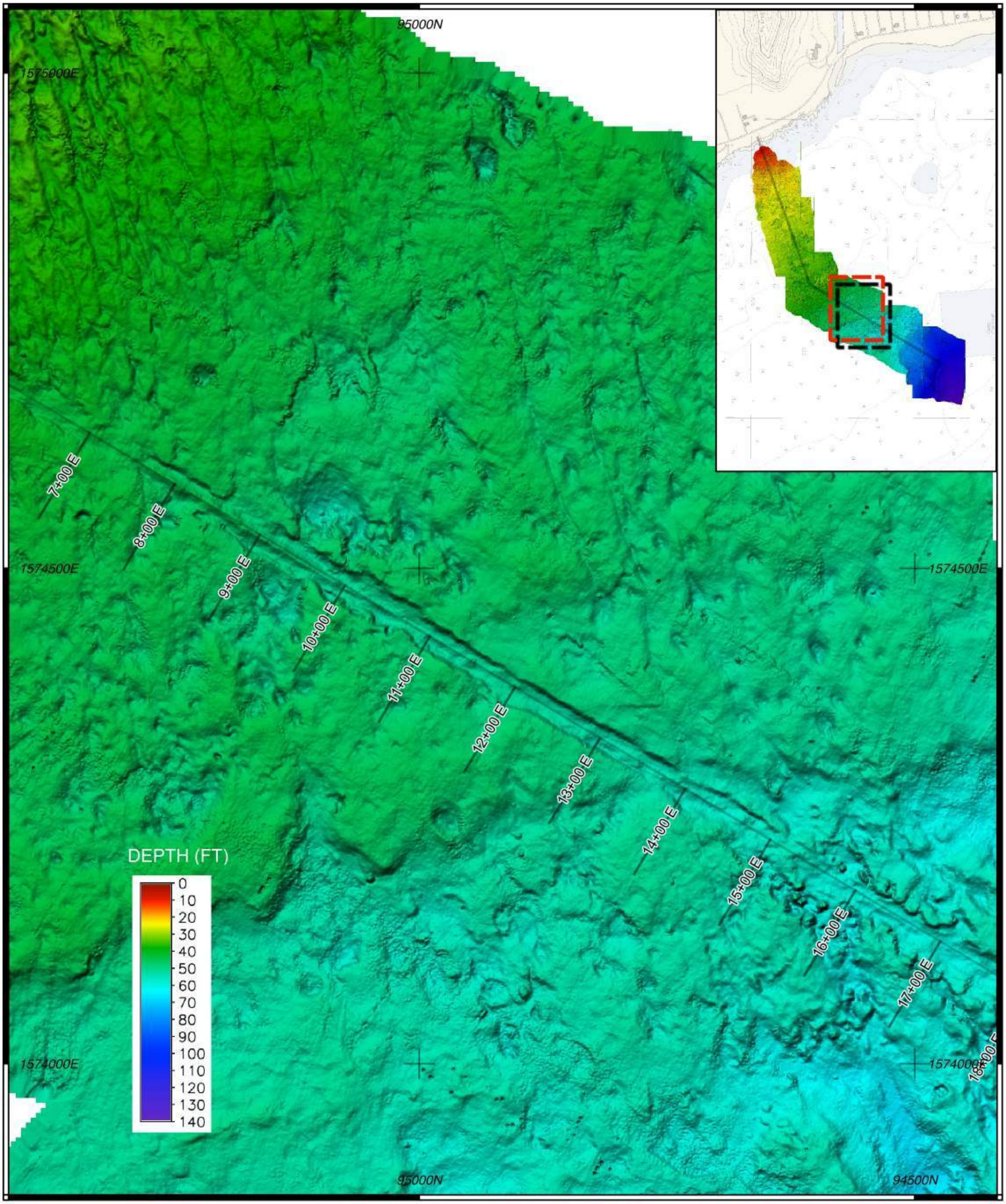

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PLATE 3 (42" OUTFALL EXTENSION)
Color-Shaded Bathymetry
Waianae Ocean Outfall, Waianae, Hawaii
SPCS-HI Zone 3, NAD83, feet

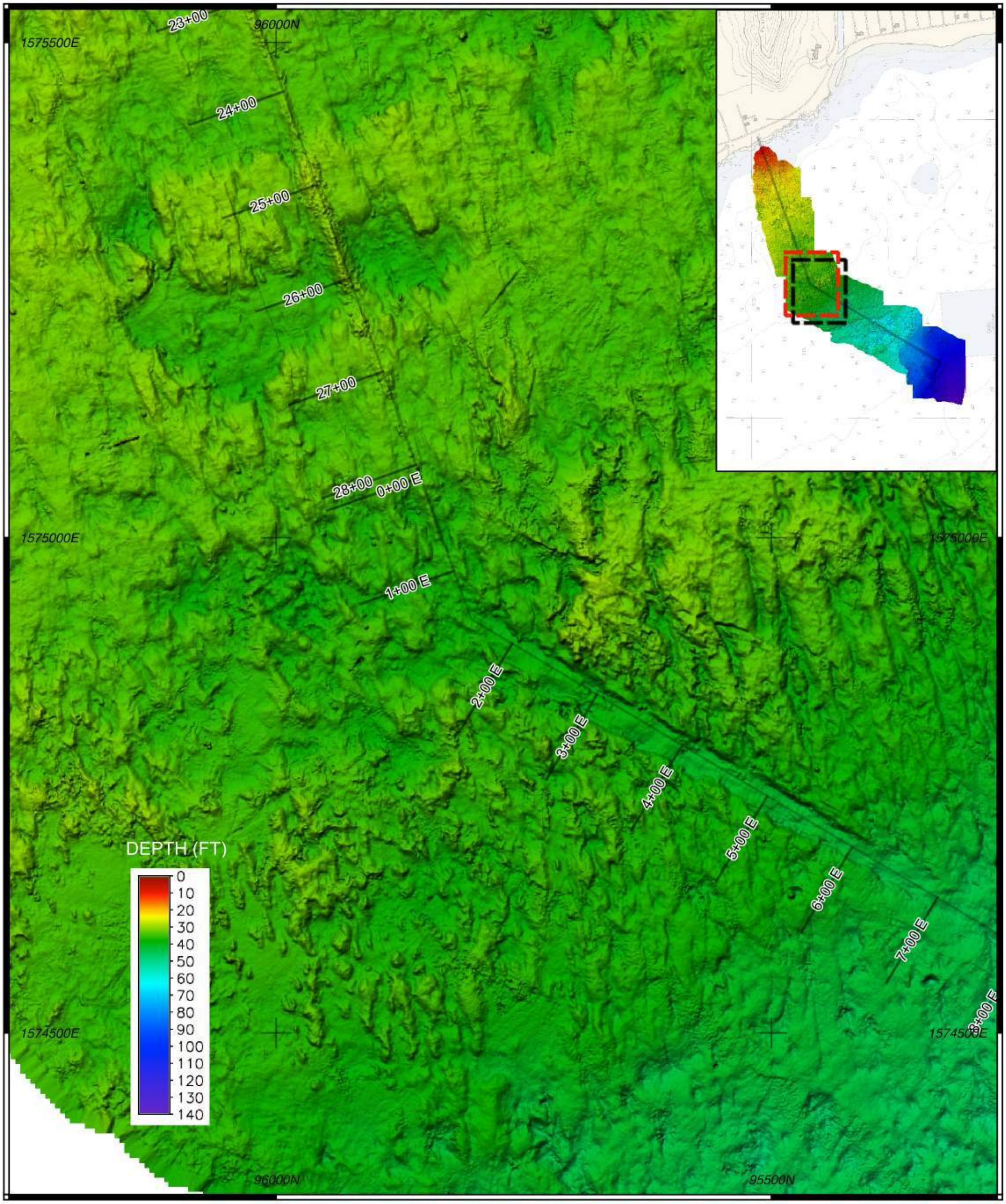

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PLATE 4 (36" TO 42" TRANSITION)
Color-Shaded Bathymetry
Waianae Ocean Outfall, Waianae, Hawaii
SPCS-HI Zone 3, NAD83, feet

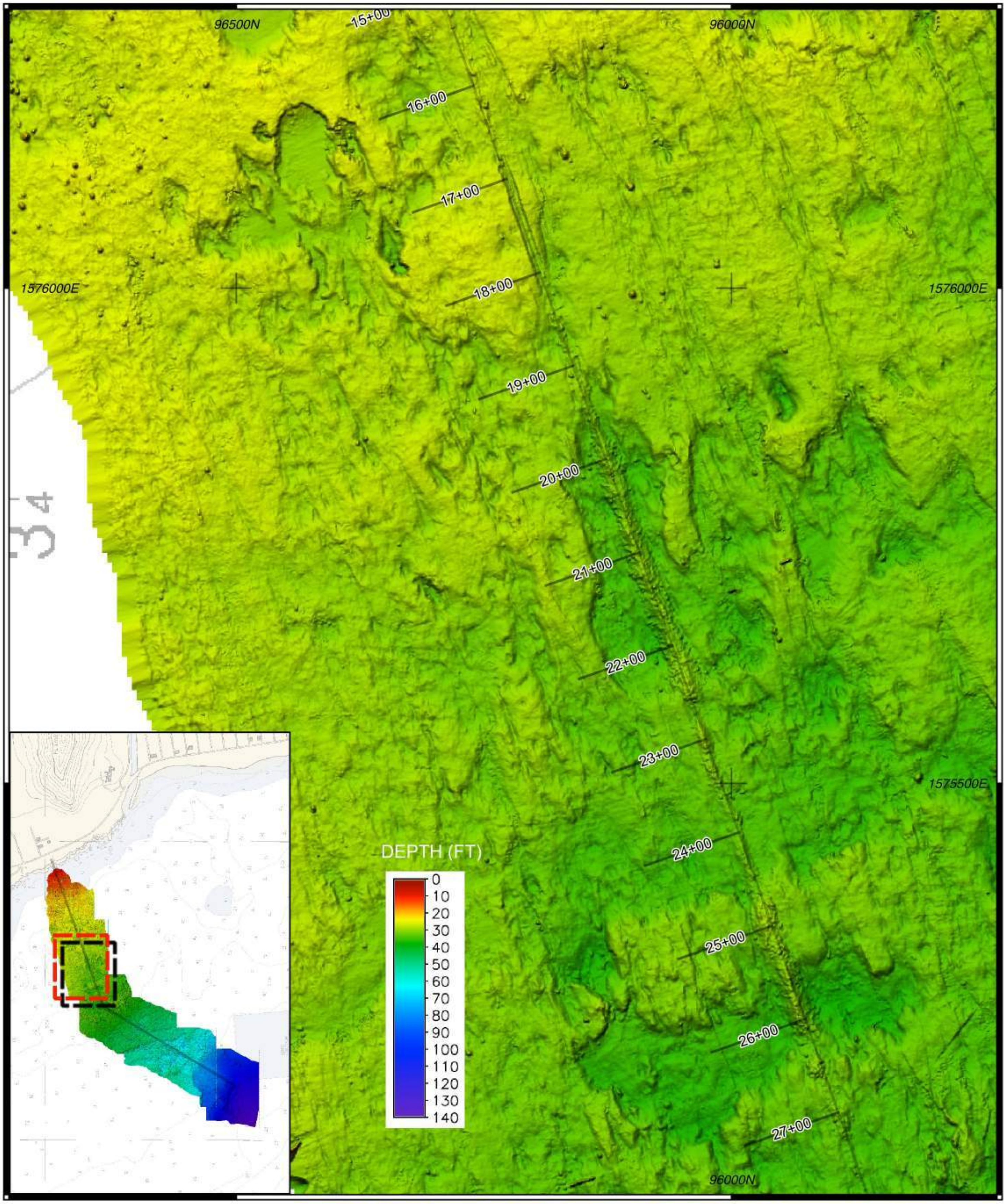

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PLATE 5 (36" ORIGINAL OUTFALL)
Color-Shaded Bathymetry
Waianae Ocean Outfall, Waianae, Hawaii
SPCS-HI Zone 3, NAD83, feet

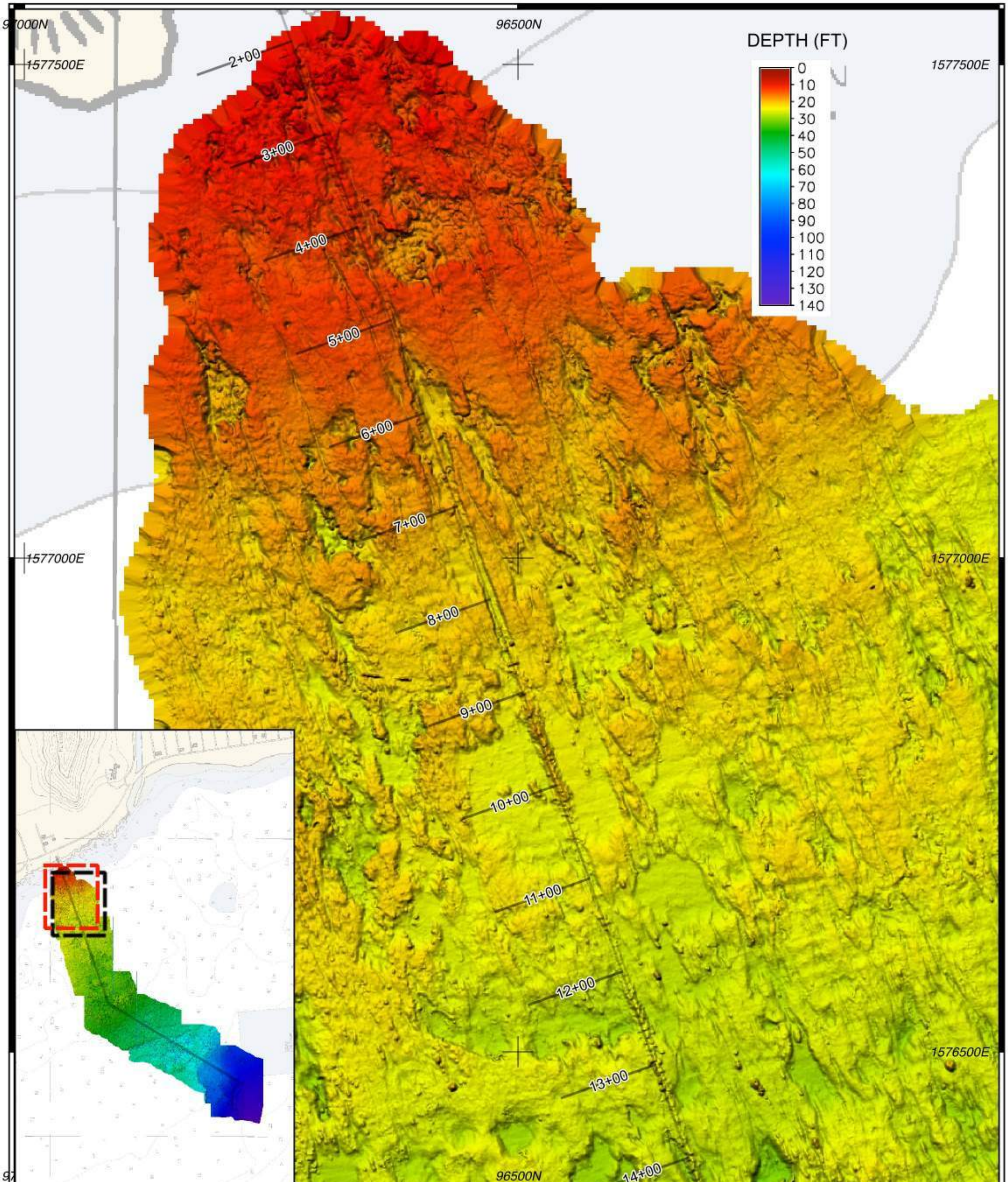

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PLATE 6 (36" ORIGINAL OUTFALL)
Color-Shaded Bathymetry
Waianae Ocean Outfall, Waianae, Hawaii
SPCS-HI Zone 3, NAD83, feet

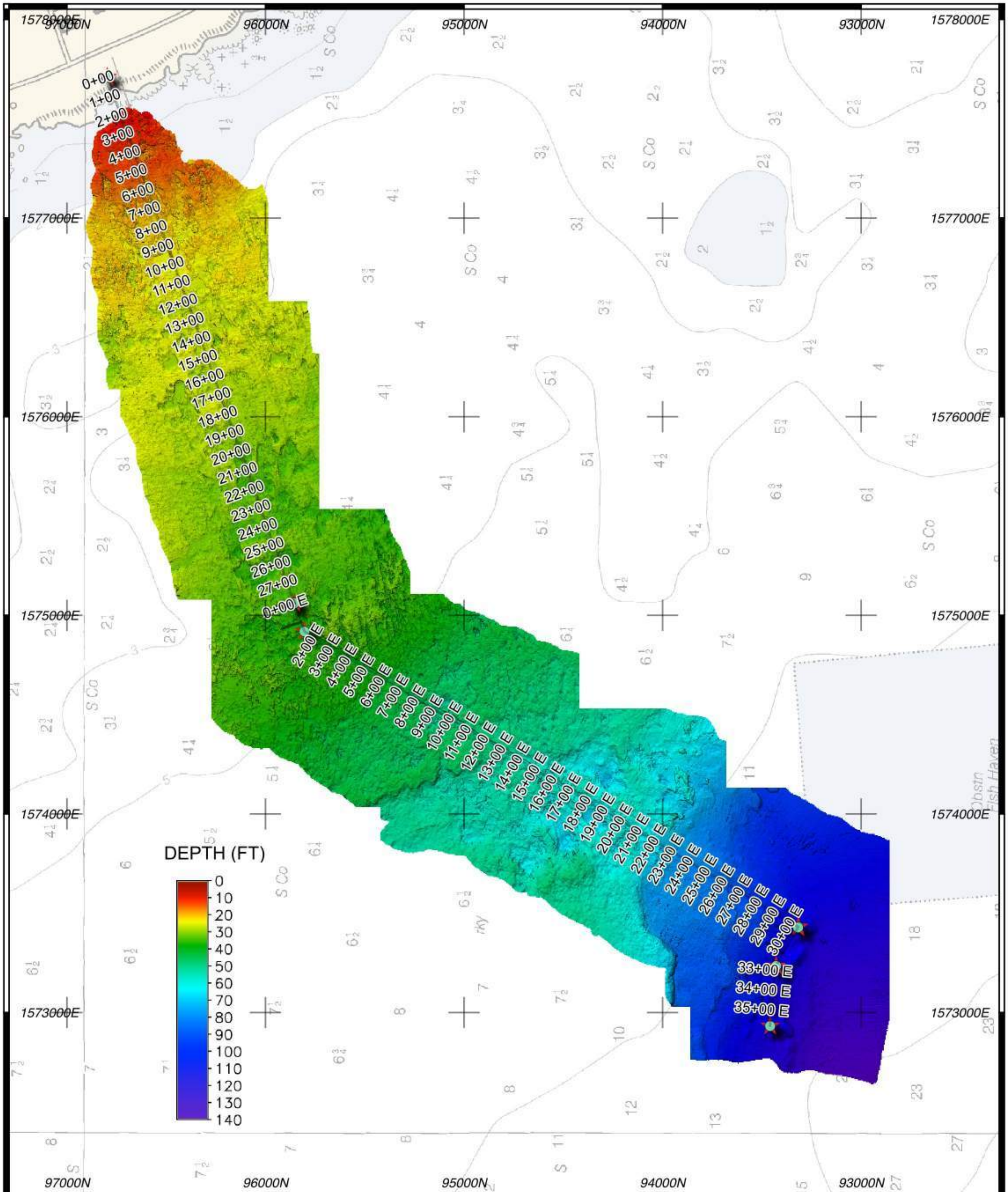

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PLATE 7 (OUTFALL OVERVIEW)
Color-Shaded Bathymetry
Waianae Ocean Outfall, Waianae, Hawaii
SPCS-HI Zone 3, NAD83, feet

APPENDIX C

MULTIBEAM BATHYMETRY WITH ANNOTATION

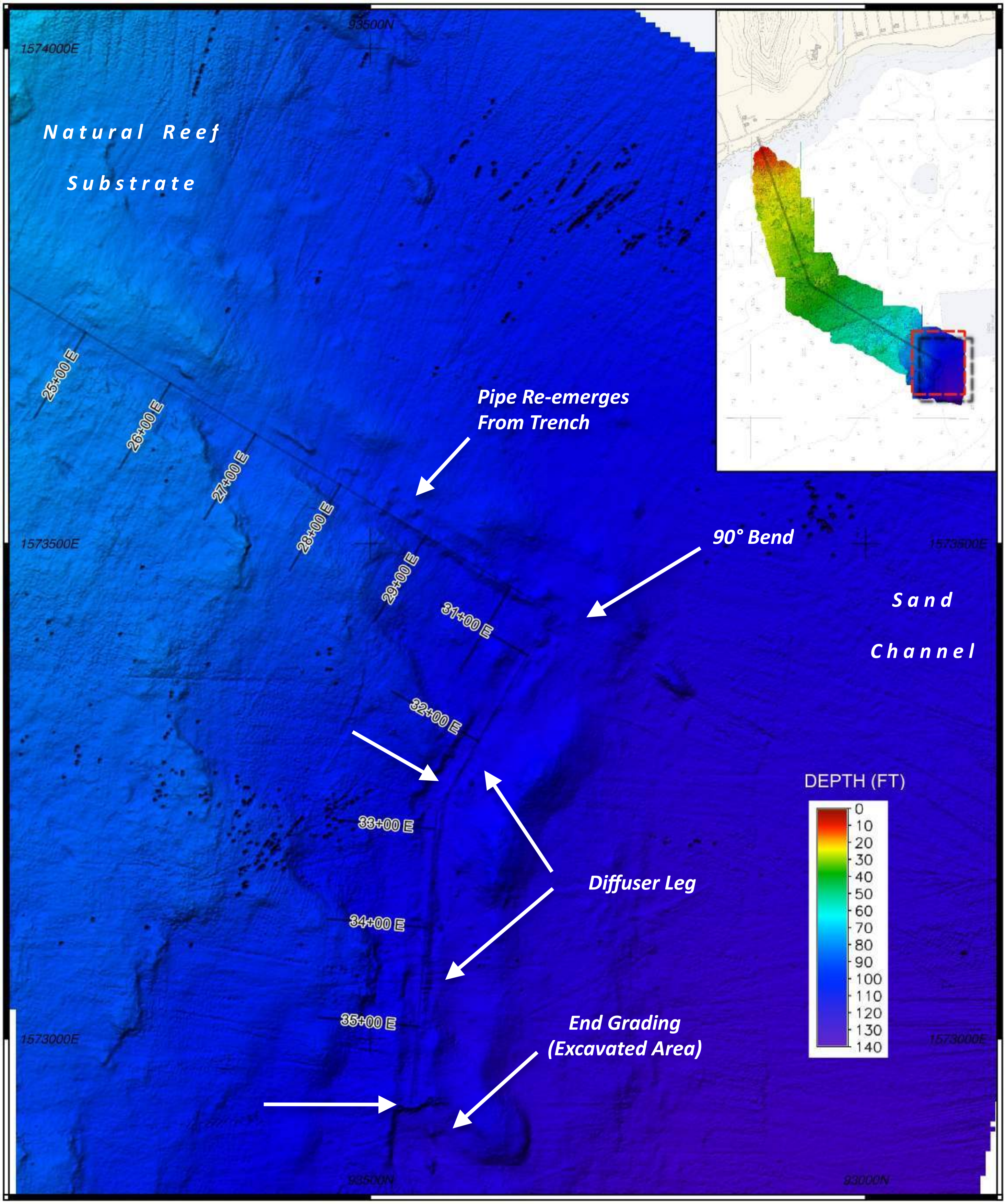

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PLATE 1 (DIFFUSER SECTION)
Color-Shaded Bathymetry
Waianae Ocean Outfall, Waianae, Hawaii
SPCS-HI Zone 3, NAD83, feet

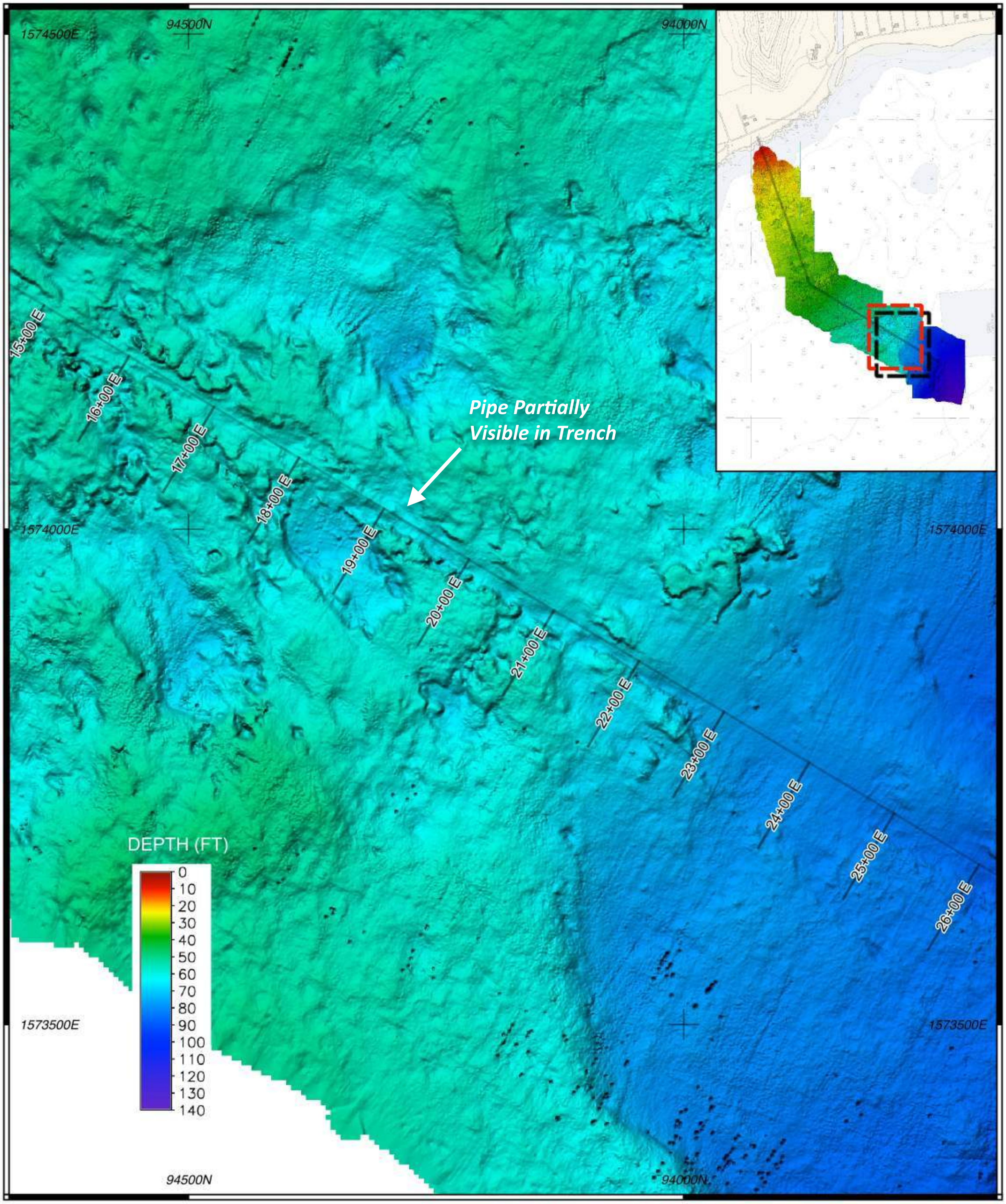

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PLATE 2 (42" OUTFALL EXTENSION)
Color-Shaded Bathymetry
Waianae Ocean Outfall, Waianae, Hawaii
SPCS-HI Zone 3, NAD83, feet

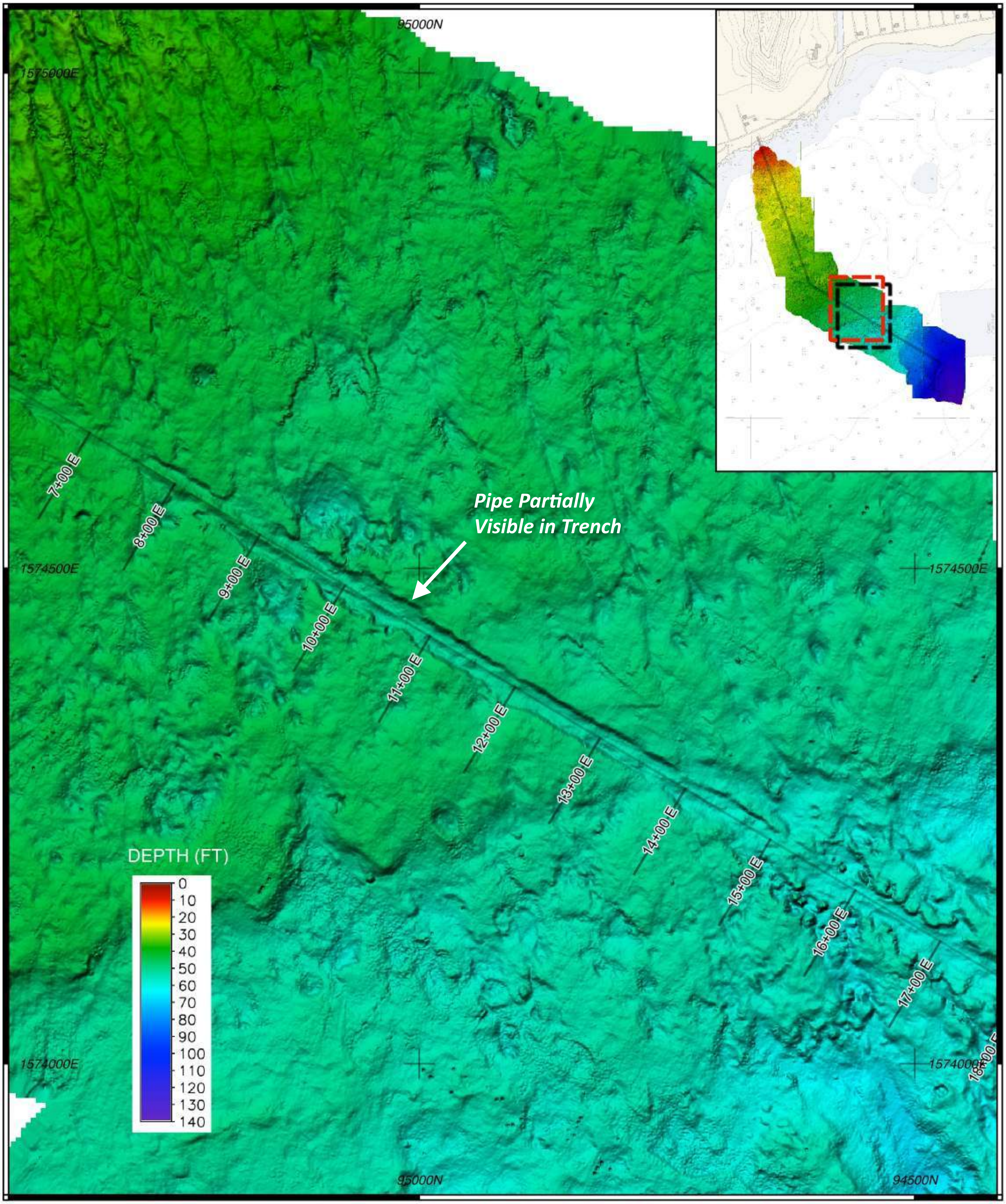

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PLATE 3 (42" OUTFALL EXTENSION)
Color-Shaded Bathymetry
Waianae Ocean Outfall, Waianae, Hawaii
SPCS-HI Zone 3, NAD83, feet

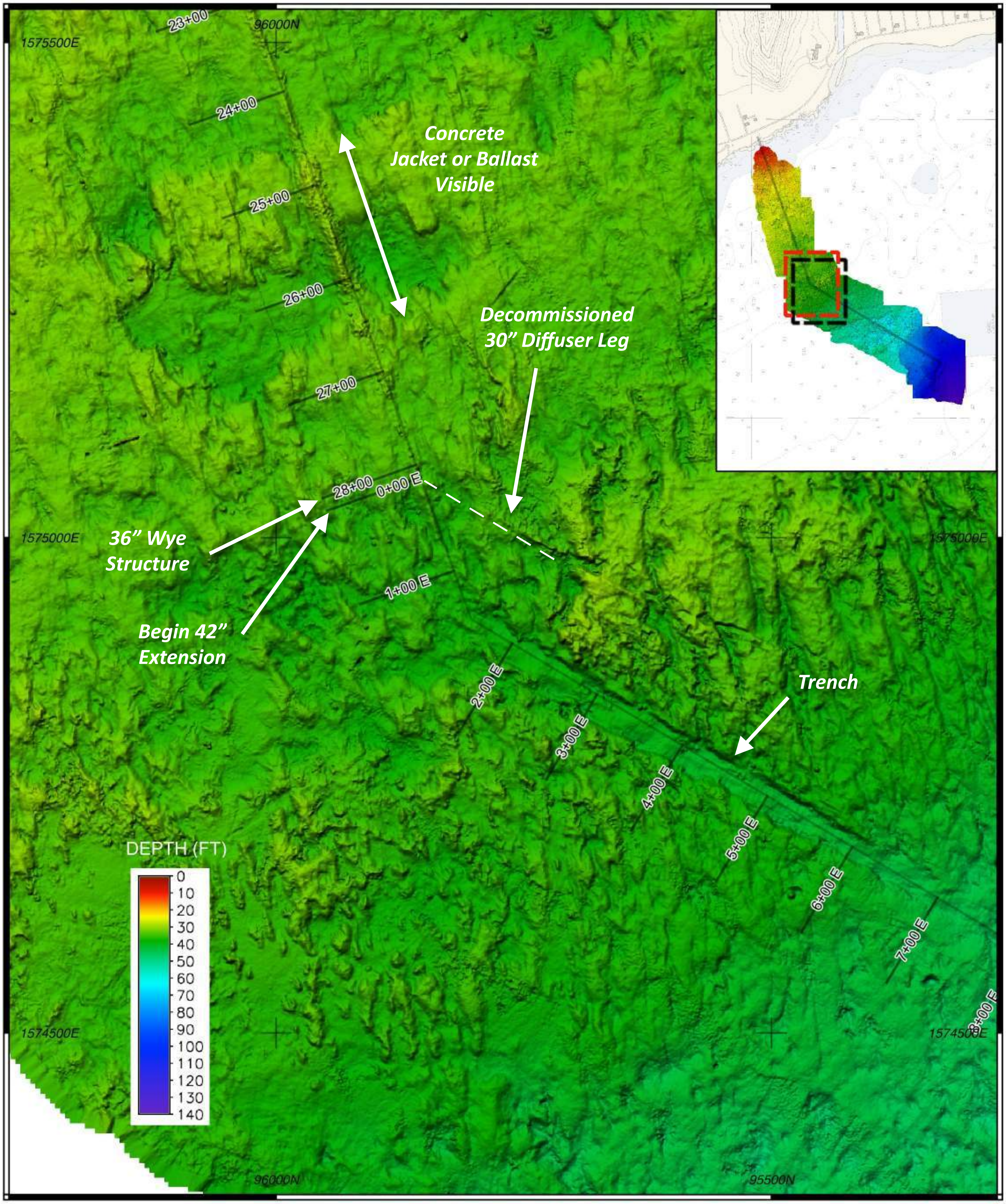

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PLATE 4 (36" TO 42" TRANSITION)
Color-Shaded Bathymetry
Waianae Ocean Outfall, Waianae, Hawaii
SPCS-HI Zone 3, NAD83, feet

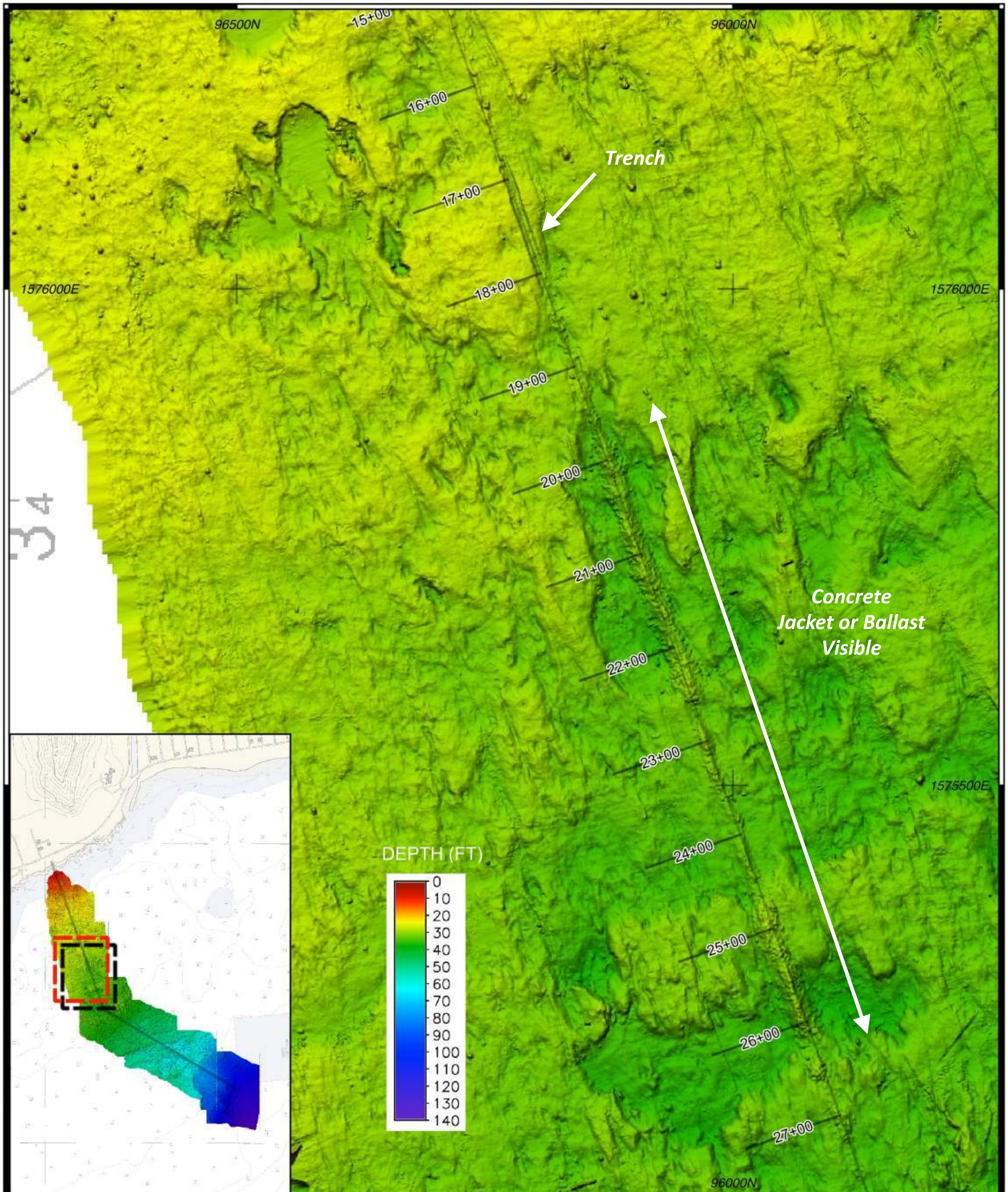

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PLATE 5 (36" ORIGINAL OUTFALL)
Color-Shaded Bathymetry
Waianae Ocean Outfall, Waianae, Hawaii
SPCS-HI Zone 3, NAD83, feet

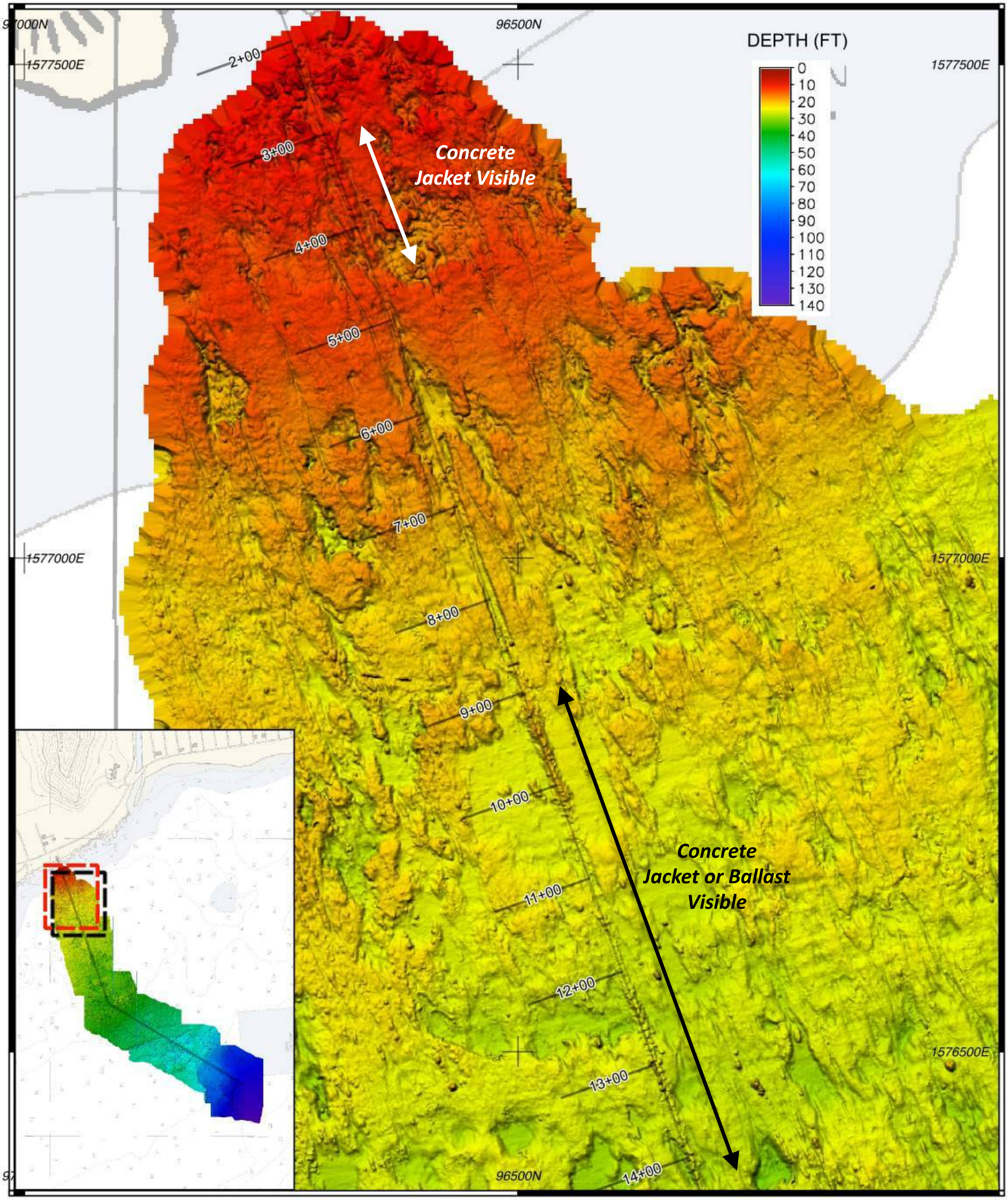

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PLATE 6 (36" ORIGINAL OUTFALL)
Color-Shaded Bathymetry
Waianae Ocean Outfall, Waianae, Hawaii
SPCS-HI Zone 3, NAD83, feet

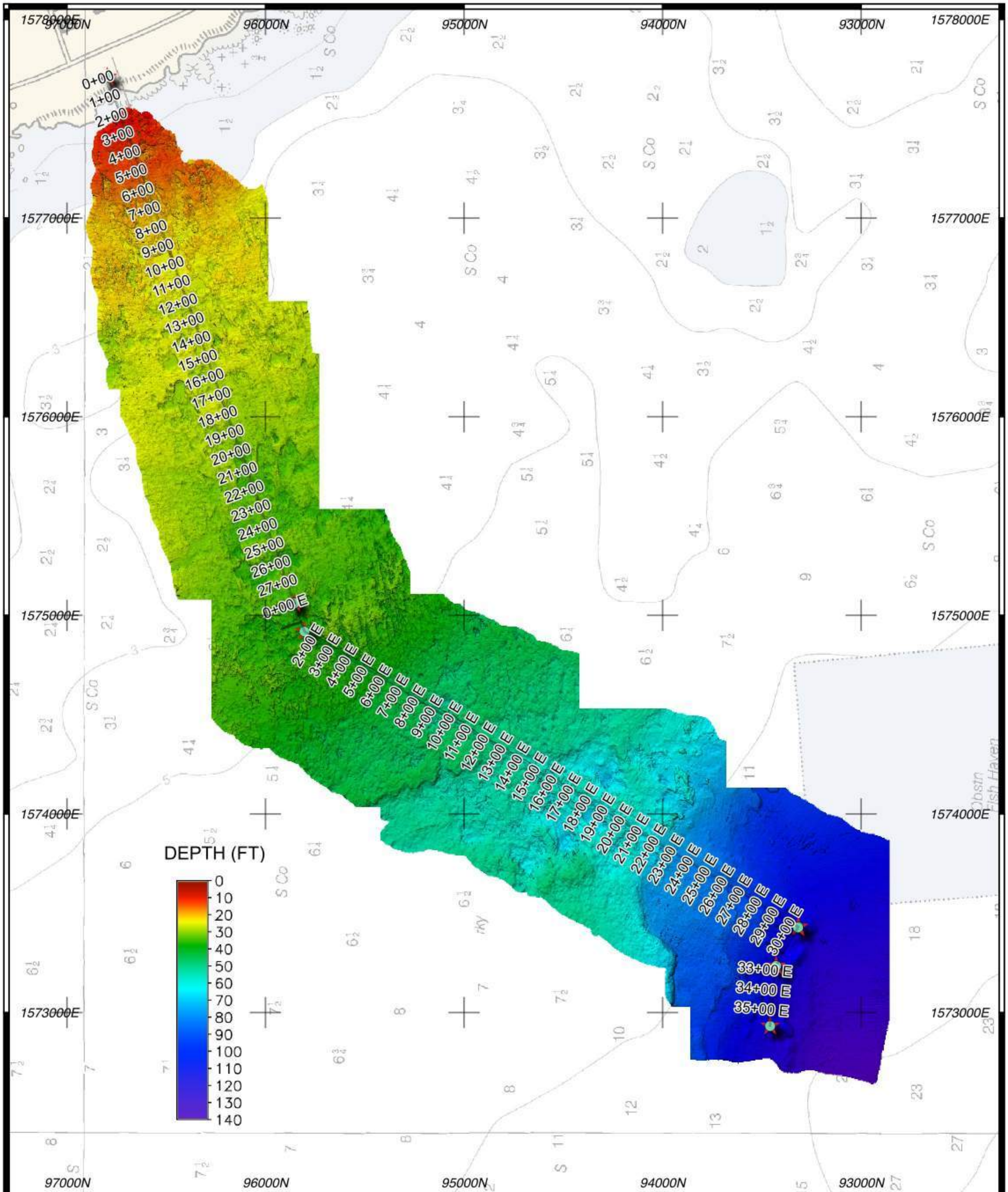

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PLATE 7 (OUTFALL OVERVIEW)
Color-Shaded Bathymetry
Waianae Ocean Outfall, Waianae, Hawaii
SPCS-HI Zone 3, NAD83, feet

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Appendix B

Construction Plans for the Proposed Action

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JOB NO. XXX-XX

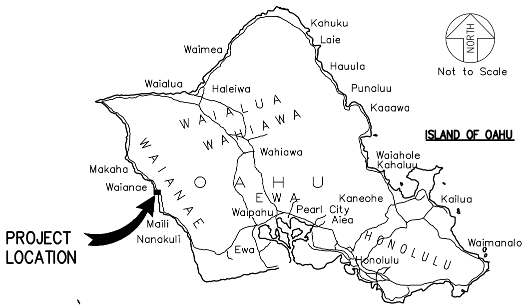
WAIANAE WASTEWATER TREATMENT PLANT OCEAN OUTFALL IMPROVEMENTS

LUALUALEI, WAIANAE, OAHU, HAWAII
TAX MAP KEY: (1) 8-6-01: POR. 07

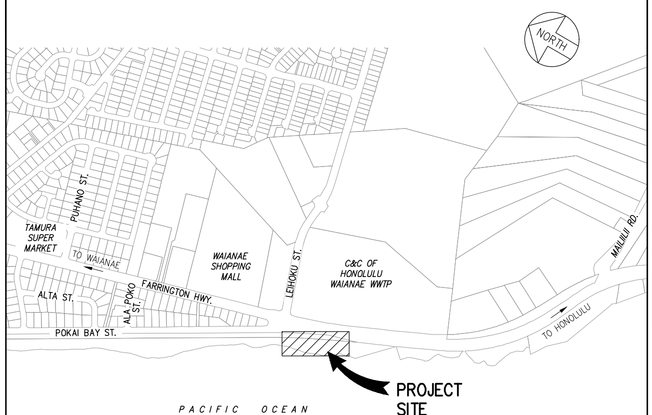
WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY & COUNTY OF HONOLULU

PREPARED BY:
SSFM INTERNATIONAL, INC.
501 SUMNER ST., SUITE 620
HONOLULU, HAWAII 96817

VICINITY MAP	LOCATION MAP	APPROVED:



VICINITY MAP
NOT TO SCALE



LOCATION MAP
NOT TO SCALE

APPROVED:

_______________________________ DATE
DIRECTOR, DEPARTMENT ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

_______________________________ DATE
CHIEF, ENVIRONMENTAL MANAGEMENT DIVISION
DEPARTMENT OF HEALTH
STATE OF HAWAII

_______________________________ DATE
DIRECTOR, DEPARTMENT OF PLANNING AND PERMITTING
CITY AND COUNTY OF HONOLULU
(FOR STOCKPILING AND SITE GRADING ONLY)

DRAWING C000 SHEET 1 OF 21

FILE	PROJECT	FOLDER	NO.

W:_CIVIL 3D PROJECTS\2010_057.000 ENV SAND ISLAND WWTP\01 CIVIL DRAWINGS\C000 TITLE SHEET.DWG 09/25/17 14:01 ecl

INDEX OF DRAWINGS:

SHEET NO.	DWG. NO.	TITLE
CIVIL		
1	C000	TITLE SHEET, LOCATION MAP, VICINITY MAP
2	C001	INDEX OF DRAWINGS AND ABBREVIATIONS
3	C002	GENERAL NOTES
4	C003	GRADING, EROSION AND SEDIMENT CONTROL NOTES
5	C004	EROSION, SEDIMENT CONTROL AND MISCELLANEOUS NOTES
6	B001	EXISTING CONDITION AND BORING LOCATION PLAN
7	B002	BORING LOGS-1
8	B003	BORING LOGS-2
9	B004	BORING LOGS-3
10	B005	BORING LOGS-4
11	C101	OVERALL SITE PLAN
12	C102	EROSION AND SEDIMENT CONTROL PLAN
13	C103	SITE PLAN
14	C200	EROSION AND SEDIMENT CONTROL DETAILS
STRUCTURAL		
15	S001	STRUCTURAL NOTES
16	S301	CONCRETE ENCASEMENT PROFILES
17	S302	CONCRETE ENCASEMENT SECTIONS
18	S303	CONCRETE ENCASEMENT SECTIONS
19	S304	CONCRETE ENCASEMENT SECTIONS
20	S501	SECTIONS AND DETAILS
21	S502	SECTIONS AND DETAILS

ABBREVIATIONS

ABAND ABANDONED
AC A/C ASPHALTIC CONCRETE

BB BOTTOM BANK
BMP BEST MANAGEMENT PRACTICES
BW BOTTOM WALL

CEB CIVIL ENGINEERING BRANCH
CLR CLEAR
CONC CONCRETE
CONT CONTINUED
CRM CONCRETE RUBBLE MASONRY
CWB CLEAN WATER BRANCH

D DIAMETER
DET DETAIL
DOH STATE DEPARTMENT OF HEALTH
DPP DEPARTMENT OF PLANNING AND PERMITTING
DWG DRAWING

E EAST/ELECTRICAL
EG EXISTING GRADE
ELEV ELEVATION
EP ELECTRIC POLE
EX EXAMPLE
EXIST EXISTING

FT FEET
FG FINISHED GRADE
FH FIRE HYDRANT
FND FOUND

G GROUND
GP GUARD POST
GW GUY WIRE

H HORIZONTAL/HEIGHT
HAR HAWAII ADMINISTRATIVE RULES
HB HOSE BIBB
HECO HAWAIIAN ELECTRIC COMPANY
HI HAWAII
HORIZ HORIZONTAL
HRS HOURS
HW HEADWALL

IN INCHES
INV INVERT

LBS POUNDS
LP LIGHT POLE

MAX MAXIMUM
MIN MINIMUM
MH MANHOLE
MHHW MEAN HIGHER HIGH WATER
MLLW MEAN LOWER LOW WATER
MSL MEAN SEA LEVEL

N NORTH
NGPC NOTICE OF GENERAL PERMIT COVERAGE
NPDES NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

OC ON CENTER
OH/U OVERHEAD UTILITY

PH PHONE
PI POINT OF INTERSECTION
POR PORTION
PSF POUNDS PER SQUARE FOOT
PSI POUNDS PER SQUARE INCH

R RADIUS
RC REINFORCED CONCRETE
RCP REINFORCED CONCRETE PIPE
ROH REVISED ORDINANCE OF HONOLULU
ROW RIGHT-OF-WAY

S SPREAD/SOUTH
SL SEWER LINE
SLB STREET LIGHT BOX
SMH SEWER MANHOLE
ST STREET
STA STATION

T TOP
TB TOP BANK
TMK TAX MAP KEY
TP TELEPHONE POLE
TW TOP WALL
TYP TYPICAL

UB UTILITY BOX
UP UTILITY POLE

V VERTICAL
VB VALVE BOX
VERT VERTICAL

W WEST
WV WATER VALVE

LANCE K. TOKUDA
LICENSED PROFESSIONAL ENGINEER
NO. 8631
HAWAII USA

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE

EXP. DATE 4/30/2022
EXPIRATION DATE OF THE LICENSE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT
OCEAN OUTFALL IMPROVEMENTS
LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM:
INDEX OF DRAWINGS AND ABBREVIATIONS

DESIGNED BY: ______ CHECKED BY: ______
DRAWN BY: ______ SECTION HEAD: ______
APPROVED: BRANCH HEAD: ______
CHIEF DATE

JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

DRAWING C001 SHEET 2 OF 21

W:_CIVIL 3D PROJECTS\2010_057.000 ENV SAND ISLAND WWTP\01 CIVIL DRAWINGS\TITLE BLOCK.DWG 09/13/17 16:19 ecl

GENERAL NOTES:

1. THE CONTRACTOR SHALL VERIFY THE EXISTING SITE CONDITIONS PRIOR TO COMMENCING WORK. ANY DISCREPANCIES BETWEEN EXISTING CONDITIONS AND THAT SHOWN ON THE DRAWINGS SHALL BE BROUGHT TO THE ATTENTION OF THE ENGINEER IMMEDIATELY.

2. THE CONTRACTOR SHALL PROVIDE AND MAINTAIN DURING THE LIFE OF THE CONTRACT, ENVIRONMENTAL PROTECTION AS DEFINED. PLAN FOR AND PROVIDE ENVIRONMENTAL PROTECTIVE MEASURES TO CONTROL POLLUTION THAT DEVELOPS DURING NORMAL CONSTRUCTION PRACTICE. PLAN FOR AND PROVIDE ENVIRONMENTAL PROTECTIVE MEASURES REQUIRED TO CORRECT CONDITIONS THAT DEVELOP DURING CONSTRUCTION OF PERMANENT OR TEMPORARY ENVIRONMENTAL FEATURES ASSOCIATED WITH THE PROJECT. COMPLY WITH FEDERAL, STATE, AND LOCAL REGULATIONS PERTAINING TO THE ENVIRONMENT, INCLUDING BUT NOT LIMITED TO WATER, AIR, AND NOISE POLLUTION.

3. CONTRACTOR SHALL VERIFY ALL DIMENSIONS AND CONDITIONS AND SHALL REPORT ANY DISCREPANCIES IN WRITING TO THE ENGINEER BEFORE COMMENCING WORK. DETAILS ON DRAWINGS SHALL BE TYPICAL FOR ALL SIMILAR CONDITIONS. MODIFY DETAILS FOR SPECIAL CONDITIONS AS DIRECTED BY THE ENGINEER.

4. THE CONTRACTOR IS RESPONSIBLE FOR THE PROPER HANDLING, STORAGE AND/OR DISPOSAL OF ALL WASTE GENERATED BY THIS CONSTRUCTION. WASTE MATERIAL SHALL NOT BE DEPOSITED AT ANY OF THE COUNTY TRANSFER STATIONS, BUT SHALL BE TRANSPORTED FOR DISPOSAL TO THE LANDFILL.

5. CONTRACTOR MUST LOCATE AND FIELD VERIFY EXISTING OUTFALL PIPELINE. CONTRACTOR MUST PROTECT EXISTING OUTFALL PIPELINE WITH APPROPRIATE MEASURES TO PREVENT DAMAGE OF ANY KIND AT ALL LOCATIONS WHERE CONSTRUCTION ACTIVITY MAY AFFECT THE UTILITY.

PERMIT NOTES:

THE CONTRACTOR SHALL APPLY AND PAY FOR ALL PERMITS REQUIRED FOR COMPLETION OF THE PROJECT. THIS COST SHALL BE INCIDENTAL TO THE VARIOUS ITEMS TO WORK. SUBMIT TO THE DEPARTMENT OF PLANNING AND PERMITTING (DPP) THE STOCKPILE AND GRADING PERMITS. CONTRACTOR IS RESPONSIBLE FOR THE DPP-CIVIL ENGINEERING BRANCH (CEB) GRADING PERMIT AND STOCKPILING PERMIT. CONSULTATION WITH DLNR-DAR AND A PRE-CONSTRUCTION CORAL SURVEY WILL BE REQUIRED PRIOR TO ANCHORING BARGES FOR INSTALLATION OF PRECAST CONCRETE COVERS.

CONSTRUCTION NOTES:

1. ALL APPLICABLE CONSTRUCTION WORK SHALL BE DONE IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION, SEPTEMBER 1986, AND STANDARD DETAILS FOR PUBLIC WORKS CONSTRUCTION, SEPTEMBER 1984, AS AMENDED, OF THE DEPARTMENTS OF PUBLIC WORKS, CITY & COUNTY OF HONOLULU, AND THE COUNTIES OF KAUAI, MAUI, AND HAWAII.

2. NO CONTRACTOR SHALL PERFORM ANY CONSTRUCTION OPERATION SO AS TO CAUSE FALLING ROCKS, SOIL OR DEBRIS IN ANY FORM TO FALL, SLIDE OR FLOW INTO EXISTING CITY DRAINAGE SYSTEMS, OR ADJOINING PROPERTIES, STREETS OR NATURAL WATERCOURSES. SHOULD SUCH VIOLATIONS OCCUR, THE CONTRACTOR MAY BE CITED AND THE CONTRACTOR SHALL IMMEDIATELY MAKE ALL REMEDIAL ACTIONS NECESSARY AT HIS OWN EXPENSE AND WITHOUT COMPENSATION FOR DELAYS FOR THE OWNER.

3. FOR CITY PROJECTS, THE CONTRACTOR SHALL SUBMIT SHOP DRAWINGS TO THE RESPONSIBLE CITY AGENCY FOR REVIEW AND APPROVAL. ALSO, THE CONTRACTOR SHALL COORDINATE INSPECTIONAL SERVICES WITH THE RESPONSIBLE CITY AGENCY.

4. CONFINED SPACE

   FOR ENTRY BY CITY PERSONNEL, INCLUDING INSPECTORS, INTO A PERMIT REQUIRED CONFINED SPACE AS DEFINED IN 29 CFR PART 1910.146(B), THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROVIDING:

   I. ALL SAFETY EQUIPMENT REQUIRED BY THE CONFINED SPACE REGULATIONS APPLICABLE TO ALL PARTIES OTHER THAN THE CONSTRUCTION INDUSTRY, TO INCLUDE, BUT NOT LIMITED TO, THE FOLLOWING:

   A) FULL BODY HARNESSES FOR UP TO TWO PERSONNEL.
   B) LIFELINE AND ASSOCIATED CLIPS.
   C) INGRESS/EGRESS AND FALL PROTECTION EQUIPMENT.
   D) TWO-WAY RADIOS (WALKIE-TALKIES) IF OUT OF LINE-OF-SIGHT.
   E) EMERGENCY (ESCAPE) RESPIRATOR (10 MINUTE DURATION).
   F) CELLULAR TELEPHONE TO CALL FOR EMERGENCY ASSISTANCE.
   G) CONTINUOUS GAS DETECTOR (CALIBRATED) TO MEASURE OXYGEN, HYDROGEN SULFIDE, CARBON MONOXIDE AND FLAMMABLES (CAPABLE OF MONITORING AT A DISTANCE AT LEAST 20-FEET AWAY).
   H) PERSONAL MULTI-GAS DETECTOR TO BE CARRIED BY INSPECTOR.

   II. CONTINUOUS FORCED AIR VENTILATION ADEQUATE TO PROVIDE SAFE ENTRY CONDITIONS.

   III. ONE ATTENDANT/RESCUE PERSONNEL TOPSIDE (TWO, IF CONDITIONS WARRANT IT).

5. PURSUANT TO CHAPTER 6E, HRS, IN THE EVENT ANY ARTIFACTS OR HUMAN REMAINS ARE UNCOVERED DURING CONSTRUCTION OPERATIONS, THE CONTRACTOR SHALL IMMEDIATELY SUSPEND WORK AND NOTIFY THE HONOLULU POLICE DEPARTMENT, THE STATE DEPARTMENT OF LAND AND NATURAL RESOURCES-HISTORIC PRESERVATION DIVISION (692-8015). FOR CITY PROJECTS, NOTIFY THE RESPONSIBLE CITY AGENCY.

6. DUMP TRUCKS DELIVERING MATERIALS SHALL NOT EXCEED THE ALLOWABLE WEIGHT CAPACITY FOR STATE ROADWAYS AND BRIDGES. SEE HAWAII REVISED STATUTES 291-3, 291-35, 291-39(c). REDUCE LOADS TO LESS THAN 80 PSI TIRE CONTACT SURFACE AREA AND PROVIDE NON-SKID TRAFFIC PLATES WHEN DRIVING OVER EXISTING UTILITIES, SUCH AS THE EXISTING OUTFALL PIPE.

STOCKPILING NOTES:

1. ALL STOCKPILING WORK SHALL BE DONE IN ACCORDANCE WITH CHAPTER 14, ARTICLES 13, 14, 15 AND 16, AS RELATED TO STOCKPILING, SOIL EROSION AND SEDIMENT CONTROL OF THE REVISED ORDINANCES OF HONOLULU, 1990, AS AMENDED.

2. NO CONTRACTOR SHALL PERFORM ANY STOCKPILING OPERATION SO AS TO CAUSE FALLING ROCKS, SOIL OR DEBRIS IN ANY FORM TO FALL, SLIDE OR FLOW ONTO ADJOINING PROPERTIES, STREETS OR NATURAL WATERCOURSES. SHOULD SUCH VIOLATIONS OCCUR, THE CONTRACTOR MAY BE CITED AND THE CONTRACTOR SHALL IMMEDIATELY MAKE ALL REMEDIAL ACTIONS NECESSARY.

3. THE CONTRACTOR, AT HIS OWN EXPENSE, SHALL KEEP THE PROJECT AREA AND SURROUNDING AREA FREE FROM DUST NUISANCE. THE WORK SHALL BE IN CONFORMANCE WITH THE AIR POLLUTION CONTROL STANDARDS CONTAINED IN THE HAWAII ADMINISTRATIVE RULES, TITLE 11, CHAPTER 60.1, "AIR POLLUTION CONTROL".

4. THE UNDERGROUND PIPES, CABLES AND DUCTLINES KNOWN TO EXIST BY THE ENGINEER FROM HIS SEARCH OF RECORDS ARE INDICATED ON THE PLANS. THE CONTRACTOR SHALL VERIFY THE LOCATIONS AND DEPTHS OF THE FACILITIES AND EXERCISE PROPER CARE IN EXCAVATING IN THE AREA. WHEREVER CONNECTIONS OF NEW UTILITIES ARE SHOWN ON THE PLANS, THE CONTRACTOR SHALL EXPOSE THE EXISTING LINES AT THE PROPOSED CONNECTIONS TO VERIFY LOCATIONS AND DEPTHS PRIOR TO EXCAVATION FOR THE NEW LINES.

5. ADEQUATE PROVISIONS SHALL BE MADE TO PREVENT SURFACE WATERS FROM DAMAGING THE CUT FACE OF AN EXCAVATION OR THE SLOPED SURFACES OF A FILL. FURTHERMORE, ADEQUATE PROVISIONS SHALL BE MADE TO PREVENT SEDIMENT-LADEN RUNOFF FROM LEAVING THE SITE.

6. ALL SLOPES AND EXPOSED AREAS SHALL BE SODDED OR PLANTED AS SOON AS FINAL GRADES HAVE BEEN ESTABLISHED. PLANTING SHALL NOT BE DELAYED UNTIL ALL GRADING WORK HAS BEEN COMPLETED. GRADING TO FINAL GRADE SHALL BE CONTINUOUS, AND ANY AREA WITHIN WHICH WORK HAS BEEN INTERRUPTED OR DELAYED SHALL BE PLANTED.

7. FILL SLOPES STEEPER THAN 5:1 SHALL BE KEYED.

8. THE CITY SHALL BE INFORMED OF THE LOCATION OF THE BORROW/DISPOSAL SITE FOR THE PROJECT WHEN THE APPLICATION FOR A STOCKPILING PERMIT IS MADE. THE BORROW/DISPOSAL SITE MUST ALSO FULFILL THE REQUIREMENTS OF THE GRADING ORDINANCE.

9. NO STOCKPILING WORK SHALL BE DONE ON SATURDAYS, SUNDAYS AND HOLIDAYS AT ANY TIME WITHOUT PRIOR NOTICE TO THE DIRECTOR, DPP, PROVIDED SUCH STOCKPILING WORK IS ALSO IN CONFORMANCE WITH THE COMMUNITY NOISE CONTROL STANDARDS CONTAINED IN THE HAWAII ADMINISTRATIVE RULES, TITLE 11, CHAPTER 46, "COMMUNITY NOISE CONTROL".

10. THE LIMITS OF THE AREA TO BE STOCKPILED SHALL BE FLAGGED BEFORE THE COMMENCEMENT OF THE GRADING WORK.

11. THE GENERAL CONTRACTOR/DEVELOPER/OWNER OF THE PROJECT SHALL BE RESPONSIBLE FOR ALL STOCKPILING OPERATIONS TO BE PERFORMED IN CONFORMANCE WITH APPLICABLE PROVISIONS OF THE HAR, TITLE 11, CHAPTER 54, "WATER QUALITY STANDARDS", AND TITLE 11, CHAPTER 55, "WATER POLLUTION CONTROL", AS WELL AS CHAPTER OF THE ROH, AS AMENDED. BMPS SHALL BE EMPLOYED AT ALL TIMES DURING CONSTRUCTION.

    THE GENERAL CONTRACTOR/DEVELOPER/OWNER OF THE PROJECT SHALL OBTAIN NPDES PERMIT COVERAGE(S) FOR THE FOLLOWING:

    1. STORM WATER DISCHARGES ASSOCIATED WITH CONSTRUCTION ACTIVITIES THAT DISTURB ONE (1) ACRE OR MORE, AND;

    2. DISCHARGES OF HYDROTESTING EFFLUENT, DEWATERING EFFLUENT, AND WELL DRILLING EFFLUENT TO STATE WATERS.

    IN ACCORDANCE WITH STATE LAW, ALL DISCHARGES RELATED TO PROJECT CONSTRUCTION OR OPERATIONS ARE REQUIRED TO COMPLY WITH STATE WATER QUALITY STANDARDS (HAR, CHAPTER 11-54). BMPS SHALL BE USED TO MINIMIZE OR PREVENT THE DISCHARGE OF SEDIMENT, DEBRIS, AND OTHER POLLUTANTS TO STATE WATERS. PERMIT COVERAGE IS AVAILABLE FROM THE DOH CWB AT HHTP://HEALTH.HAWAII.GOV/CWB. THE OWNER/DEVELOPER/CONTRACTOR IS RESPONSIBLE FOR OBTAINING OTHER FEDERAL, STATE, OR LOCAL AUTHORIZATIONS AS REQUIRED BY LAW.

12. WHERE APPLICABLE AND FEASIBLE THE MEASURES TO CONTROL EROSION AND OTHER POLLUTANTS SHALL BE IN PLACE BEFORE ANY EARTH MOVING PHASE OF THE STOCKPILING IS INITIATED.

13. TEMPORARY EROSION CONTROLS SHALL NOT BE REMOVED BEFORE PERMANENT EROSION CONTROLS ARE IN-PLACE AND ESTABLISHED.

14. TEMPORARY EROSION CONTROL PROCEDURES SHALL BE SUBMITTED FOR APPROVAL PRIOR TO APPLICATION FOR THE STOCKPILING PERMIT.

15. IF THE STOCKPILING WORK INVOLVES CONTAMINATED SOIL, THEN ALL GRADING WORK SHALL BE DONE IN CONFORMANCE WITH APPLICABLE STATE AND FEDERAL REQUIREMENTS.

16. THE CONTRACTOR SHALL NOTIFY THE CEB, DPP AT 768-8084 TO ARRANGE FOR INSPECTION SERVICES AND SUBMIT TWO (2) SETS OF APPROVED CONSTRUCTION PLANS SEVEN (7) DAYS PRIOR TO COMMENCEMENT OF CONSTRUCTION WORK.

17. FOR ALL PROJECTS, WHICH WILL DISTURB ONE (1) ACRE OR MORE OF LAND, THE CONTRACTOR SHALL NOT START CONSTRUCTION UNTIL A NOTICE OF GENERAL PERMIT COVERAGE (NGPC) IS RECEIVED FROM THE DOH, STATE OF HAWAII, AND HAS SATISFIED ANY OTHER APPLICABLE REQUIREMENTS OF THE NPDES PERMIT PROGRAM. ALSO, FOR NON-CITY AND OTHER NON-GOVERNMENTAL AGENCY PROJECTS, THE CONTRACTOR SHALL PROVIDE A WRITTEN COPY OF THE NGPC TO THE PERMITTING AND INSPECTION SECTION, CEB, DPP, AT LEAST SEVEN (7) CALENDAR DAYS BEFORE THE START OF THE CONSTRUCTION. FOR CITY AND OTHER GOVERNMENTAL PROJECTS, THE CONTRACTOR SHOULD PROVIDE A WRITTEN COPY OF THE NGPC TO THE APPROPRIATE CITY DEPARTMENT GOVERNMENTAL AGENCY PER THEIR REQUIREMENTS.

18. ALL STOCKPILING AND CONSTRUCTION WORK SHALL IMPLEMENT MEASURES TO ENSURE THAT THE DISCHARGE OF POLLUTANTS FROM THE CONSTRUCTION SITE WILL BE REDUCED TO THE MAXIMUM EXTENT PRACTICABLE AND WILL NOT CAUSE OR CONTRIBUTE TO AN EXCEEDANCE OF WATER QUALITY STANDARDS.

19. NON-COMPLIANCE TO ANY OF THE ABOVE REQUIREMENTS SHALL MEAN IMMEDIATE SUSPENSION OF ALL WORK, AND REMEDIAL WORK SHALL COMMENCE IMMEDIATELY. ALL COSTS INCURRED SHALL BE BILLED TO THE VIOLATOR. FURTHERMORE, VIOLATORS SHALL BE SUBJECTED TO ADMINISTRATIVE, CIVIL AND/OR CRIMINAL PENALTIES.

20. FOR BENCHMARK, SHEET C005 EXISTING CONDITION AND BORING LOCATION PLAN.

21. LIFE OF THE STOCKPILING SHALL BE ONE YEAR.

GRADING NOTES:

1. ALL GRADING WORK SHALL BE DONE IN ACCORDANCE WITH CHAPTER 14, ARTICLES 13, 14, 15 AND 16, AS RELATED TO GRADING, SOIL EROSION AND SEDIMENT CONTROL OF THE REVISED ORDINANCES OF HONOLULU, 1990, AS AMENDED.

2. NO CONTRACTOR SHALL PERFORM ANY GRADING OPERATION SO AS TO CAUSE FALLING ROCKS, SOIL OR DEBRIS IN ANY FORM TO FALL, SLIDE OR FLOW ONTO ADJOINING PROPERTIES, STREETS OR NATURAL WATERCOURSES. SHOULD SUCH VIOLATIONS OCCUR, THE CONTRACTOR MAY BE CITED AND THE CONTRACTOR SHALL IMMEDIATELY MAKE ALL REMEDIAL ACTIONS NECESSARY.

3. THE CONTRACTOR, AT HIS OWN EXPENSE, SHALL KEEP THE PROJECT AREA AND SURROUNDING AREA FREE FROM DUST NUISANCE. THE WORK SHALL BE IN CONFORMANCE WITH THE AIR POLLUTION CONTROL STANDARDS CONTAINED IN THE HAWAII ADMINISTRATIVE RULES, TITLE 11, CHAPTER 60.1, "AIR POLLUTION CONTROL".

4. THE UNDERGROUND PIPES, CABLES AND DUCTLINES KNOWN TO EXIST BY THE ENGINEER FROM HIS SEARCH OF RECORDS ARE INDICATED ON THE PLANS. THE CONTRACTOR SHALL VERIFY THE LOCATIONS AND DEPTHS OF THE FACILITIES AND EXERCISE PROPER CARE IN EXCAVATING IN THE AREA. WHEREVER CONNECTIONS OF NEW UTILITIES ARE SHOWN ON THE PLANS, THE CONTRACTOR SHALL EXPOSE THE EXISTING LINES AT THE PROPOSED CONNECTIONS TO VERIFY LOCATIONS AND DEPTHS PRIOR TO EXCAVATION FOR THE NEW LINES.

5. ADEQUATE PROVISIONS SHALL BE MADE TO PREVENT SURFACE WATERS FROM DAMAGING THE CUT FACE OF AN EXCAVATION OR THE SLOPED SURFACES OF A FILL. FURTHERMORE, ADEQUATE PROVISIONS SHALL BE MADE TO PREVENT SEDIMENT-LADEN RUNOFF FROM LEAVING THE SITE.

6. ALL SLOPES AND EXPOSED AREAS SHALL BE SODDED OR PLANTED AS SOON AS FINAL GRADES HAVE BEEN ESTABLISHED. PLANTING SHALL NOT BE DELAYED UNTIL ALL GRADING WORK HAS BEEN COMPLETED. GRADING TO FINAL GRADE SHALL BE CONTINUOUS, AND ANY AREA WITHIN WHICH WORK HAS BEEN INTERRUPTED OR DELAYED SHALL BE PLANTED.

7. FILL SLOPES STEEPER THAN 5:1 SHALL BE KEYED.

8. THE CITY SHALL BE INFORMED OF THE LOCATION OF THE BORROW/DISPOSAL SITE FOR THE PROJECT WHEN THE APPLICATION FOR A GRADING PERMIT IS MADE. THE BORROW/DISPOSAL SITE MUST ALSO FULFILL THE REQUIREMENTS OF THE GRADING ORDINANCE.

9. NO GRADING WORK SHALL BE DONE ON SATURDAYS, SUNDAYS AND HOLIDAYS AT ANY TIME WITHOUT PRIOR NOTICE TO THE DIRECTOR, D.P.P., PROVIDED SUCH GRADING WORK IS ALSO IN CONFORMANCE WITH THE COMMUNITY NOISE CONTROL STANDARDS CONTAINED IN THE HAWAII ADMINISTRATIVE RULES, TITLE 11, CHAPTER 46, "COMMUNITY NOISE CONTROL".

10. THE LIMITS OF THE AREA TO BE GRADED SHALL BE FLAGGED BEFORE THE COMMENCEMENT OF THE GRADING WORK.

11. THE GENERAL CONTRACTOR/DEVELOPER/OWNER OF THE PROJECT SHALL BE RESPONSIBLE FOR ALL GRADING OPERATIONS TO BE PERFORMED IN CONFORMANCE WITH APPLICABLE PROVISIONS OF THE HAR, TITLE 11, CHAPTER 54, "WATER QUALITY STANDARDS", AND TITLE 11, CHAPTER 55, "WATER POLLUTION CONTROL", AS WELL AS CHAPTER OF THE ROH, AS AMENDED. BMPS SHALL BE EMPLOYED AT ALL TIMES DURING CONSTRUCTION.

    THE GENERAL CONTRACTOR/DEVELOPER/OWNER OF THE PROJECT SHALL OBTAIN NPDES PERMIT COVERAGE(S) FOR THE FOLLOWING:

    1. STORM WATER DISCHARGES ASSOCIATED WITH CONSTRUCTION ACTIVITIES THAT DISTURB ONE (1) ACRE OR MORE, AND
    2. DISCHARGES OF HYDROTESTING EFFLUENT, DEWATERING EFFLUENT, AND WELL DRILLING EFFLUENT TO STATE WATERS.

    IN ACCORDANCE WITH STATE LAW, ALL DISCHARGES RELATED TO PROJECT CONSTRUCTION OR OPERATIONS ARE REQUIRED TO COMPLY WITH STATE WATER QUALITY STANDARDS (HAR, CHAPTER 11-54). BMPS SHALL BE USED TO MINIMIZE OR PREVENT THE DISCHARGE OF SEDIMENT, DEBRIS, AND OTHER POLLUTANTS TO STATE WATERS. PERMIT COVERAGE IS AVAILABLE FROM THE DOH CWB AT HHTP://HEALTH.HAWAII.GOV/CWB. THE OWNER/DEVELOPER/CONTRACTOR IS RESPONSIBLE FOR OBTAINING OTHER FEDERAL, STATE, OR LOCAL AUTHORIZATIONS AS REQUIRED BY LAW.

APPROVED:

CHIEF, CIVIL ENGINEERING BRANCH, DPP   DATE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT
OCEAN OUTFALL IMPROVEMENTS
LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM:
GENERAL NOTES

DESIGNED BY: CHECKED BY:
DRAWN BY: SECTION HEAD:
APPROVED: BRANCH HEAD:

CHIEF   DATE

LANCE K. TOKUDA
LICENSED PROFESSIONAL ENGINEER
NO. 8631
HAWAII USA

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE

EXP. DATE 4/30/2022
EXPIRATION DATE OF THE LICENSE

JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

DRAWING C002   SHEET 3 OF 21

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GRADING NOTES: (CONT.)

12. WHERE APPLICABLE AND FEASIBLE THE MEASURES TO CONTROL EROSION AND OTHER POLLUTANTS SHALL BE IN PLACE BEFORE ANY EARTH MOVING PHASE OF THE GRADING IS INITIATED.
13. TEMPORARY EROSION CONTROLS SHALL NOT BE REMOVED BEFORE PERMANENT EROSION CONTROLS ARE IN-PLACE AND ESTABLISHED.
14. TEMPORARY EROSION CONTROL PROCEDURES SHALL BE SUBMITTED FOR APPROVAL PRIOR TO APPLICATION FOR GRADING PERMIT.
15. IF THE GRADING WORK INVOLVES CONTAMINATED SOIL, THEN ALL GRADING WORK SHALL BE DONE IN CONFORMANCE WITH APPLICABLE STATE AND FEDERAL REQUIREMENTS.
16. NON-COMPLIANCE TO ANY OF THE ABOVE REQUIREMENTS SHALL MEAN IMMEDIATE SUSPENSION OF ALL WORK, AND REMEDIAL WORK SHALL COMMENCE IMMEDIATELY. ALL COSTS INCURRED SHALL BE BILLED TO THE VIOLATOR. FURTHERMORE, VIOLATORS SHALL BE SUBJECTED TO ADMINISTRATIVE, CIVIL AND/OR CRIMINAL PENALTIES.
17. FOR BENCHMARK, SEE SHEET C005 EXISTING CONDITION AND BORING LOCATION PLAN.

EROSION AND SEDIMENT CONTROL (ESC) NOTES:

1. SEE "RULE RELATING TO WATER QUALITY" OF THE ADMINISTRATIVE RULES, TITLE 20, DEPARTMENT OF PLANNING AND PERMITTING, CHAPTER 3 (AUGUST 16, 2016).
2. MEASURES TO CONTROL EROSION AND OTHER POLLUTANTS SHALL BE IN PLACE BEFORE ANY LAND DISTURBANCE IS INITIATED.
3. SLOPE PROTECTION IS REQUIRED ON AREAS WITH SLOPES GREATER THAN 15% AND ON AREAS OF MODERATE SLOPE THAT ARE PRONE TO EROSION UNLESS THEY ARE BEING ACTIVELY WORKED. USE DIVERSION UPSTREAM OF SLOPE (DIKES, SWALES, SLOPE DRAINS) TO DIVERT WATER AROUND THE SLOPE. PROVIDE A 10-FOOT BUFFER ZONE AT THE TOE OF SLOPE. ONLY 5 ACRES MAY BE DISTURBED AT ANYTIME ON SLOPE GREATER THAN 15%.
4. TEMPORARY STABILIZATION IS REQUIRED ON DISTURBED AREAS WHICH ARE AT FINISH GRADE OR WHEN THE DISTURBED AREA WILL NOT BE WORKED FOR 7 CONSECUTIVE DAYS OR MORE.
5. PERMANENT STABILIZATION. ALL DISTURBED AREAS SHALL BE PERMANENTLY STABILIZED USING VEGETATIVE COVERING, PAVEMENT, OR EQUIVALENT, PRIOR TO REMOVING EROSION AND SEDIMENT MEASURES. TRAPPED SEDIMENT AND AREAS OF DISTURBED SOIL WHICH RESULT FROM THE REMOVAL OF THE TEMPORARY MEASURES SHALL BE IMMEDIATELY AND PERMANENTLY STABILIZED.
6. PRESERVE EXISTING VEGETATION CLEARLY MARK THE AREAS TO BE PRESERVED WITH FLAGS OR TEMPORARY FENCING. WHERE TEMPORARY FENCING IS USED, FENCING MUST BE ADEQUATELY SUPPORTED BY POSTS AND MAINTAINED IN AN UPRIGHT POSITION.
7. MINIMIZE SOIL COMPACTION AREAS WHERE FINAL STABILIZATION OR INFILTRATION PRACTICES WILL BE INSTALLED SHALL BE PROTECTED FROM EXCESSIVE COMPACTION DURING CONSTRUCTION. VEHICLE AND EQUIPMENT USE SHALL BE RESTRICTED OR TECHNIQUES TO CONDITION THE SOILS TO SUPPORT VEGETATION SHALL BE IMPLEMENTED IN THE AREAS THAT HAVE BEEN COMPACTED AND ARE DESIGNATED TO REMAIN VEGETATIVE OR POST-CONSTRUCTION INFILTRATION AREAS. CLEARLY MARK THE AREAS TO BE AVOIDED WITH FLAGS OR TEMPORARY FENCING. WHERE TEMPORARY FENCING IS USED, FENCING MUST BE ADEQUATELY SUPPORTED BY POSTS AND MAINTAINED IN AN UPRIGHT POSITION.
8. PERIMETER CONTROLS ARE REQUIRED DOWNSLOPE OF ALL DISTURBED AREAS. MAINTAIN DOWNSTREAM VEGETATED BUFFER AREA.
9. TRACKING CONTROL
   - MINIMIZE SEDIMENT TRACK-OUT ONTO OFF SITE STREETS, OTHER PAVED AREAS, AND SIDEWALKS FROM VEHICLES EXITING THE CONSTRUCTION SITE BY RESTRICTING VEHICLE TRAFFIC TO PROPERLY DESIGNATED AREAS AND USING ADDITIONAL CONTROLS TO REMOVE SEDIMENT FROM VEHICLE TIRES PRIOR TO EXITING THE SITE.
   - VEHICULAR PARKING AND MOVEMENTS ON PROJECT SITES MUST BE CONFINED TO PAVED SURFACES OR PREDEFINED PARKING AREAS AND VEHICLE PATHS, WHICH SHALL BE MARKED WITH FLAGS OR BOUNDARY FENCING.
   - ALL POLLUTANTS AND MATERIALS THAT ARE DROPPED, WASHED, TRACKED, SPILLED, OR OTHERWISE DISCHARGED FROM A PROJECT SITE TO OFF-SITE STREETS, OTHER PAVED AREAS, SIDEWALKS OR THE MS4 MUST BE CLEANED USING DRY METHODS SUCH AS SWEEPING OR VACUUMING.
   - WASHING POLLUTANTS AND MATERIALS THAT ARE DISCHARGED FROM THE PROJECT SITE TO THE MS4 INTO DRAIN INLETS OR CATCH BASINS IS PROHIBITED UNLESS THE MATERIAL IS SEDIMENT AND THE INLETS ARE DIRECTED TO A SEDIMENT BASIN OR SEDIMENT TRAP.
10. BEST MANAGEMENT PRACTICES (BMPs) SHALL NOT BE REMOVED UNTIL FINAL STABILIZATION IS COMPLETE FOR THAT PHASE.
11. REFER TO CITY AND COUNTY OF HONOLULU BMPS MANUAL-CONSTRUCTION, FOR MORE INFORMATION OF BMPS.
12. THE FOLLOWING BMPs WERE DETERMINED TO BE NOT APPLICABLE BASED ON THE SPECIFIC SITE CONDITIONS. AS CONSTRUCTION PROGRESSES, REVISIONS MAY BE NECESSARY AND WILL BE PROVIDED TO DPP INSPECTORS.
   - TURBIDITY CURTAINS SANDBAGS
   - SEDIMENT BARRIERS
13. THE CONTRACTOR SHALL COMPLY WITH THE PROJECT SCHEDULING REQUIREMENTS OF THE CITY'S RULES RELATING TO WATER QUALITY.
14. AN EROSION AND SEDIMENT CONTROL PLAN (ESCP) COORDINATOR MUST BE DESIGNATED USING THE FORM IN APPENDIX A TO THE RULES RELATING TO WATER QUALITY PRIOR TO PERMITTING.

EROSION AND SEDIMENT CONTROL PLAN SCHEDULE AND RAIN RESPONSE PLAN:

PROJECT SEQUENCE:

1. INSTALL STABILIZED CONSTRUCTION ENTRANCES, PERIMETER CONTROLS, HAUL ROUTE RAMP AND AGGREGATE CONSTRUCTION PAD (STOCKPILING), TRAFFIC PLATES, AND TEMPORARY FENCING OR PROTECTED AREAS, CLEARING AND GRUBBING AS NECESSARY FOR THE INSTALLATION OF THESE BMPS. TENTATIVE SCHEDULED FOR JUNE 2021.
2. INSTALL A RAIN GAGE PRIOR TO FIELD WORK. THE RAIN GAGE SHALL HAVE A TOLERANCE OF AT LEAST 0.05 INCHES OF RAINFALL. INSTALL THE RAIN GAGE ON THE PROJECT SITE IN AN AREA THAT WILL NOT DETER RAINFALL FROM ENTERING THE GAGE OPENING. DO NOT INSTALL IN A LOCATION WHERE RAIN WATER MAY SPLASH INTO THE RAIN GAGE. THE RAIN GAGE INSTALLATION SHALL BE STABLE AND PLUMBED. DO NOT BEGIN FIELD WORK UNTIL THE RAIN GAGE IS INSTALLED AND SITE-SPECIFIC BEST MANAGEMENT PRACTICES ARE IN PLACE.
3. PROCEED WITH GRADING AND CONSTRUCTION WITH LEAST POSSIBLE DISTURBANCE OF VEGETATIVE AREAS AND TEMPORARY STRUCTURES. INITIATE TEMPORARY STABILIZATION ONCE GRADING IS COMPLETED.
4. PRACTICE GOOD HOUSEKEEPING MEASURES THROUGHOUT THE DURATION OF CONSTRUCTION.
5. BMP MAINTENANCE INSPECTIONS WILL BE PERFORMED WEEKLY BY THE CONTRACTOR OR WHENEVER THERE IS RAIN EVENT EXCEEDING 0.25", WHICHEVER IS GREATER.
6. REMOVE HAUL ROUTE ROADWAY AND AGGREGATE CONSTRUCTION PAD (STOCKPILING).
7. STABILIZE ALL EXPOSED DISTURBED AREAS
8. DISMANTLE AND REMOVE ALL TEMPORARY EROSION CONTROL STRUCTURES AFTER FULL ESTABLISHMENT OF PERMANENT VEGETATIVE COVER.

RAIN RESPONSE PLAN:

THE FOLLOWING WILL BE PERFORMED WHEN HEAVY RAINS, TROPICAL STORM OR HURRICANE IS IMMINENT OR IS FORECASTED IN THE NEXT 48 HOURS.

1. TEMPORARY SUSPENSION OF ACTIVE GRADING.
2. INSPECT ALL PERIMETER CONTROLS AND MAINTAIN AS NEEDED. REINSTALL ANY PERIMETER CONTROLS THAT WERE REMOVED DUE TO ACTIVE WORK IN THE AREA. IF A SEVERE STORM IS EXPECTED, REMOVE INLET PROTECTION DEVICES TO PREVENT FLOODING ON SURROUNDING STREETS.
3. COVER OR RELOCATE MATERIAL STOCKPILES AND LIQUID MATERIAL CONTAINERS TO AVOID CONTACT WITH RAINWATER.
4. PLACE SPILL PANS OR OIL-ONLY SPILL PADS UNDER CONSTRUCTION VEHICLES TO PREVENT RUNOFF FROM CONTACTING ANY SPILLED PETROLEUM PRODUCTS. PROPERLY DISPOSE OF ANY ACCUMULATED SPILL CONTAINERS AND PADS.
5. RE-INSPECT SITE AFTER APPROACHING HEAVY RAINS, TROPICAL STORMS, OR HURRICANE, AND REPLACE BMPS AS NEEDED.

APPROVED:

CHIEF, CIVIL ENGINEERING BRANCH, DPP   DATE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE

EXP. DATE 4/30/2022
EXPIRATION DATE OF THE LICENSE

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT
OCEAN OUTFALL IMPROVEMENTS
LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM:
GRADING, EROSION AND SEDIMENT CONTROL NOTES

DESIGNED BY: ______ CHECKED BY: ______
DRAWN BY: ______ SECTION HEAD ______
APPROVED: BRANCH HEAD ______

CHIEF   DATE

JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

GOOD HOUSEKEEPING BMPS:

1. MATERIALS DELIVERY, STORAGE AND USE MANAGEMENT. PREVENT, REDUCE, OR ELIMINATE THE DISCHARGE OF POLLUTANTS FROM MATERIAL DELIVERY, STORAGE, AND USE TO THE STORM WATER SYSTEM OR WATERCOURSES BY MINIMIZING THE STORAGE OF HAZARDOUS MATERIALS ONSITE, STORING MATERIALS IN A DESIGNATED AREA, INSTALLING SECONDARY CONTAINMENT. CONSTRUCTION MATERIALS, WASTE TOXIC AND HAZARDOUS SUBSTANCES, STOCKPILES AND OTHER SOURCES OF POLLUTION SHALL NOT BE STORED IN BUFFER AREAS, NEAR AREAS OF CONCENTRATED FLOW, OR AREAS ABUTTING TO MS4, RECEIVING WATERS, OR DRAINAGE IMPROVEMENTS THAT DISCHARGE OFF-SITE. PRIMARY AND SECONDARY CONTAINMENT CONTROLS AND COVERS SHALL BE IMPLEMENTED TO THE MEP.

2. SPILL PREVENTION AND CONTROL. CREATE AND IMPLEMENT SPILL PREVENTION AND RESPONSE PLANS TO ELIMINATE AND MINIMIZE THE DISCHARGE OF POLLUTANTS TO THE MS4 AND RECEIVING WATERS FROM LEAKS AND SPILLS BY REDUCING THE CHANCE OF SPILLS, ABSORBING, CONTAINING AND CLEANING UP SPILLS AND PROPERLY DISPOSING OF SPILL MATERIALS. AT A MINIMUM, ALL PROJECTS SHALL CLEAN-UP ALL LEAKS AND SPILLS IMMEDIATELY.

3. HAZARDOUS MATERIALS. PREVENT OR REDUCE THE DISCHARGE OF POLLUTANTS TO STORM WATER FROM HAZARDOUS WASTE THROUGH PROPER MATERIAL USE AND WASTE DISPOSAL. IN THE EVENT THAT HAZARDOUS MATERIALS ARE DISCHARGED TO THE RECEIVING WATER, THE PROPERTY OWNER OR ESCP COORDINATOR SHALL IMMEDIATELY CALL 9-1-1, AND NOTIFY THE DEPARTMENT OF HEALTH HAWAII STATE EMERGENCY RESPONSE COMMISION (HSERC) 586-4249 / 247-2191 AFTER HOURS, CITY DEPARTMENT OF EMERGENCY MANAGEMENT LOCAL EMERGENCY PLANNING COMMITTEE (LEPC) 723-8958 / 723-8690, HONOLULU FIRE DEPARTMENT 723-7101, AND CITY INSPECTOR OR ENGINEER BY TELEPHONE. A WRITTEN REPORT DESCRIBING THE POLLUTANTS THAT WERE DISCHARGED, THE REASONS FOR THE DISCHARGE, AND THE MEASURES THAT HAVE BEEN TAKEN TO PREVENT A REOCCURENCE OF THE DISCHARGE SHALL BE SUBMITTED TO THE DIRECTOR NO LESS THAN 3 DAYS AFTER NOTIFICATION BY PHONE,

4. NONHAZARDOUS MATERIALS. IN THE EVENT THAT NONHAZARDOUS MATERIALS ARE DISCHARGED TO THE MS4, THE PROPERTY OWNER OR ESCP COORDINATOR SHALL NOTIFY THE CITY DEPARTMENT OF FACILITIES MAINTENANCE BY TELEPHONE NO LATER THAN THE NEXT BUSINESS DAY. A WRITTEN REPORT DESCRIBING THE POLLUTANTS THAT WERE DISCHARGED, THE REASONS FOR THE DISCHARGE, AND THE MEASURES THAT HAVE BEEN TAKEN OR WILL BE TAKEN TO PREVENT A REOCCURENCE OF THE DISCHARGE SHALL BE SUBMITTED TO THE DIRECTOR NO LESS THAN 3 DAYS AFTER THE NOTIFICATION BY PHONE.

5. VEHICLE AND EQUIPMENT CLEANING. ELIMINATE AND MINIMIZE THE DISCHARGE OF POLLUTANTS TO STORM WATER FROM VEHICLE AND EQUIPMENT CLEANING OPERATIONS BY USING OFF-SITE FACILITIES WHEN FEASIBLE, WASHING IN DESIGNATED, CONTAINED AREAS ONLY, AND ELIMINATING DISCHARGES TO THE STORM DRAIN SYSTEM BY EVAPORATING AND/OR TREATING WASH WATER, AS APPROPRIATE OR INFILTRATING WASH WATER FOR EXTERIOR CLEANING ACTIVITIES THAT USE WATER ONLY.

6. VEHICLE AND EQUIPMENT FUELING. PREVENT FUEL SPILL AND LEAKS BY USING OFF-SITE FACILITIES, FUELING ONLY IN DESIGNATED AREAS, ENCLOSING OR COVERING STORED FUEL, AND IMPLEMENTING SPILL CONTROLS SUCH AS SECONDARY CONTAINMENTS AND ACTIVE MEASURES USING SPILL RESPONSE KITS.

7. VEHICLE AND EQUIPMENT MAINTENANCE. ELIMINATE AND MINIMIZE THE DISCHARGE OF POLLUTANTS TO STORM WATER FROM VEHICLE AND EQUIPMENT CLEANING OPERATIONS BY USING OFF-SITE FACILITIES WHEN FEASIBLE, PERFORMING WORK IN DESIGNATED AREAS ONLY, USING SPILL PADS UNDER VEHICLES AND EQUIPMENT, CHECKING FOR LEAKS AND SPILLS, AND CONTAINING AND CLEANING UP SPILLS IMMEDIATELY.

8. SOLID WASTE MANAGEMENT. PREVENT OR REDUCE DISCHARGE OF POLLUTANTS TO THE LAND, GROUNDWATER, AND IN THE STORM WATER FROM SOLID WASTE OR CONSTRUCTION AND DEMOLITION WASTE BY PROVIDING DESIGNATED WASTER COLLECTION AREAS, COLLECT SITE TRASH DAILY, AND ENSURING THAT CONSTRUCTION WASTE IS COLLECTED, REMOVED, AND DISPOSED OF ONLY AT AUTHORIZED DISPOSAL AREAS.

9. SANITARY/SEPTIC WASTE MANAGEMENT. TEMPORARY AND PORTABLE SANITARY AND SEPTIC WASTE SYSTEMS SHALL BE MOUNTED OR STAKED IN, WELL-MAINTAINED AND SCHEDULED FOR REGULAR WASTE DISPOSAL AND SERVICING. SOURCES OF SANITARY AND/OR SEPTIC WASTE SHALL NOT BE STORED NEAR THE MS4 OR RECEIVING WATERS.

10. STOCKPILE MANAGEMENT. DESIGNATED STOCKPILES AND STORAGE AREA AS SHOWN ON PLANS. STOCKPILES SHALL NOT BE LOCATED IN DRAINAGE WAYS, OR WITHIN 50 FEET FROM AREAS OF CONCENTRATED FLOWS. SEDIMENT BARRIERS OR SILT FENCES SHALL BE USED AROUND THE BASE OF ALL STOCKPILES. STOCKPILES SHALL NOT EXCEED 15 FEET IN HEIGHT. STOCKPILES MUST BE COVERED WITH PLASTIC SHEETING OR A COMPARABLE MATERIAL IF THEY WILL NOT BE ACTIVELY USED WITHIN 7 DAYS.

11. LIQUID WASTE MANAGEMENT. LIQUID WASTE SHALL BE CONTAINED IN A CONTROLLED AREA SUCH AS HOLDING PIT, SEDIMENT BASIN, ROLL-OFF BIN, OR PORTABLE TANK OF SUFFICIENT VOLUME AND TO CONTAIN THE LIQUID WASTES GENERATED. CONTAINMENT AREAS OR DEVICES MUST BE IMPERMEABLE AND LEAK FREE AND SHOULD NOT BE LOCATED WHERE ACCIDENTAL RELEASE OF THE CONTAINED LIQUID CAN DISCHARGE TO WATER BODIES, CHANNELS, OR STORM DRAINS.

12. CONCRETE WASTE MANAGEMENT. PREVENT OR REDUCE THE DISCHARGE OF POLLUTANTS TO STORM WATER FROM CONCRETE WASTE BY CONDUCTING WASHOUT OFFSITE OR PERFORMING ONSITE WASHOUT IN A DESIGNATED AREA CONSTRUCTED AND MAINTAINED IN SUFFICIENT QUANTITY AND SIZE TO CONTAIN ALL LIQUID AND CONCRETE WASTE GENERATED BY WASHOUT OPERATIONS. PLASTIC LINING MATERIAL SHOULD BE A MINIMUM OF 10 MILLIMETER POLYETHYLENE SHEETING AND SHOULD BE FREE OF HOLES, TEARS, OR OTHER DEFECTS THAT COMPROMISE THE IMPERMEABILITY OF THE MATERIAL. CONTAINMENT AREAS OR DEVICES SHOULD NOT BE LOCATED WHERE ACCIDENTAL RELEASE OF THE CONTAINED LIQUID CAN DISCHARGE TO WATER BODIES, CHANNELS, OR STORM DRAINS. WASHOUT FACILITIES MUST BE CLEANED, OR NEW FACILITIES MUST BE CONSTRUCTED AND READY FOR USE ONCE THE WASHOUT IS 75 PERCENT FULL. ONCE CONCRETE WASTES AREA WASHED INTO THE DESIGNATED AREA AND ALLOWED TO HARDEN, THE CONCRETE SHOULD BE BROKEN UP, REMOVED, AND DISPOSED OF AS SOLID WASTES.

13. CONTAMINATED SOIL MANAGEMENT. AT MINIMUM CONTAIN CONTAMINATED MATERIAL SOIL BY SURROUNDING WITH IMPERMEABLE LINED BERMS OR COVER EXPOSED CONTAMINATED MATERIAL WITH PLASTIC SHEETING. CONTAMINATED SOIL SHOULD BE DISPOSED OF PROPERLY IN ACCORDANCE WITH ALL APPLICABLE REGULATIONS.

14. DUST CONTROL: WORK MUST CONFORM WITH AIR POLLUTION CONTROL STANDARDS CONTAINED IN THE HAR, TITLE 11, CHAPTER 60.1 "AIR POLLUTION CONTROL". SPRINKLE EXPOSED SOILS WITH WATER TO MAINTAIN MOISTNESS AT A DEPTH OF 2-3 INCHES DURING WORKING HOURS AND NOT TO GENERATE ANY RUNOFF.

15. MAINTAIN SITE AND BMPS. THE ESCP COORDINATOR SHALL INSPECT ONCE EVERY SEVEN DAYS. INSPECTION RESULTS AND CORRECTIVE ACTION SHALL BE DOCUMENTED WITH PHOTOGRAPHS AND BY COMPLETING THE DPP "RULES RELATING TO WATER QUALITY" FORM PROVIDED IN APPENDIX D.

MISCELLANEOUS ENVIRONMENTAL NOTES:

1. CONTRACTOR SHALL PREPARE AND SUBMIT A SITE SPECIFIC BMP PLAN TO THE ENGINEER, DEPARTMENT OF HEALTH, ARMY CORPS OF ENGINEERS.

2. THE CONTRACTOR SHALL FOLLOW THE APPROVED WATER QUALITY MONITORING PLAN.

3. TURBIDITY AND SILTATION FROM PROJECT-RELATED WORK SHOULD BE MINIMIZED AND CONTAINED TO WITHIN THE VICINITY OF THE SITE THROUGH THE APPROPRIATE USE OF EFFECTIVE SILT CONTAINMENT DEVICES AND THE CURTAILMENT OF WORK DURING ADVERSE TIDAL AND WEATHER CONDITIONS.

4. ANY CONSTRUCTION-RELATED DEBRIS THAT MAY POSE AN ENTANGLEMENT HAZARD TO MARINE PROTECTED SPECIES MUST BE REMOVED FROM THE PROJECT SITE IF NOT ACTIVELY BEING USED AND/OR AT THE CONCLUSION OF THE CONSTRUCTION WORK.

5. ALL PROJECT-RELATED MATERIALS AND EQUIPMENT PLACED IN THE WATER SHOULD BE FREE OF POLLUTANTS.

6. NO CONTAMINATION (TRASH OR DEBRIS DISPOSAL, ALIEN SPECIES INTRODUCTIONS, ETC.) OF MARINE (REEF FLATS, LAGOONS, OPEN OCEAN, ETC.) ENVIRONMENTS ADJACENT TO THE PROJECT SITE SHOULD RESULT FROM PROJECT-RELATED ACTIVITIES.

7. FUELING OF PROJECT-RELATED VEHICLES AND EQUIPMENT SHOULD TAKE PLACE AWAY FROM THE WATER. A CONTINGENCY PLAN TO CONTROL THE ACCIDENTAL SPILLS OF PETROLEUM PRODUCTS AT THE CONSTRUCTION SITE SHOULD BE DEVELOPED. ABSORBENT PADS, CONTAINMENT BOOMS AND SKIMMERS WILL BE STORED ON-SITE TO FACILITATE THE CLEANUP OF PETROLEUM SPILLS.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION NOTES:

1. AVOID CONSTRUCTION DURING HIGH WAVE CONDITIONS (FRONT SIDE WAVE HEIGHTS GREATER THAN 2 FEET)

2. ENSURE APPROPRIATE BMPS AND SOURCE CONTROL MEASURES ARE DEFINED AND IMPLEMENTED TO MINIMIZE AND POTENTIAL ADVERSE EFFECTS TO EXISTING FISH HABITAT FROM THE INTRODUCTION OF CONSTRUCTION-RELATED POLLUTANTS.

3. HALT CONSTRUCTION ACTIVITIES DURING RAINY PERIODS. DEVELOP A RAIN EVENT ACTION PLAN THAT INCLUDES PREPARATIONS AND PLANS FOR MANAGING ACTIVITIES DURING RAIN EVENTS.

4. AVOID PHYSICAL CONTACT WITH LIVE CORALS AND ANY SUBMERGED AQUATIC VEGETATION (SAV) INCLUDING SEAGRASS AND CALCIFYING AND CRUSTOSE CORALLINE ALGAE.

5. INSTALL SILT FENCES AND BERMS ALONG THE BEACH TO PREVENT SEDIMENTS AND DEBRIS FROM ENTERING THE OCEAN.

6. INSTALL TURBIDITY CURTAINS IN THE MARINE ENVIRONMENT TO ISOLATE THE CONSTRUCTION ACTIVITY AND PREVENT RELEASE OF SEDIMENTS AND TURBIDITY PLUMES. ENSURE TURBIDITY CURTAINS ARE NOT ANCHORED ON AND ENCLOSE BOTH CORAL AND SAV.

PUBLIC HEALTH SAFETY AND CONVENIENCE NOTES:

1. CONTRACTOR SHALL OBSERVE AND COMPLY WITH ALL FEDERAL, STATE, AND LOCAL LAWS REQUIRED FOR THE PROTECTION OF PUBLIC HEALTH, SAFETY AND ENVIRONMENTAL QUALITY.

2. THE CONTRACTOR SHALL PROVIDE, INSTALL AND MAINTAIN ALL NECESSARY SIGNS, LIGHTS, FLARES, BARRICADES, MARKERS, CONES, AND OTHER PROTECTIVE FACILITIES AND SHALL TAKE ALL NECESSARY PRECAUTIONS FOR THE PROTECTION, CONVENIENCE AND SAFETY OF THE PUBLIC.

3. THE CONTRACTOR'S ATTENTION IS DIRECTED TO CHAPTER 46, PUBLIC HEALTH REGULATIONS, DEPARTMENT OF HEALTH, STATE OF HAWAII, "COMMUNITY NOISE CONTROL," IN WHICH MAXIMUM PERMISSIBLE NOISE LEVELS HAVE BEEN SET. IF THE CONSTRUCTION WORK REQUIRES A PERMIT FROM THE DIRECTOR OF HEALTH, THE CONTRACTOR SHALL OBTAIN A COPY OF CHAPTER 46 AND BECOME FAMILIAR WITH THE NOISE LEVEL RESTRICTIONS AND THE PROCEDURES FOR OBTAINING A PERMIT FOR THE CONSTRUCTION ACTIVITIES. APPLICATION AND INFORMATION ON VARIANCES ARE AVAILABLE FROM THE ENVIRONMENTAL PROTECTION AND HEALTH SERVICES DIVISION, 1250 PUNCHBOWL ST., HONOLULU, HI 96813 OR BY TELEPHONE.

4. CONSTRUCTION SITE SECURITY SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR, 24 HOURS A DAY, 7 DAYS A WEEK UNTIL CONSTRUCTION IS COMPLETED.

NOAA FISHERIES RECOMMENDED MITIGATING MEASURES TO REDUCE IMPACTS TO PROTECTED SPECIES:

1. A VISUAL SURVEY, WHICH WILL BE PERFORMED BY THE CONTRACTOR'S PROJECT AREA, MUST BE PERFORMED JUST PRIOR TO COMMENCEMENT OR RESUMPTION OF CONSTRUCTION ACTIVITY TO ENSURE THAT NO PROTECTED SPECIES ARE IN THE PROTECTED AREA. IF PROTECTED SPECIES ARE DETECTED, CONSTRUCTION ACTIVITIES MUST BE POSTPONED UNTIL ANIMAL(S) VOLUNTARILY LEAVE THE AREA.

2. IF ANY LISTED SPECIES ENTERS THE AREA DURING THE CONDUCT OF CONSTRUCTION ACTIVITIES, ALL ACTIVITIES MUST CEASE UNTIL THE ANIMAL(S) VOLUNTARILY DEPARTS THE AREA.

3. ALL ON-SITE PROJECT PERSONNEL MUST BE APPRISED OF THE STATUS OF ANY LISTED SPECIES POTENTIALLY PRESENT IN THE PROJECT AREA AND THE PROTECTIONS AFFORDED TO THOSE SPECIES UNDER FEDERAL LAWS.

4. ANY INCIDENTAL TAKE OF MARINE MAMMALS MUST BE REPORTED IMMEDIATELY TO NOAA FISHERIES' 24-HOUR HOTLINE AT 1-888-256-9840. ANY INJURIES TO SEA TURTLES MUST BE REPORTED AND MUST INCLUDE THE NAME AND PHONE NUMBER OF THE POINT OF CONTACT, LOCATION OF THE INCIDENT, AND NATURE OF THE TAKE AND/OR INJURY.

WASTE DISPOSAL NOTES:

1. WASTE MATERIALS
COLLECT AND STORE ALL WASTE MATERIALS IN A SECURELY LIDDED METAL DUMPSTER OR ROLL-OFF CONTAINER WITH COVER TO KEEP RAIN OUT OR LOSS OF WASTE DURING WINDY CONDITIONS. THE DUMPSTER SHALL MEET ALL LOCAL AND STATE SOLID WASTE MANAGEMENT REGULATIONS. DEPOSIT ALL TRASH AND CONSTRUCTION DEBRIS FROM THE SITE IN THE DUMPSTER. EMPTY THE DUMPSTER WEEKLY OR WHEN THE CONTAINER IS TWO-THIRDS FULL, WHICHEVER IS SOONER. DO NOT BURY CONSTRUCTION WASTE MATERIALS ONSITE. THE CONTRACTOR'S SUPERVISORY PERSONNEL SHALL BE INSTRUCTED REGARDING THE CORRECT PROCEDURE FOR WASTE DISPOSAL. POST NOTICES STATING THESE PRACTICES IN THE OFFICE TRAILER, ON A WEATHERPROOF BULLETIN BOARD, OR OTHER ACCESSIBLE LOCATION ACCEPTABLE TO THE ENGINEER. THE CONTRACTOR SHALL BE RESPONSIBLE FOR SEEING THAT THESE PROCEDURES ARE FOLLOWED. SUBMIT THE SOLID WASTE DISCLOSURE FORM FOR CONSTRUCTION SITES TO THE ENGINEER WITHIN 30 CALENDAR DAYS OF CONTRACT EXECUTION. PROVIDE A COPY OF ALL THE DISPOSAL RECEIPTS FROM THE FACILITY PERMITTED BY THE DEPARTMENT OF HEALTH TO RECEIVE SOLID WASTE TO THE ENGINEER MONTHLY. THIS SHOULD ALSO INCLUDE DOCUMENTATION FROM ANY INTERMEDIARY FACILITY WHERE SOLID WASTE IS HANDLED OR PROCESSED.

2. WORK SHALL BE DONE IN CONFORMANCE WITH THE AIR POLLUTION CONTROL STANDARDS CONTAINED IN THE HAWAII ADMINISTRATIVE RULES, TITLE 11, CHAPTER 60.1 "AIR POLLUTION CONTROL".

3. CONTRACTOR SHALL PREPARE AND SUBMIT A SITE SPECIFIC BMP PLAN TO THE ENGINEER, DEPARTMENT OF HEALTH, ARMY CORPS OF ENGINEERS.

4. THE CONTRACTOR SHALL FOLLOW THE APPROVED WATER QUALITY MONITORING PLAN.

5. TURBIDITY AND SILTATION FROM PROJECT-RELATED WORK SHOULD BE MINIMIZED AND CONTAINED TO WITHIN THE VICINITY OF THE SITE THROUGH THE APPROPRIATE USE OF EFFECTIVE SILT CONTAINMENT DEVICES AND THE CURTAILMENT OF WORK DURING ADVERSE TIDAL AND WEATHER CONDITIONS.

6. ANY CONSTRUCTION-RELATED DEBRIS THAT MAY POSE AN ENTANGLEMENT HAZARD TO MARINE PROTECTED SPECIES MUST BE REMOVED FROM THE PROJECT SITE IF NOT ACTIVELY BEING USED AND/OR AT THE CONCLUSION OF THE CONSTRUCTION WORK.

7. ALL PROJECT-RELATED MATERIALS AND EQUIPMENT PLACED IN THE WATER SHALL BE FREE OF POLLUTANTS.

8. NO CONTAMINATION (TRASH OR DEBRIS DISPOSAL, ALIEN SPECIES INTRODUCTIONS, ETC.) OF MARINE (REEF FLATS, LAGOONS, OPEN OCEAN, ETC.) ENVIRONMENTS ADJACENT TO THE PROJECT SITE SHOULD RESULT FROM PROJECT-RELATED ACTIVITIES.

9. FUELING OF PROJECT-RELATED VEHICLES AND EQUIPMENT SHALL TAKE PLACE AWAY FROM THE WATER. A CONTINGENCY PLAN TO CONTROL THE ACCIDENTAL SPILLS OF PETROLEUM PRODUCTS AT THE CONSTRUCTION SITE SHOULD BE DEVELOPED. ABSORBENT PADS, CONTAINMENT BOOMS AND SKIMMERS WILL BE STORED ON-SITE TO FACILITATE THE CLEANUP OF PETROLEUM SPILLS.

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES):

1. THE GENERAL CONTRACTOR/DEVELOPER/OWNER OF THE PROJECT SHALL BE RESPONSIBLE FOR CONFORMANCE WITH APPLICABLE PROVISIONS OF THE HAWAII ADMINISTRATIVE RULES, TITLE 11, CHAPTER 54, "WATER QUALITY STANDARDS," AND; TITLE 11, CHAPTER 55, "WATER POLLUTION CONTROL", AS WELL AS CHAPTER 14 OF THE REVISED ORDINANCES OF HONOLULU, AS AMENDED. BEST MANAGEMENT PRACTICES SHALL BE EMPLOYED AT ALL TIMES DURING CONSTRUCTION.

   THE GENERAL CONTRACTOR/DEVELOPER/OWNER OF THE PROJECT SHALL OBTAIN NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT COVERAGE(S) FOR THE FOLLOWING:

   A. STORM WATER DISCHARGES ASSOCIATED WITH CONSTRUCTION ACTIVITIES THAT DISTURB ONE (1) ACRE OR MORE, AND

   B. DISCHARGE OF HYDROTESTING EFFLUENT, DEWATERING EFFLUENT, AND WELL DRILLING EFFLUENT TO STATE WATERS.

   IN ACCORDANCE WITH THE STATE LAW, ALL DISCHARGES RELATED TO PROJECT CONSTRUCTION OR OPERATIONS ARE REQUIRED TO COMPLY WITH THE STATE WATER QUALITY STANDARDS (HAWAII ADMINISTRATIVE RULES, CHAPTER 11-54). BEST MANAGEMENT PRACTICES SHALL BE USED TO MINIMIZE OR PREVENT THE DISCHARGE OF SEDIMENT, DEBRIS, AND OTHER POLLUTANTS TO STATE WATERS. PERMIT COVERAGE IS AVAILABLE FROM THE DEPARTMENT OF HEALTH, CLEAN WATER BRANCH AT HTTP://HEALTH.HAWAII.GOV/CWB. THE OWNER/DEVELOPER/CONTRACTOR IS RESPONSIBLE FOR OBTAINING OTHER FEDERAL, STATE, OR LOCAL AUTHORIZATIONS AS REQUIRED BY LAW.

2. THE CONTRACTOR SHALL PREPARE AND SUBMIT A SITE SPECIFIC BMP PLAN FOR APPROVAL BY THE STATE OF HAWAII DEPARTMENT OF HEALTH, CLEAN WATER BRANCH AS PART OF THE 401 WATER QUALITY CERTIFICATION WITH REFERENCE COPIES SENT TO DEPARTMENT OF THE ARMY CORPS OF ENGINEERS REGULATORY BRANCH.

APPROVED:

CHIEF, CIVIL ENGINEERING BRANCH, DPP — DATE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

LANCE K. TOKUDA
LICENSED PROFESSIONAL ENGINEER
NO. 8631
HAWAII USA

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.
SIGNATURE
EXP. DATE 4/30/2022
EXPIRATION DATE OF THE LICENSE

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT OCEAN OUTFALL IMPROVEMENTS
LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM:
EROSION, SEDIMENT CONTROL AND MISCELLANEOUS NOTES

DESIGNED BY:
DRAWN BY:
APPROVED:
CHECKED BY:
SECTION HEAD
BRANCH HEAD
CHIEF
DATE

JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

DRAWING C004 SHEET 5 OF 21

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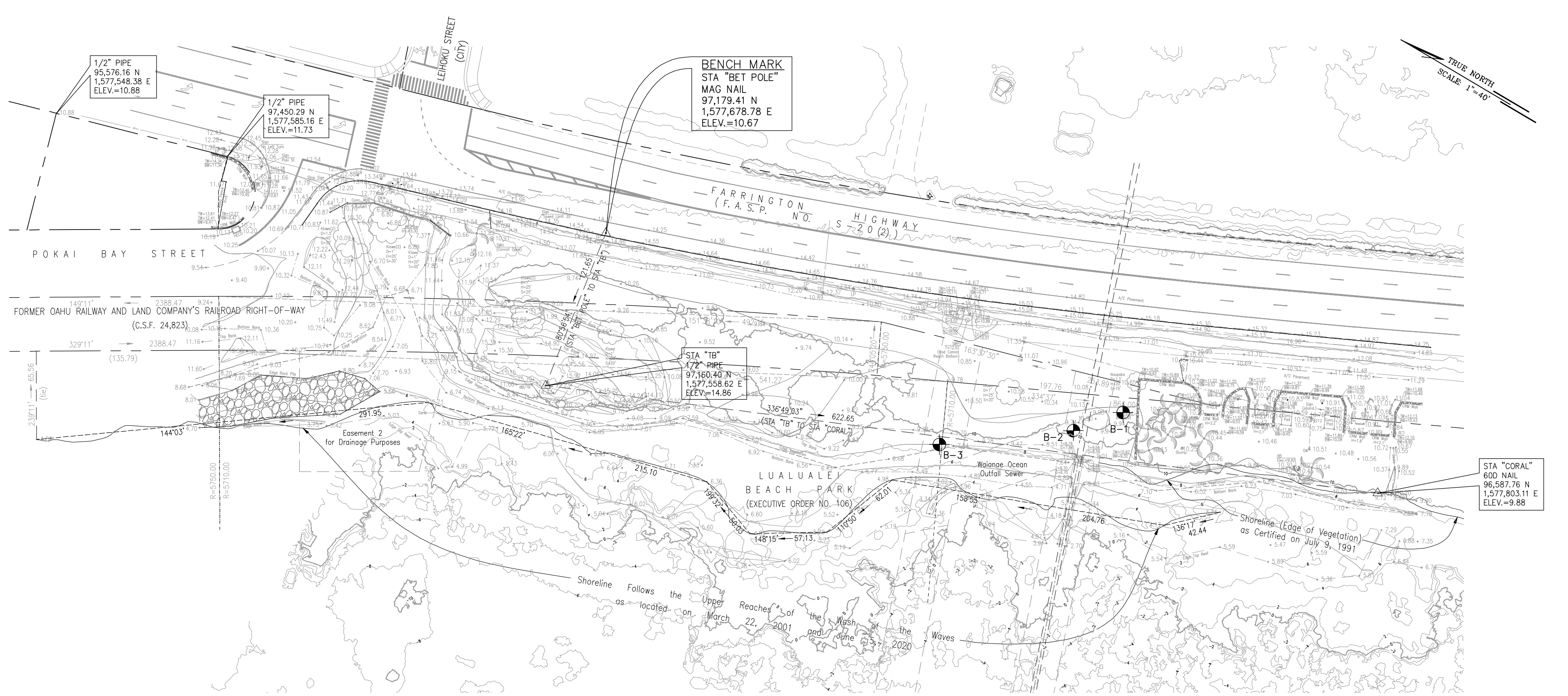

EXISTING CONDITION AND BORING LOCATION PLAN

SCALE: 1"=40'

LEGEND

B-1 BORING LOG LOCATION AND NUMBER

SHORELINE (EDGE OF VEGETATION) AS CERTIFIED ON JULY 1991

EXISTING ROCK PILE

SURVEY NOTES:

1. AZIMUTHS ARE REFERRED TO GOVERNMENT SURVEY TRIANGULATION STATION "PAHEEHEE NEW" △.
2. BOUNDARIES ARE SHOWN FROM RECORD DATA.
3. COORDINATES ARE REFERRED TO NAD83 HAWAII STATE PLANE, ZONE 3, US FOOT.
4. ELEVATIONS ARE BASED ON MEAN LOWER LOW WATER (MLLW).
5. SURVEY PERFORMED BY R.M. TOWILL CORP. REF NO.: 1-23664-0-S. FB NO.: 8909 AND 8928.

GRAPHIC SCALE:

40' 20' 0 40' 80'

SCALE: 1"=40'

LANCE K. TOKUDA
LICENSED PROFESSIONAL ENGINEER
NO. 8631
HAWAII USA

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE

EXP. DATE 4/30/2022
EXPIRATION DATE OF THE LICENSE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT OCEAN OUTFALL IMPROVEMENTS
LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM: EXISTING CONDITION AND BORING LOCATION PLAN

DESIGNED BY: CHECKED BY:
DRAWN BY: SECTION HEAD:
APPROVED: BRANCH HEAD:
CHIEF DATE

JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

DRAWING B001 SHEET 6 OF 21

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GEOLABS, INC.
Geotechnical Engineering

Soil Log Legend

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

MAJOR DIVISIONS			USCS	TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS MORE THAN 50% OF MATERIAL RETAINED ON NO. 200 SIEVE	GRAVELS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS LESS THAN 5% FINES	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES MORE THAN 12% FINES	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SANDS 50% OR MORE OF COARSE FRACTION PASSING THROUGH NO. 4 SIEVE	CLEAN SANDS LESS THAN 5% FINES	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES MORE THAN 12% FINES	SM	SILTY SANDS, SAND-SILT MIXTURES
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE-GRAINED SOILS 50% OR MORE OF MATERIAL PASSING THROUGH NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT 50 OR MORE	MH	INORGANIC SILT, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

LEGEND

- (2-INCH) O.D. STANDARD PENETRATION TEST
- (3-INCH) O.D. MODIFIED CALIFORNIA SAMPLE
- S — SHELBY TUBE SAMPLE
- G — GRAB SAMPLE
- CORE SAMPLE
- ▽ WATER LEVEL OBSERVED IN BORING AT TIME OF DRILLING
- WATER LEVEL OBSERVED IN BORING AFTER DRILLING
- WATER LEVEL OBSERVED IN BORING OVERNIGHT

- LL — LIQUID LIMIT (NP=NON-PLASTIC)
- PI — PLASTICITY INDEX (NP=NON-PLASTIC)
- TV — TORVANE SHEAR (tsf)
- UC — UNCONFINED COMPRESSION OR UNIAXIAL COMPRESSIVE STRENGTH
- TXUU — UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION (ksf)

Plate
A-0.1

LOG LEGEND FOR SOIL 8240-00.GPJ GEOLABS.GDT 6/7/21

GEOLABS, INC.
Geotechnical Engineering

Soil Classification Log Key
(with deviations from ASTM D2488)

GEOLABS, INC. CLASSIFICATION*

GRANULAR SOIL (- #200 <50%)	COHESIVE SOIL (- #200 ≥50%)
• PRIMARY constituents are composed of the largest percent of the soil mass. Primary constituents are capitalized and bold (i.e., GRAVEL, SAND)	• PRIMARY constituents are based on plasticity. Primary constituents are capitalized and bold (i.e., CLAY, SILT)
• SECONDARY constituents are composed of a percentage less than the primary constituent. If the soil mass consists of 12 percent or more fines content, a cohesive constituent is used (SILTY or CLAYEY); otherwise, a granular constituent is used (GRAVELLY or SANDY) provided that the secondary constituent consists of 20 percent or more of the soil mass. Secondary constituents are capitalized and bold (i.e., SANDY GRAVEL, CLAYEY SAND) and precede the primary constituent.	• SECONDARY constituents are composed of a percentage less than the primary constituent, but more than 20 percent of the soil mass. Secondary constituents are capitalized and bold (i.e., SANDY CLAY, SILTY CLAY, CLAYEY SILT) and precede the primary constituent.
• accessory descriptions compose of the following: with some: >12% with a little: 5 - 12% with traces of: <5% accessory descriptions are lower cased and follow the Primary and Secondary Constituents (i.e., SILTY GRAVEL with a little sand)	• accessory descriptions compose of the following: with some: >12% with a little: 5 - 12% with traces of: <5% accessory descriptions are lower cased and follow the Primary and Secondary Constituents (i.e., SILTY CLAY with some sand)

EXAMPLE: Soil Containing 60% Gravel, 25% Sand, 15% Fines. Described as: SILTY GRAVEL with some sand

RELATIVE DENSITY / CONSISTENCY

Granular Soils			Cohesive Soils			
N-Value (Blows/Foot)		Relative Density	N-Value (Blows/Foot)		PP Readings (tsf)	Consistency
SPT	MCS		SPT	MCS		
0 - 4	0 - 7	Very Loose	0 - 2	0 - 4		Very Soft
4 - 10	7 - 18	Loose	2 - 4	4 - 7	< 0.5	Soft
10 - 30	18 - 55	Medium Dense	4 - 8	7 - 15	0.5 - 1.0	Medium Stiff
30 - 50	55 - 91	Dense	8 - 15	15 - 27	1.0 - 2.0	Stiff
> 50	> 91	Very Dense	15 - 30	27 - 55	2.0 - 4.0	Very Stiff
			> 30	> 55	> 4.0	Hard

MOISTURE CONTENT DEFINITIONS

Dry: Absence of moisture, dry to the touch

Moist: Damp but no visible water

Wet: Visible free water

ABBREVIATIONS

WOH: Weight of Hammer

WOR: Weight of Drill Rods

SPT: Standard Penetration Test Split-Spoon Sampler

MCS: Modified California Sampler

PP: Pocket Penetrometer

GRAIN SIZE DEFINITION

Description	Sieve Number and / or Size
Boulders	> 12 inches (305-mm)
Cobbles	3 to 12 inches (75-mm to 305-mm)
Gravel	3-inch to #4 (75-mm to 4.75-mm)
Coarse Gravel	3-inch to 3/4-inch (75-mm to 19-mm)
Fine Gravel	3/4-inch to #4 (19-mm to 4.75-mm)
Sand	#4 to #200 (4.75-mm to 0.075-mm)
Coarse Sand	#4 to #10 (4.75-mm to 2-mm)
Medium Sand	#10 to #40 (2-mm to 0.425-mm)
Fine Sand	#40 to #200 (0.425-mm to 0.075-mm)

**Soil descriptions are based on ASTM D2488-09a, Visual-Manual Procedure, with the above modifications by Geolabs, Inc. to the Unified Soil Classification System (USCS).*

Plate
A-0.2

SOIL CLASS LOG KEY 8240-00.GPJ GEOLABS.GDT 6/7/21

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE

EXP. DATE 4/30/2022
EXPIRATION DATE OF THE LICENSE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT
OCEAN OUTFALL IMPROVEMENTS
LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM:
BORING LOGS - 1

DESIGNED BY: AH   CHECKED BY: RL
DRAWN BY: KN   SECTION HEAD:
APPROVED: BRANCH HEAD:
CHIEF   DATE

JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

DRAWING B002   SHEET 7 OF 21

W:_CIVIL 3D PROJECTS\2010_057.000 ENV SAND ISLAND WWTP\01 CIVIL DRAWINGS\TITLE BLOCK.DWG 09/13/17 16:19 ecl

GEOLABS, INC.

Geotechnical Engineering

Rock Log Legend

ROCK DESCRIPTIONS

	BASALT		CONGLOMERATE
	BOULDERS		LIMESTONE
	BRECCIA		SANDSTONE
	CLINKER		SILTSTONE
	COBBLES		TUFF
	CORAL		VOID/CAVITY

ROCK DESCRIPTION SYSTEM

ROCK FRACTURE CHARACTERISTICS

The following terms describe general fracture spacing of a rock:

Massive:	Greater than 24 inches apart
Slightly Fractured:	12 to 24 inches apart
Moderately Fractured:	6 to 12 inches apart
Closely Fractured:	3 to 6 inches apart
Severely Fractured:	Less than 3 inches apart

DEGREE OF WEATHERING

The following terms describe the chemical weathering of a rock:

Unweathered:	Rock shows no sign of discoloration or loss of strength.
Slightly Weathered:	Slight discoloration inwards from open fractures.
Moderately Weathered:	Discoloration throughout and noticeably weakened though not able to break by hand.
Highly Weathered:	Most minerals decomposed with some corestones present in residual soil mass. Can be broken by hand.
Extremely Weathered:	Saprolite. Mineral residue completely decomposed to soil but fabric and structure preserved.

HARDNESS

The following terms describe the resistance of a rock to indentation or scratching:

Very Hard:	Specimen breaks with difficulty after several "pinging" hammer blows. Example: Dense, fine grain volcanic rock
Hard:	Specimen breaks with some difficulty after several hammer blows. Example: Vesicular, vugular, coarse-grained rock
Medium Hard:	Specimen can be broked by one hammer blow. Cannot be scraped by knife. SPT may penetrate by ~25 blows per inch with bounce. Example: Porous rock such as clinker, cinder, and coral reef
Soft:	Can be indented by one hammer blow. Can be scraped or peeled by knife. SPT can penetrate by ~100 blows per foot. Example: Weathered rock, chalk-like coral reef
Very Soft:	Crumbles under hammer blow. Can be peeled and carved by knife. Can be indented by finger pressure. Example: Saprolite

Plate

A-0.3

LOG LEGEND FOR ROCK 8240-00.GPJ GEOLABS.GDT 8/7/21

BORING LOG NOTES:

1. For boring locations, see Sheet B-01.
2. The information presented in the logs of borings depict the subsurface conditions encountered at that specified location and at the time of the field exploration only. Variations of subsoil conditions from those depicted in logs of borings may occur between and beyond the borings.
3. The penetration resistance shown on the logs of borings indicate the number of blows required for the specific sampler type used. The blow counts may need to be factored to obtain the Standard Penetration Test (SPT) blow counts.
4. The data given is for general information only. Bidders shall examine the site and the boring data and draw their own conclusions therefrom as to the character of materials to be encountered. The Engineer will not assume responsibility for variations of subsoil quality or conditions other than at the boring locations shown at the time the borings were taken.

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SIGNATURE

EXP. DATE 4/30/2022

EXPIRATION DATE OF THE LICENSE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT OCEAN OUTFALL IMPROVEMENTS
LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM: BORING LOGS - 2

DESIGNED BY: AH   CHECKED BY: RL
DRAWN BY: KN   SECTION HEAD:
APPROVED: BRANCH HEAD:
CHIEF   DATE

JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

DRAWING B003   SHEET 8 OF 21

W:_CIVIL 3D PROJECTS\2010_057.000 ENV SAND ISLAND WWTP\01 CIVIL DRAWINGS\TITLE BLOCK.DWG 09/13/17 16:19 ecl

GEOLABS, INC.
Geotechnical Engineering

OUTFALL IMPROVEMENTS AND REHABILITATION
WAIANAE WASTEWATER TREATMENT PLANT (WWTP)
WAIANAE, OAHU, HAWAII

Log of Boring 1

Approximate Ground Surface Elevation (feet): 10 *

Other Tests	Moisture Content (%)	Dry Unit Weight (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
	10	108			44			SP-SM	Brownish tan SILTY SAND (CORALLINE) with some gravel (coralline), medium dense, moist (beach sand)
	11				15/5"				
	12	80			50/2"		5		Tan CORAL, medium hard to hard (coral formation)
Sieve - #200 = 38.6%	25				50		10	SM	Tan SILTY SAND (CORALLINE) with a little gravel (coralline), dense (coralline detritus)
Direct Shear Consol.	41	67			10		15		grades to loose
	31				16		20		grades to medium dense
	32	81			12		25		grades with a little cobbles (coralline), loose
									Whitish tan CORAL, medium hard (coral formation)
					25/2"		30		
	19	100			48		35		
									Boring terminated at 36.5 feet

* Elevations estimated from Shoreline Survey, Portion of Lualualei Beach Park by R.M. Towill Corporation received on March 22, 2021.

Latitude: 21.433022° N
Longitude: 158.184275° W

Date Started:	February 4, 2021	Water Level: ▽	7.8 ft. 02/04/2021 1032 HRS
Date Completed:	February 4, 2021		
Logged By:	D. Gremminger	Drill Rig:	CME-45C TRUCK
Total Depth:	36.5 feet	Drilling Method:	6" Hollow-Stem Auger
Work Order:	8240-00	Driving Energy:	140 lb. wt., 30 in. drop

GEOLABS, INC.
Geotechnical Engineering

OUTFALL IMPROVEMENTS AND REHABILITATION
WAIANAE WASTEWATER TREATMENT PLANT (WWTP)
WAIANAE, OAHU, HAWAII

Log of Boring 2

Approximate Ground Surface Elevation (feet): 9.5 *

Other Tests	Moisture Content (%)	Dry Unit Weight (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
Sieve - #200 = 7.8%	8	97			34			SP-SM	Tan SAND (CORALLINE) with some gravel (coralline) and a little silt, medium dense, moist (beach sand)
	6				31				grades to dense
	5	85			30/5"		5		Tan CORAL, medium hard to hard (coral formation)
	20				15/4"		10		
								SP-SM	Brownish tan GRAVELLY SAND (CORALLINE) with a little silt, loose to medium dense (coralline detritus)
	25	100			4/6" +10/0" Ref.		15		grades with some cobbles (coralline) locally
Sieve - #200 = 53.8%	48				4		20	ML	Brown SANDY SILT with a little gravel (coralline), soft (alluvium w/ coral debris)
								SM	Tan SILTY SAND (CORALLINE) with a little gravel (coralline), very loose (coralline detritus)
	27	72			5		25		
									Tan CORAL, medium hard (coral formation)
					20/2"		30		
					49		35	SP-SM	Whitish tan GRAVELLY SAND (CORALLINE) with a little silt, dense (coralline detritus)
									Boring terminated at 36.5 feet

Latitude: 21.433088° N
Longitude: 158.184339° W

Date Started:	February 4, 2021	Water Level: ▽	6.8 ft. 02/04/2021 1313 HRS
Date Completed:	February 4, 2021		
Logged By:	D. Gremminger	Drill Rig:	CME-45C TRUCK
Total Depth:	36.5 feet	Drilling Method:	6" Hollow-Stem Auger
Work Order:	8240-00	Driving Energy:	140 lb. wt., 30 in. drop

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE

EXP. DATE 4/30/2022
EXPIRATION DATE OF THE LICENSE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT OCEAN OUTFALL IMPROVEMENTS
LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM: BORING LOGS - 3

DESIGNED BY: AH   CHECKED BY: RL
DRAWN BY: KN   SECTION HEAD:
APPROVED: BRANCH HEAD:

CHIEF   DATE

JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

DRAWING B004   SHEET 9 OF 21

W:_CIVIL 3D PROJECTS\2010_057.000 ENV SAND ISLAND WWTP\01 CIVIL DRAWINGS\TITLE BLOCK.DWG 09/13/17 16:19 ecl

GEOLABS, INC.
Geotechnical Engineering

OUTFALL IMPROVEMENTS AND REHABILITATION
WAIANAE WASTEWATER TREATMENT PLANT (WWTP)
WAIANAE, OAHU, HAWAII

Log of Boring 3

Approximate Ground Surface Elevation (feet): 8 *

Other Tests	Moisture Content (%)	Dry Unit Weight (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen (tsf)	Depth (feet)	USCS	Description
	6	100			25/1"			SP-SM	Tan SAND (CORALLINE) with a little silt and traces of gravel, loose to medium dense, moist (beach sand)
Sieve - #200 = 6.6%	11				16				grades with a little cobbles (coralline) locally
	20	100			25/1"		5		Tan CORAL, medium hard (coral formation)
								GM	Tan SILTY GRAVEL (CORALLINE) with some sand (coralline), medium dense (coralline detritus)
	23				50/4"		10		grades with a little cobbles (coralline) locally
Direct Shear	23	104			5		15		grades to very loose locally
Sieve - #200 = 12.2%	22				10		20		
	24	94			25		25		
									Tan CORAL, medium hard (coral formation)
	19				25/1"		30		
	17				21		35		grades to soft
									Boring terminated at 36.5 feet

Latitude: 21.433308° N
Longitude: 158.18452° W

Date Started:	February 5, 2021	Water Level: ▼	7.3 ft. 02/04/2021 1122 HRS
Date Completed:	February 4, 2021		
Logged By:	B. Aiu	Drill Rig:	CME-45C TRUCK
Total Depth:	36.5 feet	Drilling Method:	6" Hollow-Stem Auger
Work Order:	8240-00	Driving Energy:	140 lb. wt., 30 in. drop

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SIGNATURE

EXP. DATE 4/30/2022
EXPIRATION DATE OF THE LICENSE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT
OCEAN OUTFALL IMPROVEMENTS
LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM:
BORING LOGS - 4

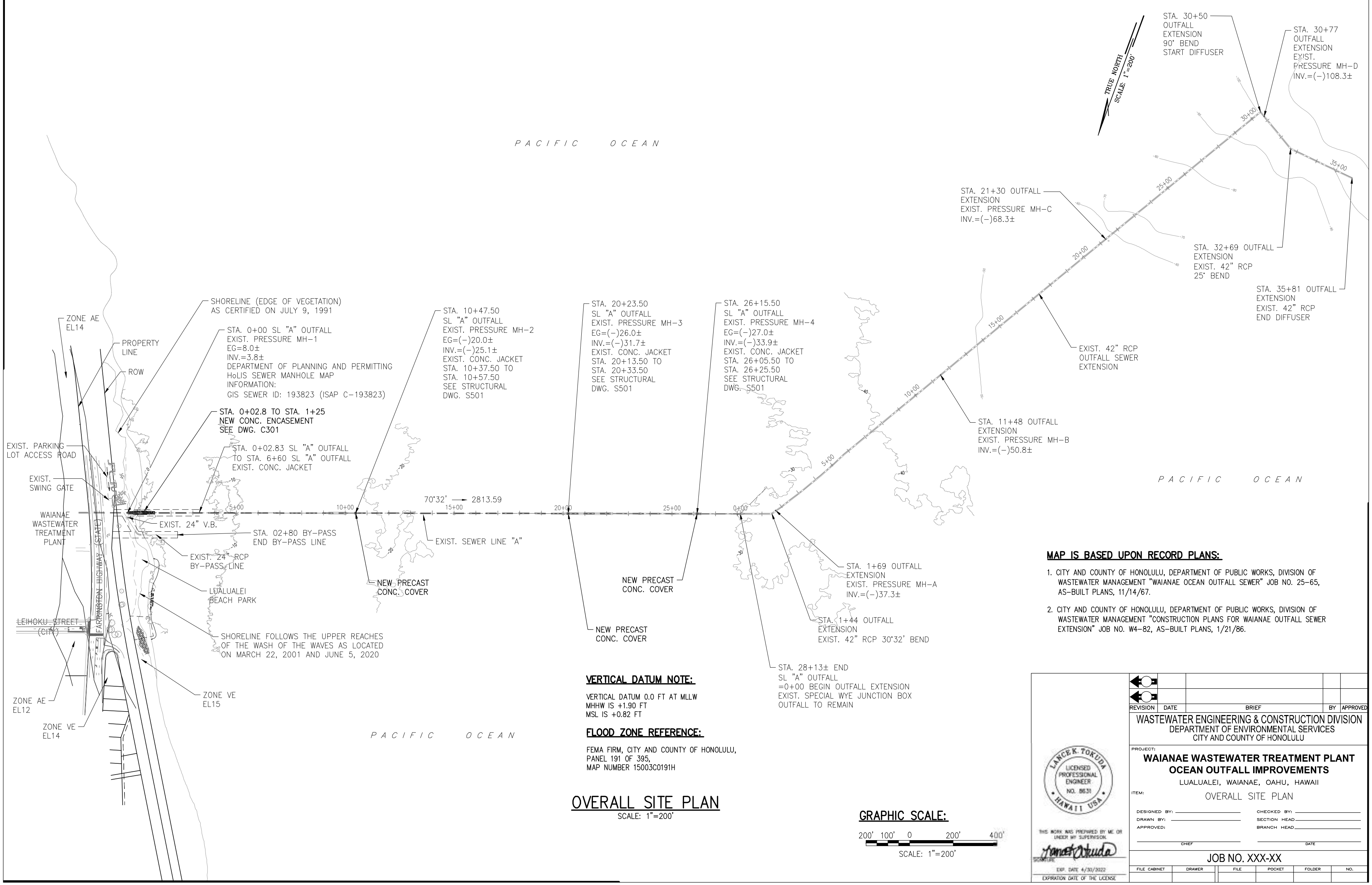
DESIGNED BY: AH
DRAWN BY: KN
APPROVED:
CHECKED BY: RL
SECTION HEAD:
BRANCH HEAD:
CHIEF
DATE

JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

DRAWING B005 SHEET 10 OF 21

W:_CIVIL 3D PROJECTS\2010_057.000 ENV SAND ISLAND WWTP\01 CIVIL DRAWINGS\TITLE BLOCK.DWG 09/13/17 16:19 ecl



W:_CIVIL 3D PROJECTS\2010_057.000 ENV SAND ISLAND WWTP\01 CIVIL DRAWINGS\TITLE BLOCK.DWG 09/13/17 16:19 ecl

MAP IS BASED UPON RECORD PLANS:

1. CITY AND COUNTY OF HONOLULU, DEPARTMENT OF PUBLIC WORKS, DIVISION OF WASTEWATER MANAGEMENT "WAIANAE OCEAN OUTFALL SEWER" JOB NO. 25-65, AS-BUILT PLANS, 11/14/67.
2. CITY AND COUNTY OF HONOLULU, DEPARTMENT OF PUBLIC WORKS, DIVISION OF WASTEWATER MANAGEMENT "CONSTRUCTION PLANS FOR WAIANAE OUTFALL SEWER EXTENSION" JOB NO. W4-82, AS-BUILT PLANS, 1/21/86.

VERTICAL DATUM NOTE:

VERTICAL DATUM 0.0 FT AT MLLW
MHHW IS +1.90 FT
MSL IS +0.82 FT

FLOOD ZONE REFERENCE:

FEMA FIRM, CITY AND COUNTY OF HONOLULU, PANEL 191 OF 395, MAP NUMBER 15003C0191H

OVERALL SITE PLAN

SCALE: 1"=200'

GRAPHIC SCALE:

200' 100' 0 200' 400'

SCALE: 1"=200'

LANCE K. TOKUDA LICENSED PROFESSIONAL ENGINEER NO. 8631 HAWAII USA

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SIGNATURE

EXP. DATE 4/30/2022
EXPIRATION DATE OF THE LICENSE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT OCEAN OUTFALL IMPROVEMENTS
LUALUALEI, WAIANAE, OAHU, HAWAII

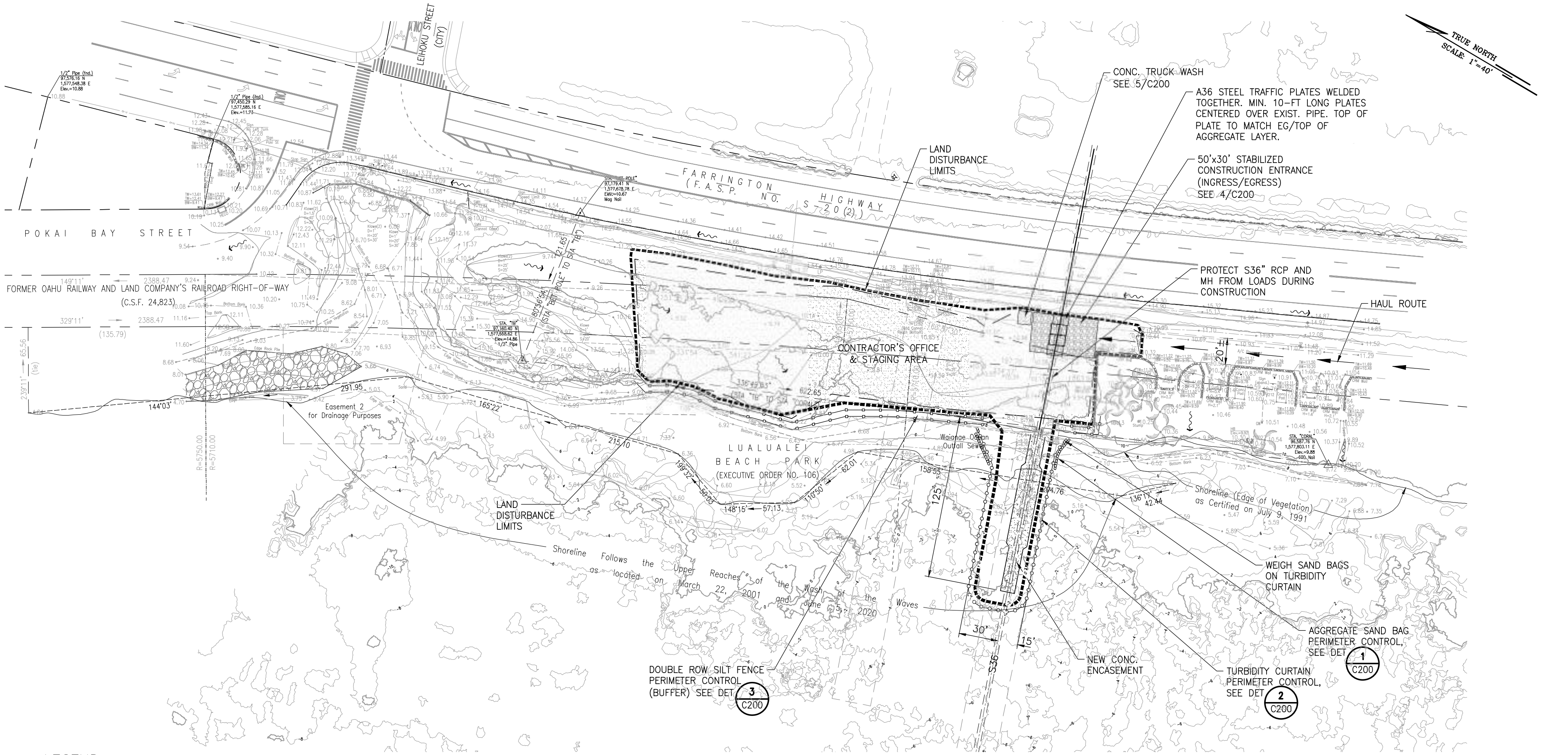
ITEM:
OVERALL SITE PLAN

DESIGNED BY: ____ CHECKED BY: ____
DRAWN BY: ____ SECTION HEAD ____
APPROVED: ____ BRANCH HEAD ____
CHIEF DATE

JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

DRAWING C101 SHEET 11 OF 21



LEGEND:

- DOUBLE ROW SILT FENCES 5' APART
- TURBIDITY CURTAIN
- AGGREGATE SAND BAG
- S36 — APPROXIMATE LOCATION OF EXISTING 36" SEWER LINE
- LAND DISTURBANCE LIMITS
- AGGREGATE CONSTRUCTION PAD (AREA TO BE STOCKPILED/DISTURBED)
- EXISTING FLOW DIRECTION
- EXISTING BOULDERS

EROSION AND SEDIMENT CONTROL PLAN

SCALE: 1"=40'

NOTES:

1. EROSION AND SEDIMENT CONTROL PLAN (ESCP) COORDINATOR MUST SUBMIT DESIGNATION FORM IN APPENDIX A RULES RELATING TO WATER QUALITY PRIOR TO PERMITTING.
2. CONTRACTOR SHALL LOCATE AND FIELD VERIFY EXISTING OUTFALL PIPELINE. CONTRACTOR SHALL PROTECT EXISTING OUTFALL PIPELINE WITH APPROPRIATE MEASURES TO PREVENT DAMAGE OF ANY KIND AT ALL LOCATIONS WHERE CONSTRUCTION ACTIVITY MAY AFFECT THE UTILITY.
3. SEE EROSION AND SEDIMENT CONTROL NOTES SHOWN ON DRAWINGS C003 AND C004.
4. SEE EARTHWORK QUANTITIES ON STRUCTURAL ENCASEMENT SECTIONS CUT AND FILL VOLUMES.

VERTICAL DATUM NOTE:

VERTICAL DATUM 0.0 FT AT MLLW
MHHW IS +1.90 FT
MSL IS +0.82 FT

GRAPHIC SCALE:

40' 20' 0 40' 80'

SCALE: 1"=40'

APPROVED:

CHIEF, CIVIL ENGINEERING BRANCH, DPP DATE

LANCE K. TOKUDA LICENSED PROFESSIONAL ENGINEER NO. 8631 HAWAII USA

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SIGNATURE

EXP. DATE 4/30/2022
EXPIRATION DATE OF THE LICENSE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT OCEAN OUTFALL IMPROVEMENTS
LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM: EROSION AND SEDIMENT CONTROL PLAN

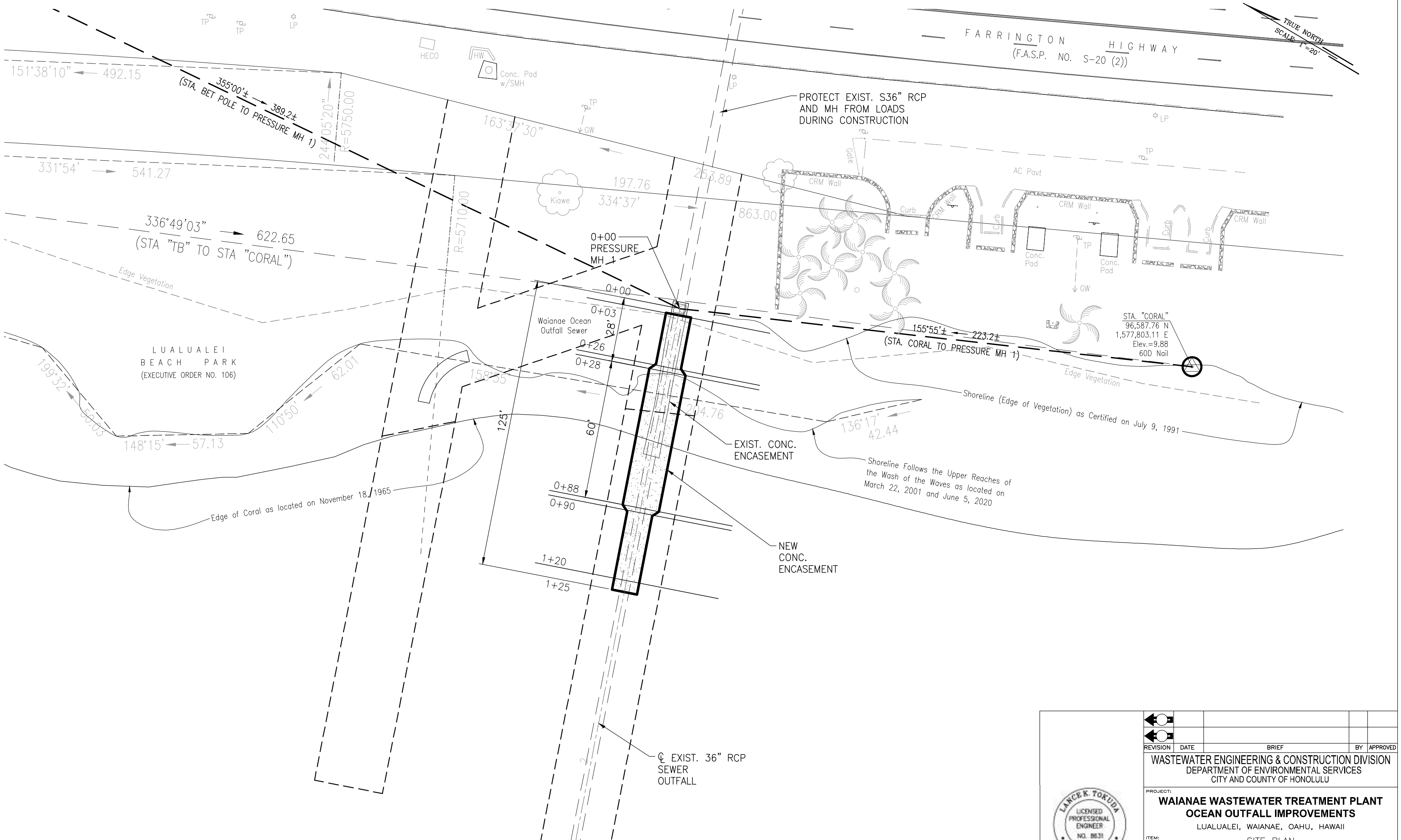
DESIGNED BY: CHECKED BY:
DRAWN BY: SECTION HEAD:
APPROVED: BRANCH HEAD:
CHIEF DATE

JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

DRAWING C102 SHEET 12 OF 21

W:_CIVIL 3D PROJECTS\2010_057.000 ENV SAND ISLAND WWTP\01 CIVIL DRAWINGS\TITLE BLOCK.DWG 09/13/17 16:19 ecl



SITE PLAN

SCALE: 1"=20'

VERTICAL DATUM NOTE:

VERTICAL DATUM 0.0 FT AT MLLW
MHHW IS +1.90 FT
MSL IS +0.82 FT

GRAPHIC SCALE:

20' 10' 0 20' 40'

SCALE: 1"=20'

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT
OCEAN OUTFALL IMPROVEMENTS
LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM: SITE PLAN

LANCE K. TOKUDA LICENSED PROFESSIONAL ENGINEER NO. 8631 HAWAII USA

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SIGNATURE

EXP. DATE 4/30/2022
EXPIRATION DATE OF THE LICENSE

DESIGNED BY:
DRAWN BY:
APPROVED:
CHIEF
CHECKED BY:
SECTION HEAD:
BRANCH HEAD:
DATE

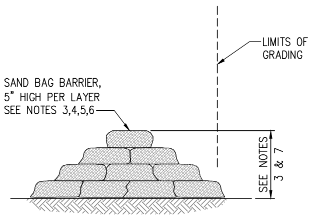
JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

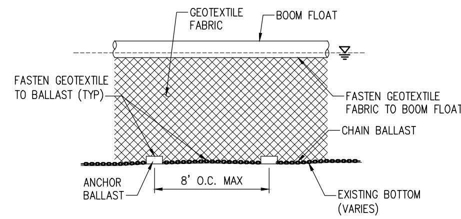
DRAWING C103 SHEET 13 OF 21

NOTES:

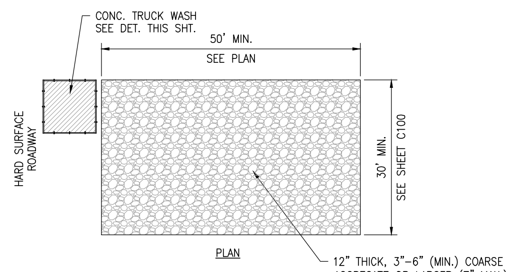
1. DRAINAGE AREA SHOULD NOT EXCEED 5 ACRES.
2. CONSTRUCT THE LENGTH OF EACH REACH SO THAT THE CHANGE IN BASE ELEVATION ALONG THE REACH DOES NOT EXCEED 1/2 HEIGHT OF THE LINEAR BARRIER. IN NO CASE SHALL THE REACH LENGTH EXCEED 500'.
3. STACK SANDBAGS AT LEAST THREE BAGS HIGH WITH PROPER SIDE SLOPES USING A PYRAMID APPROACH.
4. LOCATE SANDBAG BARRIERS ON A LEVEL CONTOUR.
   A. SLOPED BETWEEN 20:1 AND 2:1 (H:V): SANDBAGS SHOULD BE PLACED AT PLACED AT A MAXIMUM INTERVAL OF 50FT. (A CLOSER SPACING IS MORE EFFECTIVE), WITH THE FIRST ROW NEAR THE SLOPE TOE.
   B. SLOPES 2:1 (H:V) OR STEEPER: SANDBAGS SHOULD BE PLACED AT A MAXIMUM INTERVAL OF 25FT (A CLOSER SPACING IS MORE EFFECTIVE), WITH THE FIRST PLACED NEAR THE SLOPE TOE.
5. OVERLAP BUTT JOINTS OF ROW BENEATH WITH EACH SUCCESSIVE ROW.
6. THE END OF THE BARRIER SHALL BE TURNED UP SLOPE.
7. CROSS BARRIERS SHALL BE A MIN OF 1/2 AND A MAX OF 2/3 OF THE HEIGHT OF THE LINEAR BARRIER.
8. SANDBAG MATERIAL MUST CONFORM TO ASTM DESIGNATION D3788 AND ASTM DESIGNATION D4355.
9. EACH SAND-FILLED BAG SHOULD BE TYPICALLY 4" TO 5" HIGH BY 9" TO 10" WIDE BY 14" LONG AND WEIGH APPROXIMATELY 40 LBS BAG DIMENSION ARE NOMINAL, AND MAY VARY BASED ON LOCALLY AVAILABLE MATERIALS.
10. ALL SAND BAG FILL MATERIAL SHOULD BE NON-COHESIVE SOIL PERMEABLE MATERIAL FREE FROM CLAY AND DELETERIOUS MATERIAL.
11. ALTERNATIVE PRODUCTS MUST BE APPROVED BY ENGINEER.



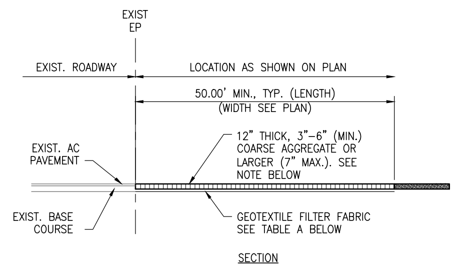
1 / C200 **AGGREGATE SAND BAG DETAIL**
SCALE: NOT TO SCALE



2 / C200 **TURBIDITY CONTAINMENT / SILT CURTAIN DETAIL**
SCALE: NOT TO SCALE

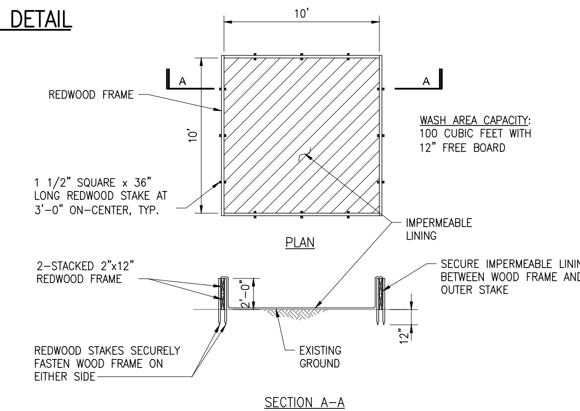


NOTE:
12" COARSE AGGREGATE LAYER SHALL BE REMOVED IMMEDIATELY PRIOR TO INSTALLATION OF ROADWAY BASE COURSE.



MINIMUM PHYSICAL REQUIREMENTS FOR PERMEABLE SEPARATOR	
PHYSICAL PROPERTY	REQUIREMENTS
GRAB TENSILE STRENGTH	180 LB (ASTM D 4632)
SEWN SEAM STRENGTH	160 LB (ASTM D 4884)
TRAPEZOID TEAR STRENGTH	75 LB (ASTM D 4533)
PUNCTURE RESISTANCE	80 LB (ASTM D4833)
PERMITTIVITY	0.02 SEC^{-1} (ASTM D 4491)
APPARENT OPENING SIZE	70-120 US SIEVE (ASTM D 4751)
ULTRAVIOLET DEGRADATION	50% AT 500 HOURS (ASTM D 4355)

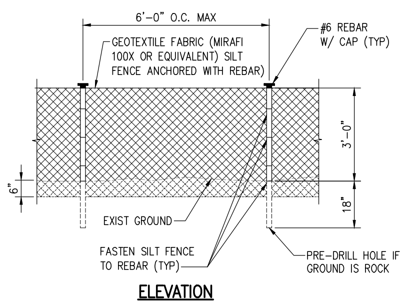
4 / C200 **STABILIZED CONSTRUCTION ENTRANCE (INGRESS/EGRESS) DETAIL**
SCALE: NOT TO SCALE

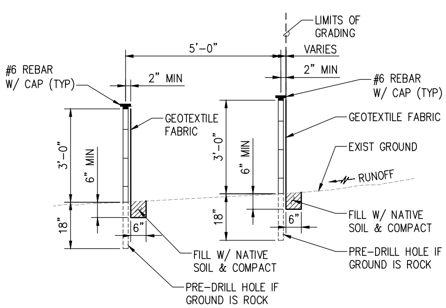


CONCRETE TRUCK WASH AREA NOTE:

CONCRETE WASH WATER WILL NOT BE ALLOWED TO OVERFLOW, AND WILL EITHER BE DISPOSED OF INTO AN APPROVED FACILITY IMMEDIATELY AFTER WASHING OPERATIONS, OR ALLOWED TO EVAPORATE AND THE REMAINDER REMOVED REGULARLY AND DISPOSED INTO AN APPROVED FACILITY TO AVOID BUILDUP OF CONCRETE MATERIAL WITHIN THE WASH AREA.

5 / C200 **CONCRETE TRUCK WASH AREA DETAIL**
SCALE: 1/4" = 1'-0"





3 / C200 **DOUBLE ROW SILT FENCES DETAIL**
SCALE: NOT TO SCALE

APPROVED:

CHIEF, CIVIL ENGINEERING BRANCH, DPP — DATE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT OCEAN OUTFALL IMPROVEMENTS
LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM:
EROSION AND SEDIMENT CONTROL DETAILS

DESIGNED BY: — CHECKED BY:
DRAWN BY: — SECTION HEAD:
APPROVED: — BRANCH HEAD:
CHIEF — DATE

LANCE K. TOKUDA — LICENSED PROFESSIONAL ENGINEER — NO. 8631 — HAWAII USA

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE

EXP. DATE 4/30/2022
EXPIRATION DATE OF THE LICENSE

JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

DRAWING C200 — SHEET 14 OF 21

W:_CIVIL 3D PROJECTS\2010_057.000 ENV SAND ISLAND WWTP\01 CIVIL DRAWINGS\TITLE BLOCK.DWG 09/13/17 16:19 ecl

GENERAL NOTES

A. SEE ALSO

1. SPECIFICATIONS AND OTHER CONTRACT DOCUMENTS.
2. SPECIAL NOTES ON DRAWINGS.

B. DISCREPANCIES - CONTRACTOR SHALL VERIFY ALL DIMENSIONS AND CONDITIONS AND SHALL REPORT ANY DISCREPANCIES IN WRITING TO THE OFFICER-IN-CHARGE BEFORE COMMENCING WORK OR ORDERING MATERIALS.

C. ALL MATERIALS AND WORKMANSHIP SHALL CONFORM TO THE REQUIREMENTS OF THE 2012 IBC INTERNATIONAL BUILDING CODE, AS AMENDED BY HAWAII STATE BUILDING CODE, 2012 EDITION.

D. DETAILS SHOWN ON DRAWING SHALL BE TYPICAL FOR ALL SIMILAR CONDITIONS. MODIFY DETAILS FOR SPECIAL CONDITIONS AS DIRECTED BY THE OFFICER-IN-CHARGE.

CONSTRUCTION NOTES

A. THE CONTRACTOR SHALL NOTIFY THE OFFICER-IN-CHRAGE AT LEAST 48 HOURS IN ADVANCE FOR REVIEW AND OBSERVATION OF EXCAVATIONS, REINFORCING, AND CONCRETE POURS.

B. CONSTRUCTION LOADING SHALL NOT EXCEED THE DESIGN LIVE LOAD UNLESS SPECIAL SHORING IS PROVIDED. ALLOWABLE LOADS SHALL BE REDUCED IN AREAS WHERE THE STRUCTURE HAS NOT ATTAINED ITS FULL DESIGN STRENGTH.

C. FORM AND SHORE REMOVAL:

1. FORMS AND SHORE REMOVAL SHALL NOT INJURE OR OVERSTRESS COMPLETED OR PARTIALLY COMPLETED STRUCTURAL ELEMENTS. TIMING OF FORM AND SHORE REMOVAL SHALL BE IN ACCORDANCE WITH ACI-347.

D. THE CONTRACTOR SHALL PERFORM A CONSULTATION WITH DLNR-DAR AND PERFORM A PRE-CONSTRUCTION CORAL SURVEY PRIOR TO ANCHORING BARGES AND INSTALLING THE NEW PRECAST CONCRETE CAPS.

E. THE CONTRACTOR SHALL USE CAUTION TO AVOID DAMAGING EXISTING LIVE CORAL. LIVE CORAL SHALL BE LOCATED AND PROPERLY RELOCATED BEFORE CONSTRUCTION CAN OCCUR.

CONCRETE NOTES

A. ALL CONCRETE SHALL DEVELOP A MINIMUM ULTIMATE COMPRESSIVE STRENGTH, f'c, OF 5000 PSI UNLESS NOTED OTHERWISE. ALL CONCRETE SHALL HAVE A MAXIMUM SIZE AGGREGATE OF 3/4" AND A MAXIMUM WATER TO CEMENT RATIO OF 0.40.

B. PROVIDE ANTI-WASHOUT ADMIXTURE MEETING THE REQUIREMENTS OF U.S. ARMY CORPS OF ENGINEERS CRD-C661-06. ANTI-WASHOUT ADMIXTURE DOSAGE SHALL FOLLOW THE MANUFACTURERS WRITTEN INSTRUCTIONS.

C. USE OF ADMIXTURE AT CONTRACTOR'S OPTION, BUT SUBJECT TO THE OFFICER-IN-CHARGE'S APPROVAL. WHERE MORE THAN ONE TYPE OF ADMIXTURE IS UTILIZED IN ANY MIX, THE ADMIXTURES SHALL BE COMPATIBLE WITH EACH OTHER AS CERTIFIED IN WRITING BY EACH ADMIXTURE MANUFACTURER.

1. AIR ENTRAINING ADMIXTURE: ASTM C260
2. WATER-REDUCING ADMIXTURE: ASTM C494, TYPE A
3. RETARDING ADMIXTURE: ASTM C494, TYPE B
4. HIGH RANGE WATER REDUCING ADMIXTURE: ASTM C494, TYPE F OR TYPE G.

D. THE USE OF ANY CALCIUM CHLORIDE IN ANY CONCRETE IS PROHIBITED.

GLASS FIBER REINFORCED POLYMER REINFORCING NOTES

A. AL REINFORCING BARS, INCLUDING STRAIGHT BARS, DOWELS, AND BAR BENDS, USED IN CONCRETE CONSTRUCTION SHALL BE ASTM D7205 GLASS FIBER REINFORCED POLYMER (GFRP) REINFORCING, GRADE F60

B. LAP SPLICES OF GFRP BARS AS FOLLOWS:

1. LENGTHS SHALL BE 48 BAR DIAMETERS OR 2'-0" WHICHEVER IS GREATER, UNLESS OTHERWISE SHOWN.

2. BENT BARS SHALL USE A SPLICE LENGTH OF 2'-6".

C. ALL CHAIRS AND TIE WIRE USED WITH GLASS FIBER REINFORCED POLYMER REBAR SHALL BE NON-METALLIC.

D. FIELD BENDING OF ANY GFRP BARS IS PROHIBITED.

E. MINIMUM CONCRETE CLEAR COVER (FOR CAST-IN-PLACE):.................................3"

F. MINIMUM CONCRETE CLEAR COVER (FOR PRECAST):...2"

PRECAST CONCRETE NOTES

A. MINIMUM 28 DAY COMPRESSIVE STRENGTHS SHALL BE 5,000 PSI.

B. UNLESS SHOWN OTHERWISE, MATERIAL AND WORKMANSHIP SHALL CONFORM TO THE LATEST RECOMMENDATIONS OF THE PRECAST CONCRETE INSTITUTE AND THE AMERICAN CONCRETE INSTITUTE.

C. THE USE OF CALCIUM CHLORIDE IN ANY PRESTRESSED CONCRETE IS PROHIBITED.

D. ALL PRECAST CONCRETE MEMBERS SHALL BE SUBJECT TO REJECTIONS BY THE OFFICER-IN-CHARGE UNLESS THEY CONFORM TO THE MANUFACTURING TOLERANCES SHOWN IN THE SPECIFICATIONS.

E. THE CONTRACTOR SHALL SUBMIT SHOP DRAWINGS SHOWING TYPES AND LOCATION OF ALL REINFORCEMENT, SIZE AND SPACING, TYPE AND LOCATION OF ALL ANCHORAGE DEVICES, GROUT AND JOINT SEALANT DETAILS.

F. GROUT SHALL CONFORM TO ASTM C109 AND ASTM 1107 WITH A MINIMUM STRENGTH OF 7000 PSI AT 28 DAYS. THE GROUT SHALL BE A COMMERIAL FORMULATION SUITABLE FOR THE APPLICATION PROPOSED.

PRECAST CONCRETE MANHOLE CAP NOTES

A. REMOVE EXISTING MARINE GROWTH, DEBRIS, SAND, AND OTHER DELETERIOUS MATERIALS TO EXPOSE EXISTING CONCRETE SURFACES AND PRESSURIZED CAST IRON MANHOLE FRAME COVER TO RECEIVE NEW PRECAST CONCRETE MANHOLE CAP, GROUT AND CONNECTION PLATES. THE CONTRACTOR SHALL NOTIFY THE OFFICER-IN-CHARGE IF ANY LIVE CORAL IS ENCOUNTERED. LIVE CORAL SHALL BE PROPERLY RELOCATED BEFORE CONSTRUCTION CAN RESUME. EXISTING LIVE CORAL SHALL NOT BE DAMAGED.

B. PROVIDE A CLEAN AND LEVEL CONCRETE SURFACE AT LOCATIONS TO RECEIVE NEW PRECAST CONCRETE MANHOLE CAP. SCARIFY EXISTING CONCRETE SURFACE TO 1/4" MAX AMPLITUDE. PROVIDE BONDING AGENT AT EXISTING CONCRETE AND NEW PRECAST CONCRETE CAP INTERFACE SUITABLE FOR MARINE ENVIRONMENTS. PROVIDE A GASKET AT THE INNER WALL OF THE PRECAST MANHOLE CAP TO PREVENT LEAKING OF FRESH GROUT. SUBMIT BONDING AGENT AND GASKET PRODUCT INFORMATION TO THE OFFICER-IN-CHARGE FOR APPROVAL.

C. THE CONTRACTOR SHALL USE CAUTION TO PREVENT DAMAGE TO THE EXISTING CAST IRON MANHOLE COVER AND RISER ASSEMBLY WHILE PREPARING SURFACE AND DURING PRECAST CAP INSTALLATION. THE OFFICER-IN-CHARGE SHALL BE NOTIFIED IMMEDIATELY OF ANY DAMAGE OR LEAKAGE OF EFFLUENT NOTED DURING CONSTRUCTION.

D. THE CONTRACTOR SHALL DETERMINE THE SIZE AND QUANTITY OF GROUT AND VENT PORTS REQUIRED TO ENSURE THAT THE PRECAST MANHOLE CAP IS COMPLETELY FILLED WITH GROUT. THE CONTRACTOR SHALL SUBMIT FOR APPROVAL THE SIZE AND QUANTITY OF GROUT AND VENT PORTS IN THE PRECAST MANHOLE CAP SHOP DRAWINGS.

E. THE CONTRACTOR SHALL DETERMINE AN APPROPRIATE GASKET MATERIAL, SIZE AND COMPOSITION. THE GASKET MATERIAL SHALL BE CAPABLE OF COMPRESSING OR EXPANDING TO SEAL DISCONTINUITIES ON THE BOTTOM SURFACE OF UP TO 3 INCHES, AND SHALL PREVENT LEAKAGE OF GROUT FROM BENEATH THE PRECAST MANHOLE CAP AT ALL TIMES. THE CONTRACTOR SHALL SUBMIT GASKET SPECIFICATIONS TO THE OFFICER-IN-CHARGE FOR REVIEW AND APPROVAL PRIOR TO INSTALLATION.

STAINLESS STEEL NOTES

A. UNLESS OTHERWISE NOTED, ALL STAINLESS STEEL MEMBERS, SHALL CONFORM TO THE FOLLOWING.

1. PLATES: ASTM A240, TYPE 316L (Fy = 25 KSI)
2. BOLTS: ASTM F593, TYPE S316L (Fy = 60 KSI)

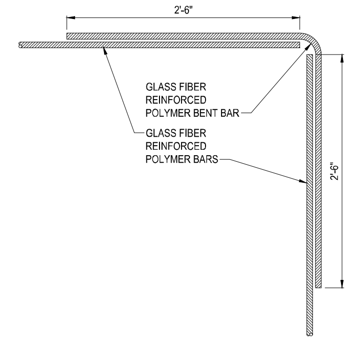
B. UNLESS SHOWN OTHERWISE, ALL STAINLESS STEEL AT A MINIMUM SHALL BE TYPE S316L.

DESIGN CODES AND STANDARDS

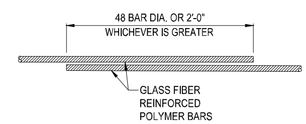
IBC 2012	-	INTERNATIONAL BUILDING CODE, 2012 EDITION AS AMENDED BY THE HAWAII STATE BUILDING CODE, 2012 EDITION.
ASCE 7-10	-	AMERICAN SOCIETY OF CIVIL ENGINEERS, MINIMUM DESIGN LOADS FOR BUILDINGS AND OTHER STRUCTURES.
ACI 318-11	-	AMERICAN CONCRETE INSTITUTE, BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE.
ACI 440.1R	-	AMERICAN CONCRETE INSTITUTE, GUIDE FOR THE DESIGN AND CONSTRUCTION OF CONCRETE REINFORCED WITH FRP BARS
ACI 357.3-14	-	AMERICAN CONCRETE INSTITUTE, GUIDE FOR DESIGN AND CONSTRUCTION OF WATERFRONT AND COASTAL CONCRETE MARINE STRUCTURES
MNL-120-10	-	PRECAST/PRESTRESSED CONCRETE INSTITUTE DESIGN HANDBOOK, 2010 EDITION

ABBREVIATIONS

APPROX.	-	APPROXIMATE	MIN.	-	MINIMUM
CONC.	-	CONCRETE	O.C.	-	ON CENTER
DIA.	-	DIAMETER	RCP	-	REINFORCED CONCRETE PIPE
EXIST.	-	EXISTING			
E.W.	-	EACH WAY	SS	-	STAINLESS STEEL
GFRP	-	GLASS FIBER REINFORCED POLYMER	THK	-	THICK
			TYP.	-	TYPICAL
M.H.	-	MANHOLE			



1 S001 **GFRP SPLICE DETAIL**
SCALE: 1 1/2" = 1'-0"



2 S001 **GFRP SPLICE DETAIL**
SCALE: 1 1/2" = 1'-0"

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT OCEAN OUTFALL IMPROVEMENTS

LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM: STRUCTURAL NOTES

BENNETT Y. FUNG LICENSED PROFESSIONAL ENGINEER NO. 6293-S HAWAII USA

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

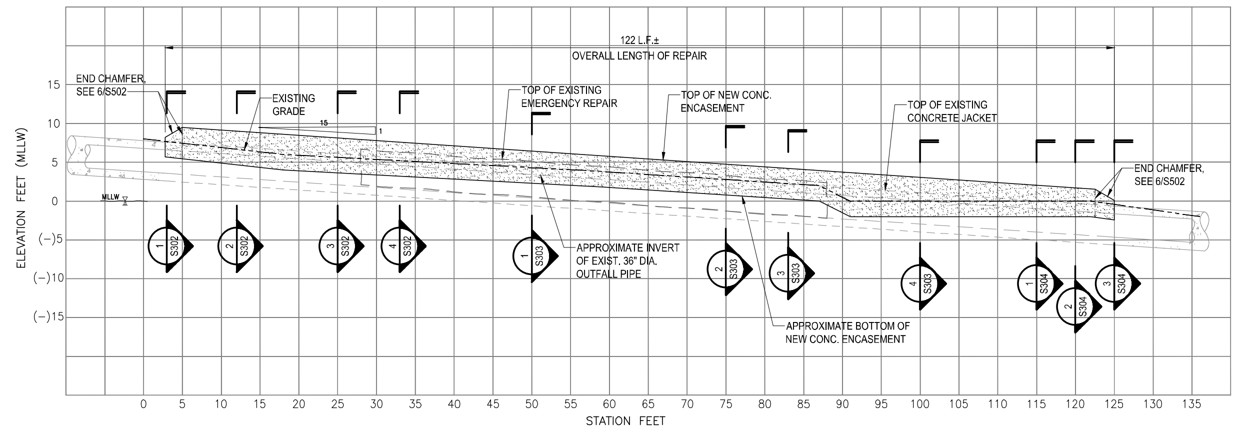
SIGNATURE

EXPIRATION DATE OF THE LICENSE

DESIGNED BY: ____ CHECKED BY: ____
DRAWN BY: ____ SECTION HEAD ____
APPROVED: ____ BRANCH HEAD ____
CHIEF DATE

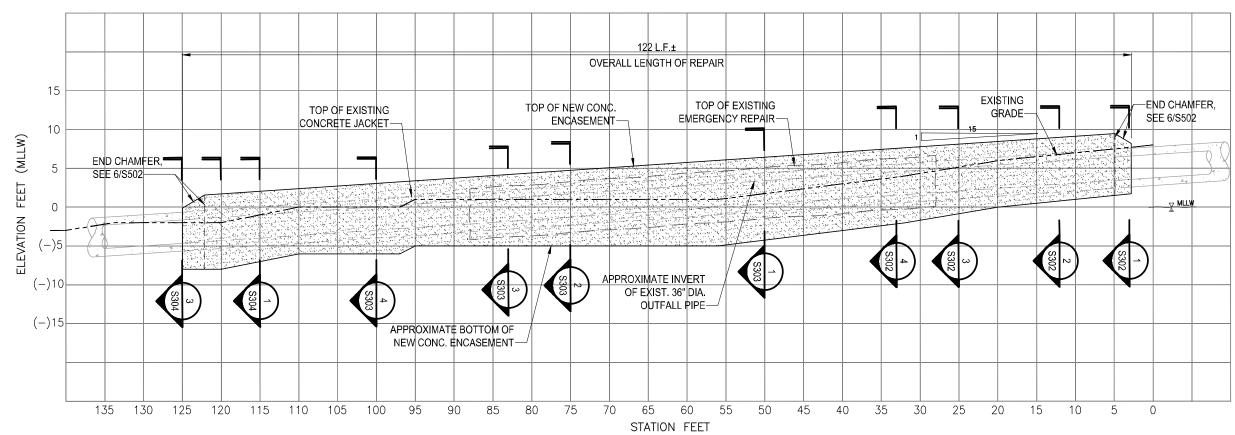
JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.



1/S301 NEW CONCRETE ENCASEMENT NORTH PROFILE VIEW

SCALE: 1/8" = 1'-0"



2/S301 NEW CONCRETE ENCASEMENT SOUTH PROFILE VIEW

SCALE: 1/8" = 1'-0"

6" 0 1' 3' 5' 8'
SCALE: 1/4" = 1'-0"

0 1' 2' 4' 6' 10' 14' 22'
SCALE: 1/8" = 1'-0"

BENNETT Y. FUNG
LICENSED PROFESSIONAL ENGINEER
NO. 6293-S
HAWAII USA

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE

EXPIRATION DATE OF THE LICENSE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT
OCEAN OUTFALL IMPROVEMENTS

LUALUALEI, WAIANAE, OAHU, HAWAII

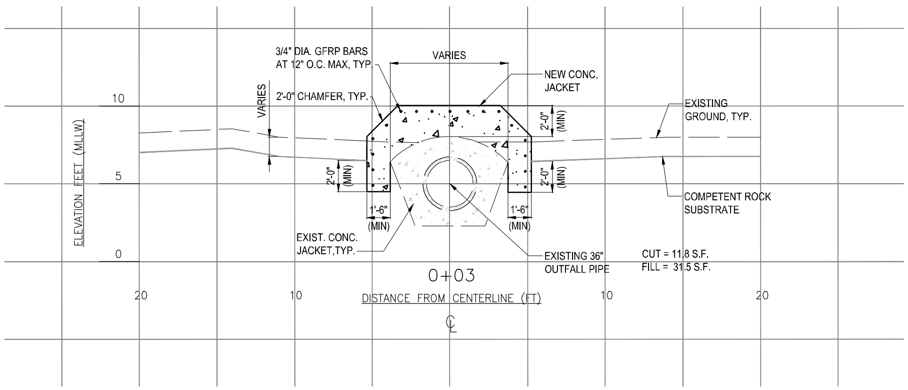
ITEM:
CONCRETE ENCASEMENT PROFILES

DESIGNED BY: ________ CHECKED BY: ________
DRAWN BY: ________ SECTION HEAD: ________
APPROVED: ________ BRANCH HEAD: ________

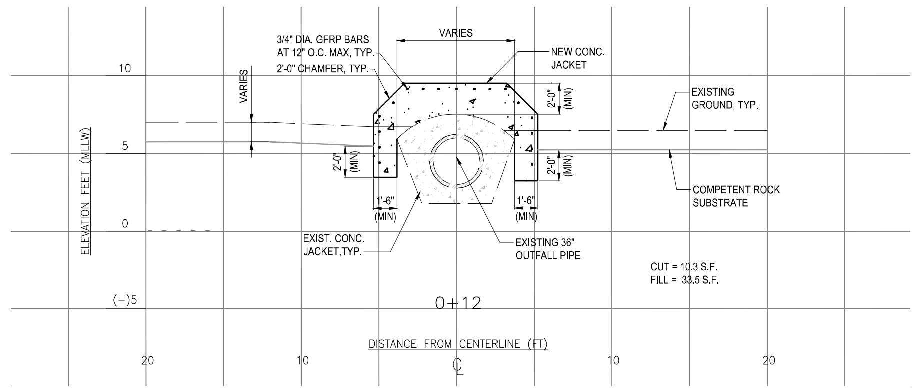
CHIEF DATE

JOB NO. XXX-XX

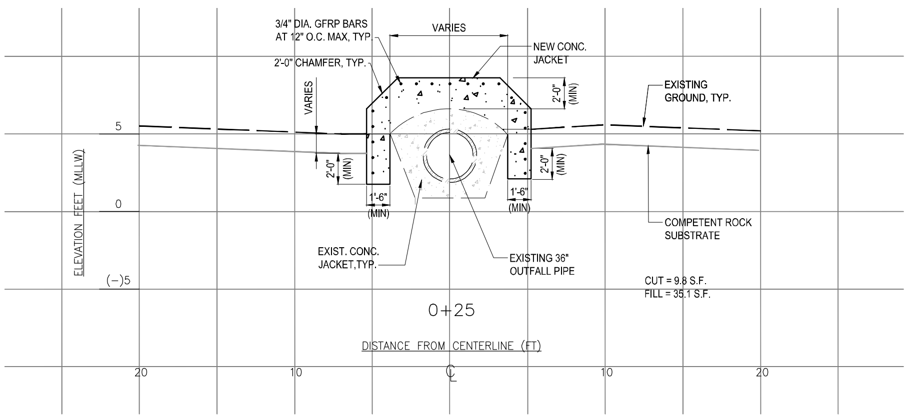
FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.



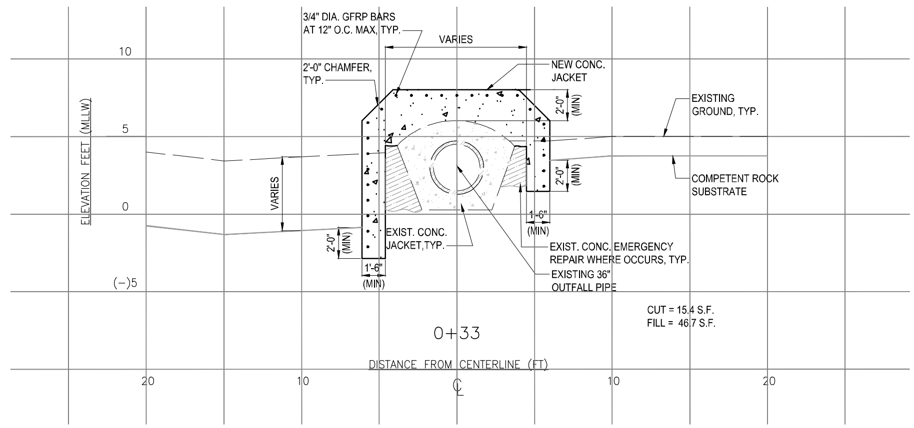
1 S302 NEW CONCRETE ENCASEMENT SECTION VIEW
SCALE: 1/4" = 1'-0"



2 S302 NEW CONCRETE ENCASEMENT SECTION VIEW
SCALE: 1/4" = 1'-0"



3 S302 NEW CONCRETE ENCASEMENT SECTION VIEW
SCALE: 1/4" = 1'-0"



4 S302 NEW CONCRETE ENCASEMENT SECTION VIEW
SCALE: 1/4" = 1'-0"

APPROVED:

CHIEF, CIVIL ENGINEERING BRANCH, D.P.P. DATE

NOTE:

1. LOCATION OF COMPETENT ROCK SUBSTRATE IS REPRESENTATIVE. THE CONTRACTOR SHALL DETERMINE THE EXACT LOCATION OF COMPETENT ROCK SUBSTRATE BELOW THE EXISTING GROUND. THE NEW CONCRETE ENCASEMENT SHALL BE EMBEDDED A MINIMUM OF 2'-0" INTO THE EXISTING COMPETENT ROCK SUBSTRATE.

6" 0 1' 3' 5' 8'
SCALE: 1/4" = 1'-0"

BENNETT Y. FUNG
LICENSED PROFESSIONAL ENGINEER
NO. 6293-S
HAWAII USA

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE

EXPIRATION DATE OF THE LICENSE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT OCEAN OUTFALL IMPROVEMENTS

LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM: CONCRETE ENCASEMENT SECTIONS

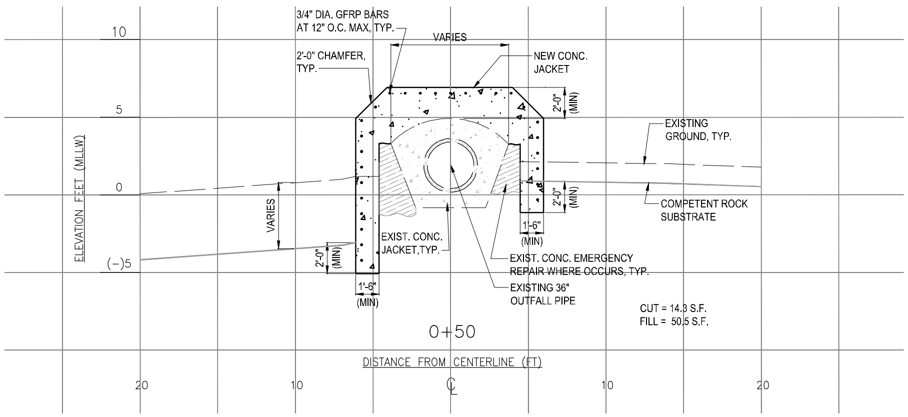
DESIGNED BY: ______ CHECKED BY: ______
DRAWN BY: ______ SECTION HEAD ______
APPROVED: BRANCH HEAD ______

CHIEF DATE

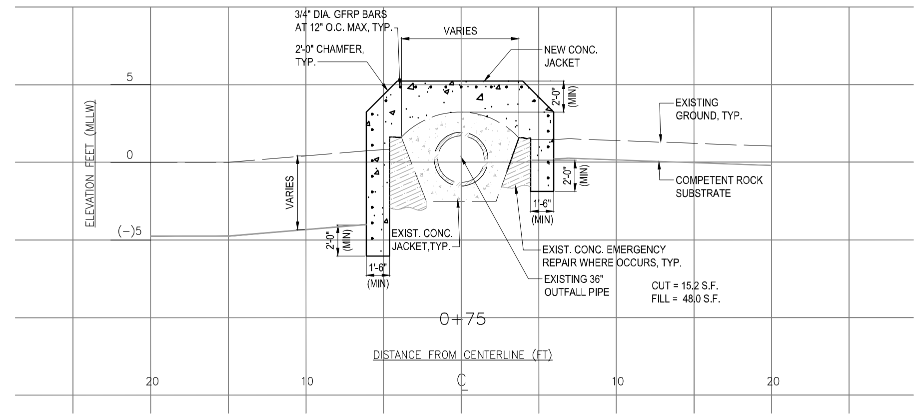
JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

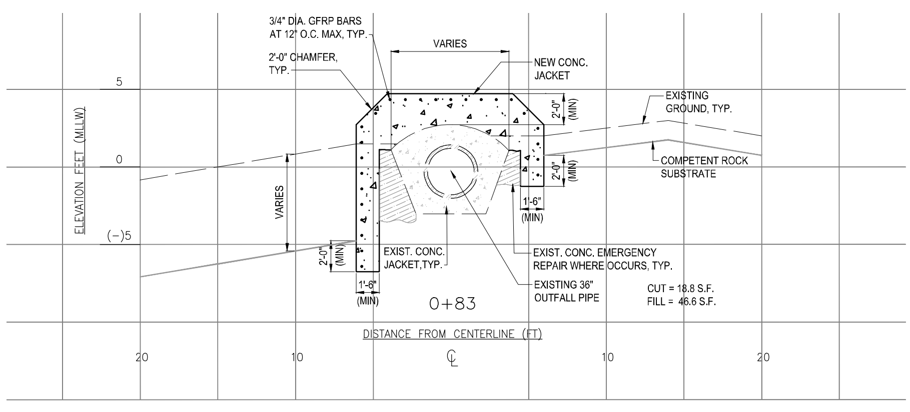
DRAWING S302 SHEET 14 OF 18



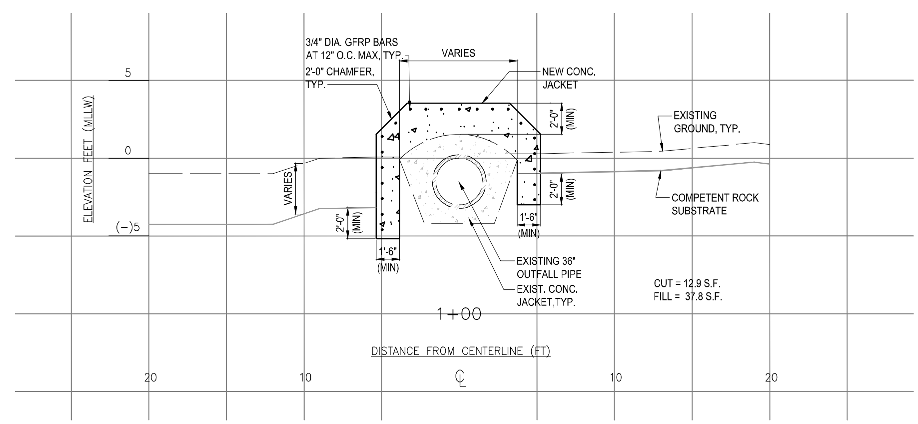
1 S303 NEW CONCRETE ENCASEMENT SECTION VIEW
SCALE: 1/4" = 1'-0"



2 S303 NEW CONCRETE ENCASEMENT SECTION VIEW
SCALE: 1/4" = 1'-0"



3 S303 NEW CONCRETE ENCASEMENT SECTION VIEW
SCALE: 1/4" = 1'-0"



4 S303 NEW CONCRETE ENCASEMENT SECTION VIEW
SCALE: 1/4" = 1'-0"

APPROVED:

CHIEF, CIVIL ENGINEERING BRANCH, D.P.P. DATE

NOTE:

1. LOCATION OF COMPETENT ROCK SUBSTRATE IS REPRESENTATIVE. THE CONTRACTOR SHALL DETERMINE THE EXACT LOCATION OF COMPETENT ROCK SUBSTRATE BELOW THE EXISTING GROUND. THE NEW CONCRETE ENCASEMENT SHALL BE EMBEDDED A MINIMUM OF 2'-0" INTO THE EXISTING COMPETENT ROCK SUBSTRATE.

6" 0 1' 3' 5' 8'
SCALE: 1/4" = 1'-0"

BENNETT Y. FUNG
LICENSED PROFESSIONAL ENGINEER
NO. 6293-S
HAWAII USA

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE

EXPIRATION DATE OF THE LICENSE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT OCEAN OUTFALL IMPROVEMENTS

LUALUALEI, WAIANAE, OAHU, HAWAII

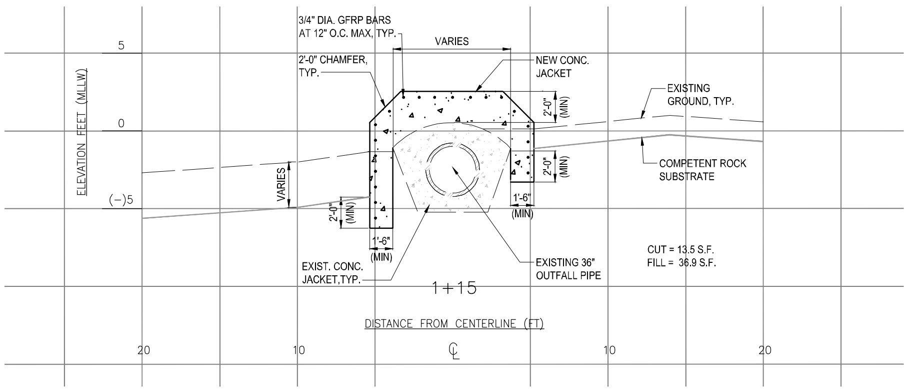
ITEM: CONCRETE ENCASEMENT SECTIONS

DESIGNED BY: CHECKED BY:
DRAWN BY: SECTION HEAD:
APPROVED: BRANCH HEAD:
CHIEF DATE

JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

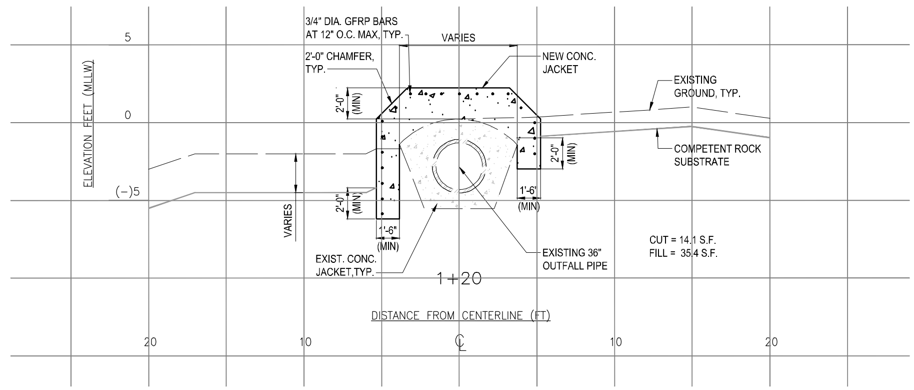
DRAWING S303 SHEET 15 OF 18



1 NEW CONCRETE ENCASEMENT SECTION VIEW

S304

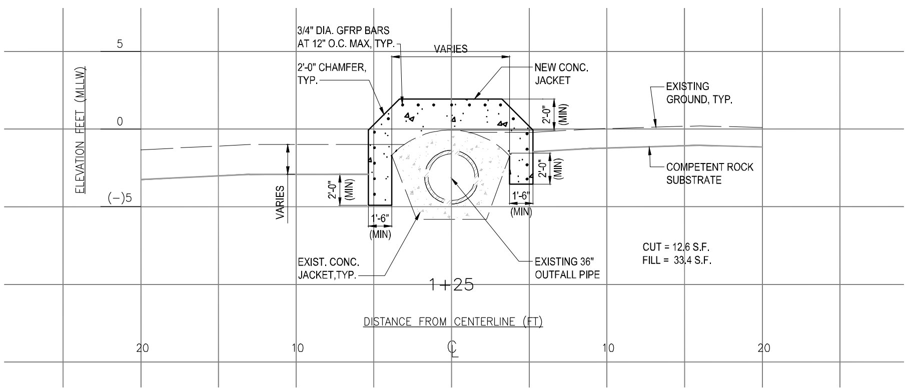
SCALE: 1/4" = 1'-0"



2 NEW CONCRETE ENCASEMENT SECTION VIEW

S304

SCALE: 1/4" = 1'-0"



3 NEW CONCRETE ENCASEMENT SECTION VIEW

S304

SCALE: 1/4" = 1'-0"

APPROVED:

CHIEF, CIVIL ENGINEERING BRANCH, D.P.P. DATE

NOTE:

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6" 0 1' 3' 5' 8'

SCALE: 1/4" = 1'-0"

BENNETT Y. FUNG
LICENSED PROFESSIONAL ENGINEER
NO. 6293-S
HAWAII USA

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WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

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WAIANAE WASTEWATER TREATMENT PLANT
OCEAN OUTFALL IMPROVEMENTS

LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM: CONCRETE ENCASEMENT SECTIONS

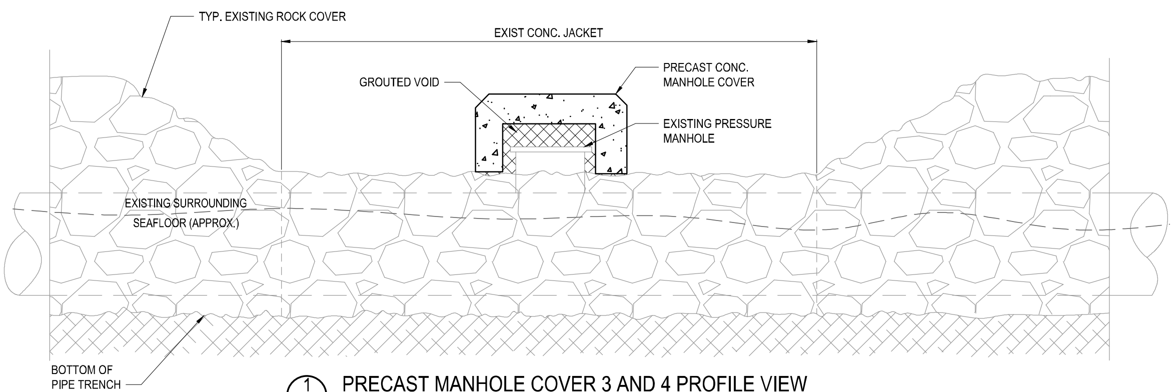
DESIGNED BY: CHECKED BY:
DRAWN BY: SECTION HEAD:
APPROVED: BRANCH HEAD:

CHIEF DATE

JOB NO. XXX-XX

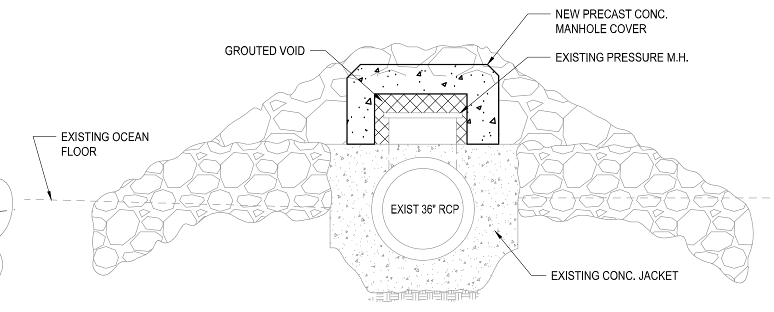
FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

DRAWING S304 SHEET 16 OF 18



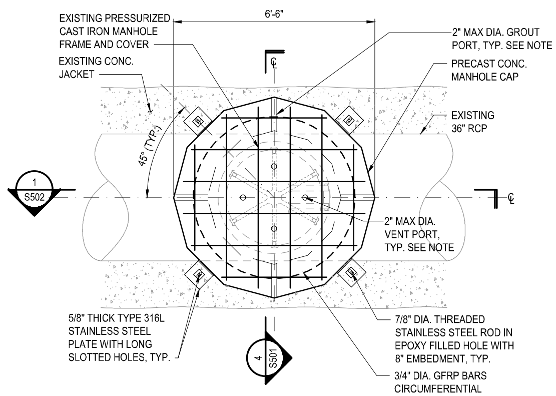
1 S501 PRECAST MANHOLE COVER 3 AND 4 PROFILE VIEW

SCALE: 3/8" = 1'-0"



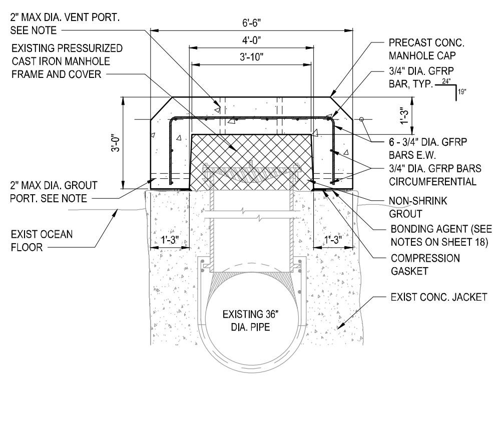
2 S501 PRECAST MANHOLE COVER 3 AND 4 SECTION VIEW

SCALE: 3/8" = 1'-0"



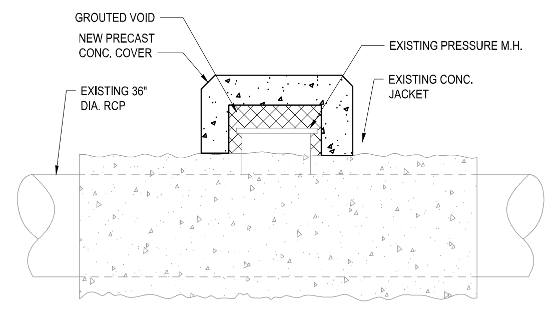
3 S501 PRECAST MANHOLE COVER DETAIL

SCALE: 1/2" = 1'-0"



4 S501 PRECAST MANHOLE COVER 2, 3, AND 4 DETAIL

SCALE: 1/2" = 1'-0"



5 S501 PRECAST MANHOLE COVER 2 PROFILE VIEW

SCALE: 3/8" = 1'-0"

NOTES:

1. REMOVE EXISTING MARINE GROWTH, DEBRIS, SAND, AND OTHER DELETERIOUS MATERIALS TO EXPOSE EXISTING CONCRETE SURFACES AND PRESSURIZED CAST IRON MANHOLE FRAME COVER TO RECEIVE NEW PRECAST CONCRETE MANHOLE CAP, GROUT AND CONNECTION PLATES. THE CONTRACTOR SHALL NOTIFY THE OFFICER-IN-CHARGE IF ANY LIVE CORAL IS ENCOUNTERED. LIVE CORAL SHALL BE PROPERLY RELOCATED BEFORE CONSTRUCTION CAN RESUME. EXISTING LIVE CORAL SHALL NOT BE DAMAGED.

2. PROVIDE A CLEAN AND LEVEL CONCRETE SURFACE AT LOCATIONS TO RECEIVE NEW PRECAST CONCRETE MANHOLE CAP. SCARIFY EXISTING CONCRETE SURFACE TO 1/4" MAX AMPLITUDE. PROVIDE BONDING AGENT AT EXISTING CONCRETE AND NEW PRECAST CONCRETE CAP INTERFACE SUITABLE FOR MARINE ENVIRONMENTS. PROVIDE A GASKET AT THE INNER WALL OF THE PRECAST MANHOLE CAP TO PREVENT LEAKING OF FRESH GROUT. SUBMIT BONDING AGENT AND GASKET PRODUCT INFORMATION TO THE OFFICER-IN-CHARGE FOR APPROVAL.

3. THE CONTRACTOR SHALL USE CAUTION TO PREVENT DAMAGE TO THE EXISTING CAST IRON MANHOLE COVER AND RISER ASSEMBLY WHILE PREPARING SURFACE AND DURING PRECAST CAP INSTALLATION. THE OFFICER-IN-CHARGE SHALL BE NOTIFIED IMMEDIATELY OF ANY DAMAGE OR LEAKAGE OF EFFLUENT NOTED DURING CONSTRUCTION.

4. THE CONTRACTOR SHALL DETERMINE THE SIZE AND QUANTITY OF GROUT AND VENT PORTS REQUIRED TO ENSURE THAT THE PRECAST MANHOLE CAP IS COMPLETELY FILLED WITH GROUT. THE CONTRACTOR SHALL SUBMIT FOR APPROVAL THE SIZE AND QUANTITY OF GROUT AND VENT PORTS IN THE PRECAST MANHOLE CAP SHOP DRAWINGS.

5. THE CONTRACTOR SHALL DETERMINE AN APPROPRIATE GASKET MATERIAL, SIZE AND COMPOSITION. THE GASKET MATERIAL SHALL BE CAPABLE OF COMPRESSING OR EXPANDING TO SEAL DISCONTINUITIES ON THE BOTTOM SURFACE OF UP TO 3 INCHES, AND SHALL PREVENT LEAKAGE OF GROUT FROM BENEATH THE PRECAST MANHOLE CAP AT ALL TIMES. THE CONTRACTOR SHALL SUBMIT GASKET SPECIFICATIONS TO THE OFFICER-IN-CHARGE FOR REVIEW AND APPROVAL PRIOR TO INSTALLATION.

1' 6" 0 1' 2' 3' 4'

SCALE: 3/8" = 1'-0"

1' 6" 0 1' 2' 3' 4' 5'

SCALE: 1/2" = 1'-0"

BENNETT Y. FUNG
LICENSED PROFESSIONAL ENGINEER
NO. 6293-S
HAWAII, USA

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE

EXPIRATION DATE OF THE LICENSE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:

WAIANAE WASTEWATER TREATMENT PLANT
OCEAN OUTFALL IMPROVEMENTS

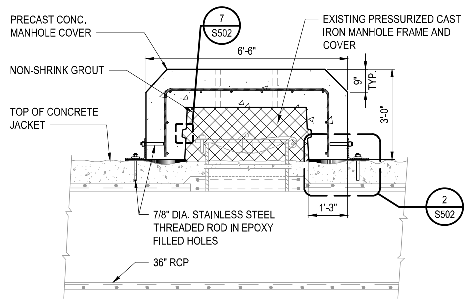
LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM: SECTIONS AND DETAILS

DESIGNED BY: CHECKED BY:
DRAWN BY: SECTION HEAD:
APPROVED: BRANCH HEAD:
CHIEF DATE

JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.



1 PRECAST MANHOLE COVER DETAIL
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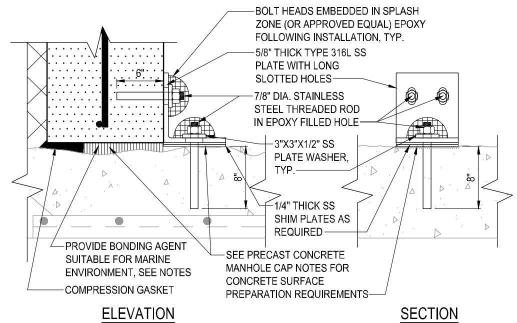

2 PRECAST MANHOLE COVER CONNECTION DETAIL
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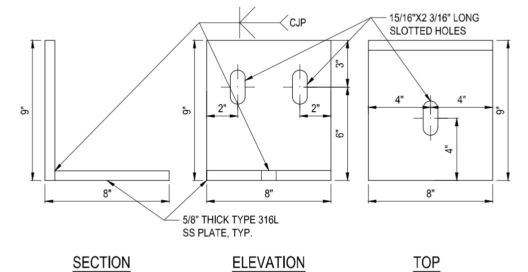

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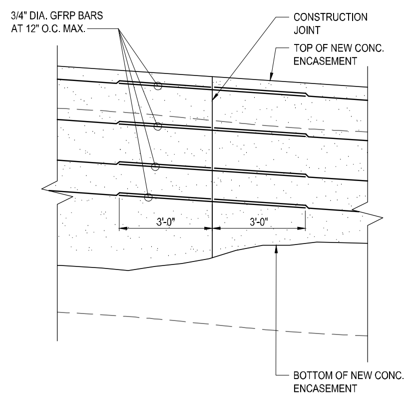
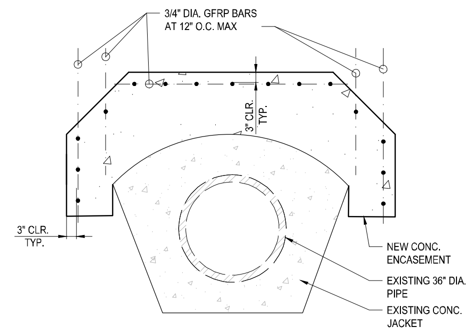


4 CONSTRUCTION JOINT DETAIL
S502 SCALE: 1/2" = 1'-0"



5 CONSTRUCTION JOINT DETAIL
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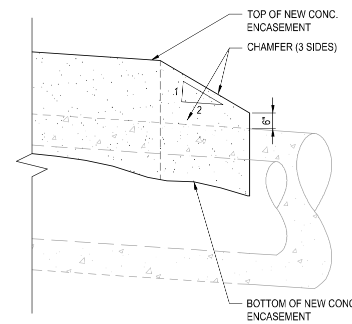
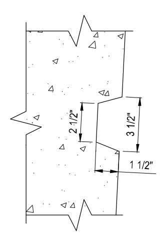


6 END CHAMFER DETAIL
S502 SCALE: 1/2" = 1'-0"



7 DETAIL
S502 SCALE: 3" = 1'-0"

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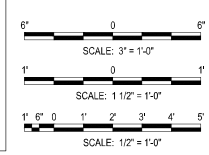

BENNETT Y. FUNG
LICENSED PROFESSIONAL ENGINEER
NO. 6293-S
HAWAII USA

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE

EXPIRATION DATE OF THE LICENSE

REVISION	DATE	BRIEF	BY	APPROVED

WASTEWATER ENGINEERING & CONSTRUCTION DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

PROJECT:
WAIANAE WASTEWATER TREATMENT PLANT OCEAN OUTFALL IMPROVEMENTS

LUALUALEI, WAIANAE, OAHU, HAWAII

ITEM:
SECTIONS AND DETAILS

DESIGNED BY: ______ CHECKED BY: ______
DRAWN BY: ______ SECTION HEAD: ______
APPROVED: BRANCH HEAD: ______
CHIEF DATE

JOB NO. XXX-XX

FILE CABINET	DRAWER	FILE	POCKET	FOLDER	NO.

DRAWING S502 SHEET 18 OF 18

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Appendix C

Waianae Wastewater Treatment Plant Flora and Fauna Report
(March 2021)

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Waianae Wastewater Treatment Plant Flora and Fauna Report

MARCH 2021

PREPARED FOR

SSFM International

PREPARED BY

SWCA Environmental Consultants

WAIANAE WASTEWATER TREATMENT PLANT FLORA AND FAUNA REPORT

Prepared for

SSFM International
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Honolulu, HI 96817
Attn: Jennifer Scheffel

Prepared by

SWCA Environmental Consultants
1200 Ala Moana Blvd, #380
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March 2021

ABSTRACT/EXECUTIVE SUMMARY

SSFM has invited SWCA to conduct marine and terrestrial flora and fauna surveys for construction improvements and rehabilitation of the Waianae Wastewater Treatment Plant (WWTP) coastal revetment structure. The project area is located in the town of Waianae on the west end of the island of Oahu. The proposed revetment site is on the shoreline adjacent to the Waianae WWTP next to Farrington Highway.

The naturally occurring vegetation types and plant species identified during the survey are not considered unique. No federally and state-listed threatened, endangered, or candidate plant species proposed for listing were observed in the survey area. In all, 18 plant species were recorded in the survey area. Of these, four species are native or possibly native to Hawai‘i. All four species—naupaka kahakai (*Scaevola taccada*), milo (*Thespesia populnea)*, naio (*Myoporum sandwicense*), and ‘uhaloa (*Waltheria indica*)—are common throughout the Hawaiian Islands (Wagner et al. 1999).

No federally and state-listed threatened, endangered, or candidate terrestrial wildlife species were found during the pedestrian surveys. The Hawaiian hoary bat (*Lasiurus cinereus semotus*), a federally and state-listed endangered mammal species that is still extant within the Hawaiian Islands (U.S. Fish and Wildlife Service 1998), was not observed, although suitable habitat for this species exists near the survey area. The hoary bat was never historically observed on or near the survey area and therefore it is not likely to occur.

None of the flora and fauna observed in the survey area are federally or state-listed threatened, endangered, proposed listed, or candidate species. Because no threatened or endangered species were recorded in the area, the proposed project is not expected to have a significant, adverse effect on biological terrestrial resources.

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CONTENTS

Figures

Tables

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1 INTRODUCTION

SSFM International (SSFM) requested that SWCA Environmental Consultants (SWCA) conduct a terrestrial flora and fauna survey of the proposed Waianae Wastewater Treatment Plant (WWTP) revetment site. The approximately 1.5-acre terrestrial survey area is located next to Farrington Highway just immediately south of the town of Waianae. This report summarizes the findings of the terrestrial biological resources survey conducted by SWCA Biologists Danielle Frohlich and Alex Lau on February 23, 2021.

2 DESCRIPTION OF THE SURVEY AREA

The project area is located just south of the town of Waianae on the west end of the island of Oahu. The proposed revetment site is on the shoreline adjacent to the Waianae WWTP next to Farrington Highway. The proposed revetment will protect the outfall pipe. The proposed project includes capping three underwater manhole covers along the existing outfall pipeline. The survey area focused on approximately 1.5 acres (Figure 1) of coastal property owned by the City and County of Honolulu. The area consists of a coastal dry setting with ruderal vegetation and landscape vegetation. Mean annual rainfall for the survey area is approximately 22 inches (561 millimeters [mm]). Rainfall is typically highest in November to January and lowest in June (Giambelluca et al. 2016).

Figure 1. Waianae Wastewater Treatment Plant survey area.

3 METHODS

Before conducting the survey, SWCA reviewed available scientific and technical literature regarding natural resources in and near the survey area. This literature review encompassed a thorough search of referenced scientific journals, technical journals and reports, environmental assessments, environmental impact statements, relevant government documents, U.S. Fish and Wildlife Service (USFWS) online data, and unpublished data that provide insight into the area's natural history and ecology. SWCA also reviewed available geospatial data, aerial photographs, and topographic maps of survey areas.

SWCA conducted the biological resources survey on February 23, 2021.

3.1 Flora

SWCA conducted a pedestrian flora survey to document all vascular plant species and vegetation types in the 1.14-acre survey area. Areas more likely to support native plants (e.g., rocky outcrops and shady areas) were more intensively examined. A global positioning system (GPS) unit was used to navigate the survey area, and a digital camera was used to document vegetation species and types.

Plants recorded during the survey are indicative of the season ("rainy" versus "dry") and the environmental conditions at the time of the survey. It is likely that additional surveys conducted at a different time of the year would result in minor variations in the species of plants observed.

3.2 Fauna

SWCA conducted the fauna survey in the morning from 08:30 to 09:45, when wildlife were most likely to be active. Visual and auditory observations were included in the survey, and visual surveys were conducted with the use of binoculars. All observed birds, mammals, reptiles, amphibians, and invertebrate species were noted during the survey. Acoustic surveys for the federal- and state-listed endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) were not conducted, although areas of suitable habitat for roosting and foraging were noted during the survey.

4 RESULTS

4.1 Flora

No federal- and state-listed threatened, endangered, or candidate plant species proposed for listing were observed in the survey area. In all, 18 plant species were recorded in the survey area (Table 1). Of these, four species are native or possibly native to Hawai‘i. All four are common throughout the Hawaiian Islands (Wagner et al. 1999).

Table 1. Plant Species Observed in the Survey Area

Family	Scientific and Authorship	Hawaiian and/or Common Name	Status
MONOCOT			
Arecaceae	*Cocos nucifera* L.	Niu, coconut	Non-native

Family	Scientific and Authorship	Hawaiian and/or Common Name	Status
Poaceae	*Cenchrus ciliaris* L.	buffelgrass	Non-native
	Chloris barbata Sw.	Swollen fingergrass	Non-native
	Cynodon dactylon (L.) Pers.	Bermuda grass	Non-native
	Urochloa maxima (Jacq.) R.D.Webster	Guinea grass	Non-native
DICOTS			
Amaranthaceae	*Alternanthera pungens* Kunth	khaki weed	Non-native
Asteraceae	*Calyptocarpus vialis* Less.		Non-native
	Pluchea carolinensis (Jacq.) G.Don	sourbush	Non-native
	Pluchea indica (L.) Less.	Indian fleabane, Indian pluchea, marsh fleabane	Non-native
Boraginaceae	*Tournefortia argentea* L.f.	tree heliotrope	Non-native
Chenopodiaceae	*Atriplex semibaccata* R.Br.	Australian saltbush	Non-native
Fabaceae	*Leucaena leucocephala* (Lam.) de Wit	koa haole	Non-native
	Prosopis pallida (Humb. & Bonpl. ex Willd.) Kunth	kiawe, algaroba	Non-native
Goodeniaceae	*Scaevola taccada* (Gaertn.) Roxb.	naupaka kahakai	Indigenous
Malvaceae	*Sida ciliaris* L.		Non-native
	Thespesia populnea (L.) Sol. ex Corrêa	milo	Indigenous
Myoporaceae	*Myoporum sandwicense* A.Gray	naio	Indigenous
Sterculiaceae	*Waltheria indica* L.	ʻuhaloa, ʻalaʻala pū loa, hala ʻuhaloa, hiʻaloa, kanakaloa	Possibly indigenous

Notes: The taxonomy and nomenclature used in this table are in accordance with Wagner et al. (1999), and Wagner and Herbst (2003). Recent name changes are those recorded in Wagner et al. (2012).

The vegetation in the survey area consists of two vegetation types: ruderal vegetation and landscaped vegetation.

4.1.1 *Ruderal Vegetation*

This vegetation type occurs throughout most of the vegetated portions of the survey area. It is composed of a mixture of grasses and weedy, mostly herbaceous, species (Figure 2). The dominant species is buffelgrass (*Cenchrus ciliaris*). Other species that can be seen occasionally include *Sida ciliaris* and swollen fingergrass (*Chloris barbata*).

Figure 2. Ruderal vegetation in the survey area. The landscaped vegetation type is shown in the background in the top right corner of this image.

4.1.2 *Landscaped vegetation*

Landscaped areas are present at the southern margin of the survey area. They consist of infrequently mowed herbaceous vegetation, with occasional coconut (*Cocos nucifera*) trees. Bermuda grass (*Cynodon dactylon*) and buffelgrass are the most abundant herbaceous species in the landscaped areas.

4.2 Fauna

No federal- and state-listed threatened, endangered, or candidate terrestrial wildlife species were found during the pedestrian surveys. However, the endangered Hawaiian hoary bat may forage or roost in the survey area because areas of suitable habitat for roosting and foraging are present. Habitat exists for the endangered Hawaiian monk seal (*Neomonachus schauinslandi*) and the threatened green sea turtle (*Chelonia mydas*) directly adjacent to the survey area. Three special-status seabirds (Hawaiian petrel, Newell's shearwater, and band-rumped storm-petrel) have potential to occur in the study area based on their movement patterns.

4.2.1 *Birds*

The bird species observed in the survey area are species commonly found in disturbed, low- to mid-elevation areas on O‘ahu. In all, six bird species were documented (Table 2). None of the species are federal- and state-listed threatened, endangered, or candidate species, and none are protected by the Migratory Bird Treaty Act.

Table 2. Bird Species Observed in and Near the Survey Area

Scientific Name	Common Name	Status	MBTA
Acridotheres tristis	Common myna	NN	–
Columba livia	Rock pigeon	NN	–
Gallus gallus	Feral chicken	NN	–
Geopelia striata	Zebra dove	NN	–
Passer domesticus	House sparrow	NN	–
	Total	**5**	**0**

Status: ST = state threatened, M = migrant, NN = non-native permanent resident; MBTA = protected under the Migratory Bird Treaty Act

4.2.2 *Mammals*

The endangered Hawaiian hoary bat is the only native terrestrial mammal species that is still extant within the Hawaiian Islands (USFWS 1998). Hawaiian hoary bats are known to occur on O‘ahu in native, non-native, agricultural, and developed landscapes (U.S. Department of Agriculture [USDA] 2009; USFWS 1998). Hawaiian hoary bats forage in open, wooded, and linear habitats with a wide range of vegetation types. These animals are insectivores and are regularly observed foraging over streams, reservoirs, and wetlands up to 300 feet (100 meters [m]) offshore (USDA 2009). Hawaiian hoary bats typically roost in trees greater than 16 feet (5 m) tall with dense canopy foliage (or in the subcanopy when canopy is sparse), with open access for launching into flight (USDA 2009). Suitable foraging habitat exists within the survey area. Roosting habitat is present in areas immediately surrounding the survey area.

Other mammals observed in the survey area include dogs (*Canis familiaris*) and small Indian mongoose (*Herpestes javanicus*). Although house mouse (*Mus musculus*) and rats (*Rattus* spp.) were not detected, they are likely to occur in the survey area because of its proximity to development and recreation areas.

4.2.3 *Marine Mammals and Turtles*

The survey area is directly adjacent to Hawaiian monk seal critical marine habitat but does not encompass any other designated or proposed critical habitat for threatened or endangered species.

The endangered Hawaiian monk seal and threatened green sea turtle were not observed during the survey; however, these animals may be found in the marine waters nearby.

4.2.4 *Reptiles and Amphibians*

All of the terrestrial reptiles or amphibians in Hawai‘i are non-native introductions. No reptiles or amphibians were detected during the survey.

4.2.5 *Insects and Other Invertebrates*

No native invertebrates were observed during the survey. Non-native invertebrates observed include the housefly (*Musca domestica*) and an unidentified grasshopper.

5 DISCUSSION AND RECOMMENDATIONS

5.1 Flora

Overall, the vegetation in the survey area is disturbed from previous and current land use activities. The vegetation types and species identified are not considered unique. Most of the plant species recorded during the survey are not native to the Hawaiian Islands. The four native species observed are indigenous (found in Hawaiʻi and elsewhere) and are common throughout the Hawaiian Islands. No threatened or endangered plants were found during the survey, and no designated plant critical habitat occurs in the area. Therefore, the proposed project is not expected to have a significant, adverse effect on flora (botanical) resources.

5.2 Fauna

5.2.1 *Seabirds*

Major threats to band-rumped storm-petrel, Hawaiian petrel, and Newell's shearwater include the attraction of adults and newly fledged juveniles to bright lights while they transit between their nest sites and the ocean. Juvenile birds are particularly vulnerable to light attraction and are sometimes grounded when they become disoriented by lights (Mitchell et al. 2005), rendering them vulnerable to mammalian predators or being struck by vehicles. The following recommendations are provided to avoid and minimize light attraction of the special-status seabirds to the survey area:

- Construction activity should be restricted to daylight hours as much as practicable during the seabird peak fallout period (September 15 to December 15) to avoid the use of nighttime lighting that could attract seabirds.
- All outdoor lights should be shielded to prevent upward radiation. This has been shown to reduce the potential for seabird attraction. A selection of acceptable, seabird-friendly lights can be found online
- Outside lights not needed for security and safety should be turned off from dusk through dawn during the fledgling fallout period (September 15 to December 15).

5.2.2 *Terrestrial Mammals*

5.2.2.1 HAWAIIAN HOARY BAT (LASIURUS CINEREUS SEMOTUS)

Hawaiian hoary bats are known to occur on Oʻahu in native, non-native, agricultural, and developed landscapes (USDA 2009; USFWS 1998). Hawaiian hoary bats forage in open, wooded, and linear habitats with a wide range of vegetation types. These animals are insectivores and are regularly observed foraging over streams, reservoirs, and wetlands up to 300 feet (100 m) offshore (USDA 2009).
The Hawaiian hoary bat could forage over all the vegetation types and the ocean within and around the survey area. Hawaiian hoary bats typically roost in trees greater than 16 feet (5 m) tall with dense canopy foliage or in subcanopy when canopy is sparse, with open access for launching into flight (USDA 2009). Although the trees in the survey area that are greater than 16 feet (5 m) tall do not have dense canopy, other trees, such as kiawe (*Prosopis pallida*), in areas surrounding the survey area do provide suitable roost habitat for the Hawaiian hoary bat.

Although the proposed project would not be likely to adversely affect the Hawaiian hoary bat, the following actions are recommended as a conservative impact avoidance measure:

- Any fences that are erected as part of the project should have barbless top-strand wire to prevent Hawaiian hoary bats from becoming entangled on barbed wire. No fences with barbed wire were observed within the survey area; however, if such fences are present, the top strand of barbed wire should be removed or replaced with barbless wire.
- No trees taller than 15 feet (4.6 m) should be trimmed or removed as a result of this project between June 1 and September 15, when juvenile bats that are not yet capable of flying may be roosting in the trees.

Implementation of these guidelines is expected to avoid all direct impacts to Hawaiian hoary bats.

5.2.3 *Hawaiian Monk Seal (Neomonachus schauinslandi) and Green Sea Turtle (Chelonia mydas)*

Hawaiian monk seals spend most of their life at sea, but they also rely on land habitat for resting, molting, pupping, nursing, and avoiding marine predators. Monk seals can often be seen hauling out on sand, corals, and volcanic rock to rest during the day and to give birth, preferring protected beaches surrounded by shallow waters when pupping (National Marine Fisheries Service [NMFS] 2015a). Pupping has been observed in a variety of terrestrial coastal habitats mostly consisting of sandy, protected beaches adjacent to shallow sheltered aquatic areas (NMFS 2015b).

Approximately 85 percent of the Hawaiian monk seal population occurs in the northwestern Hawaiian Islands. The main Hawaiian Islands subpopulation was estimated at 150 to 200 individuals in 2011 (personal communication, C. Littnan, NMFS, August 18, 2015). Seal abundance in the northwestern Hawaiian Islands subpopulation remains in decline. The main Hawaiian Islands subpopulation is experiencing increasing abundance and reproductive success, thought to be a result of a lower overall seal density and a lack of large predators that compete for food and kill pups (NMFS 2007). Trends in abundance may also be linked to changes in ocean productivity that are determined by various climate patterns (NMFS 2015b).

The following actions are recommended as conservative impact avoidance measures:

- Construction activities should not occur if a Hawaiian monk seal or green sea turtle is in the construction area or within 150 feet (46 m) of the construction area. Construction should only begin after the animal voluntarily leaves the area. If a monk seal or pup pair is present, a 300-foot (91-m) buffer should be observed.
- If a Hawaiian monk seal or green sea turtle is noticed after work has begun, that work may continue only if, in the best judgment of the project supervisor, there is no way for the activity to adversely affect the animal.
- Any construction-related debris that may pose an entanglement threat to monk seals and turtles should be removed from the construction area at the end of each day and at the conclusion of the construction project.
- Workers should not attempt to feed, touch, ride, or otherwise intentionally interact with any listed species.

6 REFERENCES CITED/LITERATURE CITED

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Appendix D

Marine Biological Survey, Waianae Wastewater Treatment Plant Ocean Outfall Improvements

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Marine Biological Survey

Waianae Wastewater Treatment Plant Ocean Outfall Improvements

Lualualei, Wai‘anae, O‘ahu, Hawai‘i

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May 2021

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

BMP	Best Management Practice
cm	Centimeter(s)
ESA	Endangered Species Act
ft	Feet or foot
FR	Final Rule
HDOH	State of Hawaiʻi Department of Health
m	Meter(s)
mgd	Million Gallons per Day
mph	Miles Per Hour
No.	Number
NOAA	National Oceanic and Atmospheric Administration
ROV	Remote-Operated Vehicle
RTE	Rare, Threatened, or Endangered
SLUD	State Land Use District
TMK	Tax Map Key
WWTP	Wastewater Treatment Plant

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1. INTRODUCTION

The Waianae Wastewater Treatment Plant (WWTP) services the Waiʻanae area from Makaha to Nānākuli and occupies an 18-acre parcel in tax map key (TMK) 8-6-001:044. The plant is designed for 5.2 million gallons per day (mgd) average dry weather flow, with a peak capacity of 13.8 mgd. The facility was constructed in 1967 and was upgraded to an advanced primary treatment plant in 1988. In 1993, the plant underwent a second round of improvements to become a secondary wastewater treatment plant (CCH DDC, 2016). The WWTP is in an "Urban" State Land Use District (SLUD) area and zoned as an Intensive Industrial District (I-2) by the City and County of Honolulu.

1.1 Site Description

The project site is located on the west coast of the island of Oʻahu, Hawaiʻi approximately one mile south of Pokai Bay and 1.5 miles south of the Waiʻanae Small Boat Harbor. The site is the ocean outfall pipeline that carries treated sewage from the WWTP makai under Farrington Highway, where it emerges at the shoreline of Lualualei Beach Park and extends more than 3,000 feet (ft) offshore before being expelled into the Pacific Ocean through a diffuser at a water depth of about 100 ft. (Figure 1-1). Three submerged manholes exist along the pipeline. The City and County of Honolulu proposes to make improvements to the outfall, which may include a concrete encasement around the pipe extending about 125 ft from the shoreline (Figure 1-2) and capping the submerged manholes with concrete (Figure 1-3). The manholes are identified by following locations:

1) *MH-2:* ~1,048 ft from shore, ~20 ft depth (Northing: 96,443.65; Easting 1,576,724.24)
2) *MH-3:* ~2,024 ft from shore, ~28 ft depth (Northing: 96,119.39; Easting 1,575,803.68)
3) *MH-4:* ~2,616 ft from shore, ~30 ft depth (Northing: 95,992.70; Easting 1,575,245.30)

The shoreline area is rocky, composed mainly of jagged limestone pavement and boulder stones. Several tents and encampments are present in proximity to the outfall pipeline. The beach park is highly trafficked by people, including recreational users and those that currently live there. Offshore of the beach park, recreational and fishing boats launched from the Waiʻanae small boat harbor often pass through the area.

1.2 Purpose

Oceanit was contracted by SWCA Environmental Consultants to conduct qualitative benthic biological surveys of the in-water areas that will be directly affected by the proposed improvements. The bottom types, corals, fish, and macroinvertebrates seen within each marine survey area were documented. All corals within the project footprints and roughly ten (10) feet from the project footprints were mapped. Relative abundances of marine species (e.g., common, rare) were indicated as appropriate. Any invasive algae seen was noted.

This report provides a summary of the findings of the biological surveys, as well as a description of potential impacts of the project to the aquatic resources known to occur in the project area, and recommendations on avoidance and minimization of impacts to native and State or Federally listed species and/or rare (either locally or State-wide) species if found within the project area. The information in this report may support consultation with County, State, and Federal agencies as necessary to discuss the potential impacts of the project on existing marine biological resources.

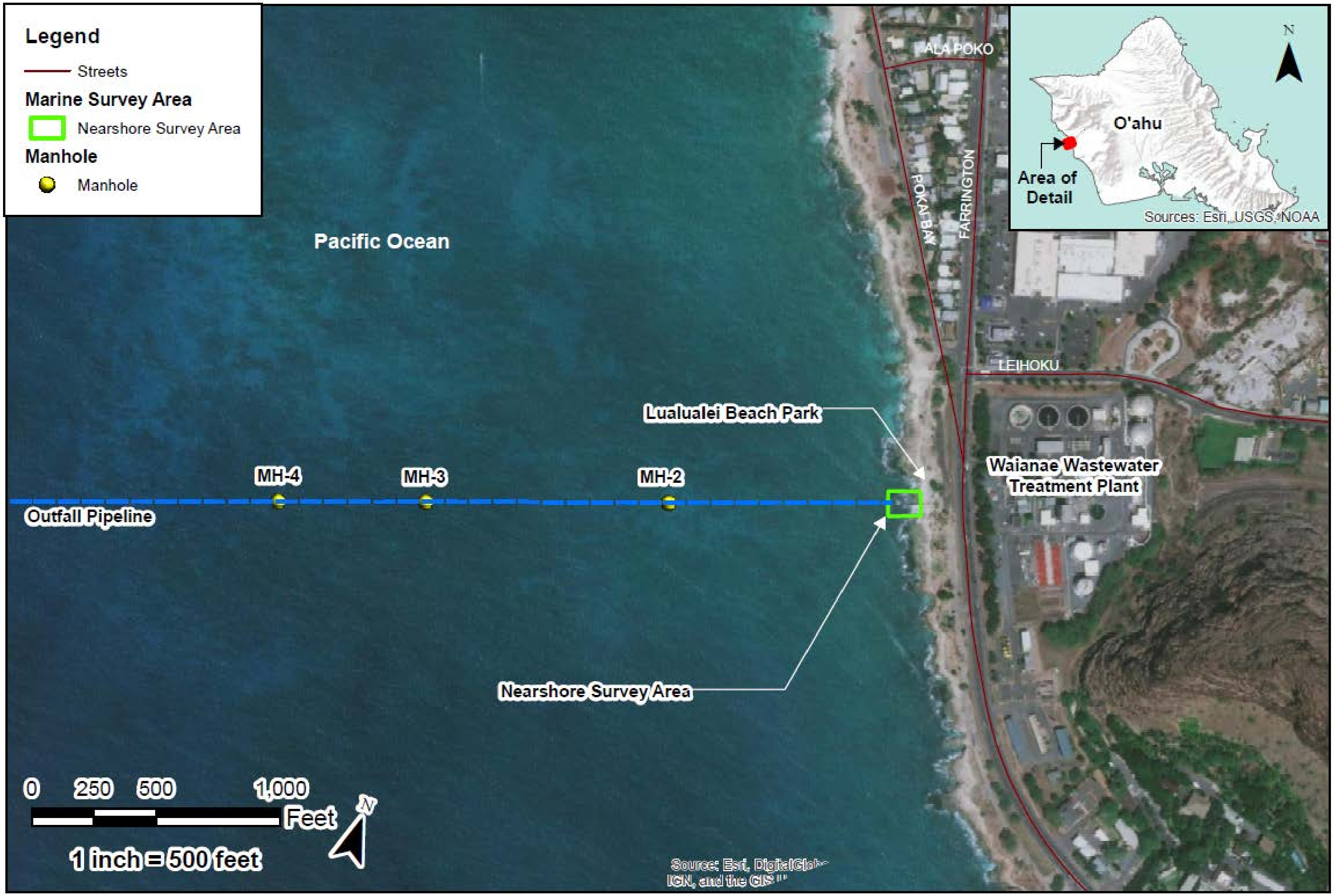
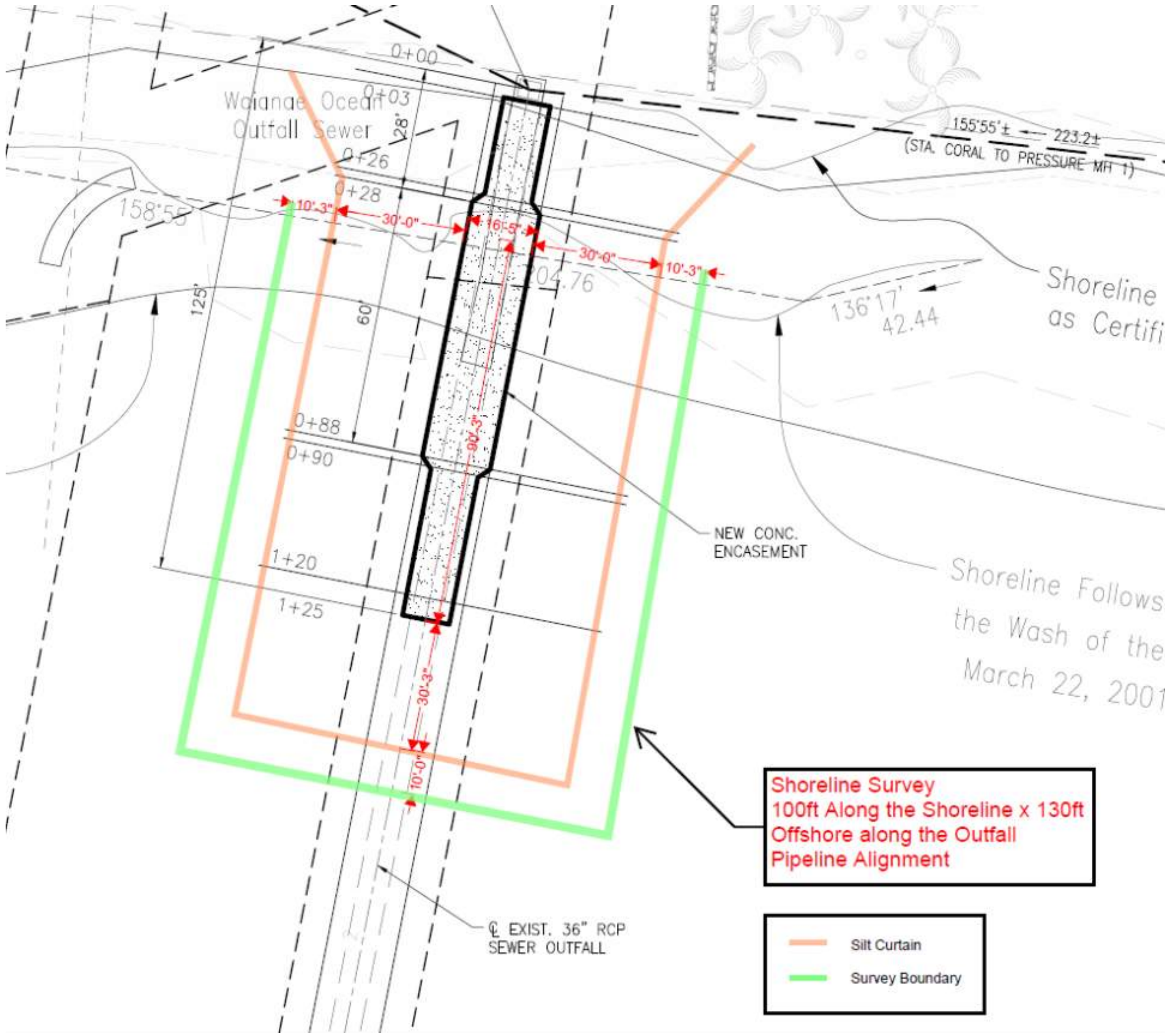
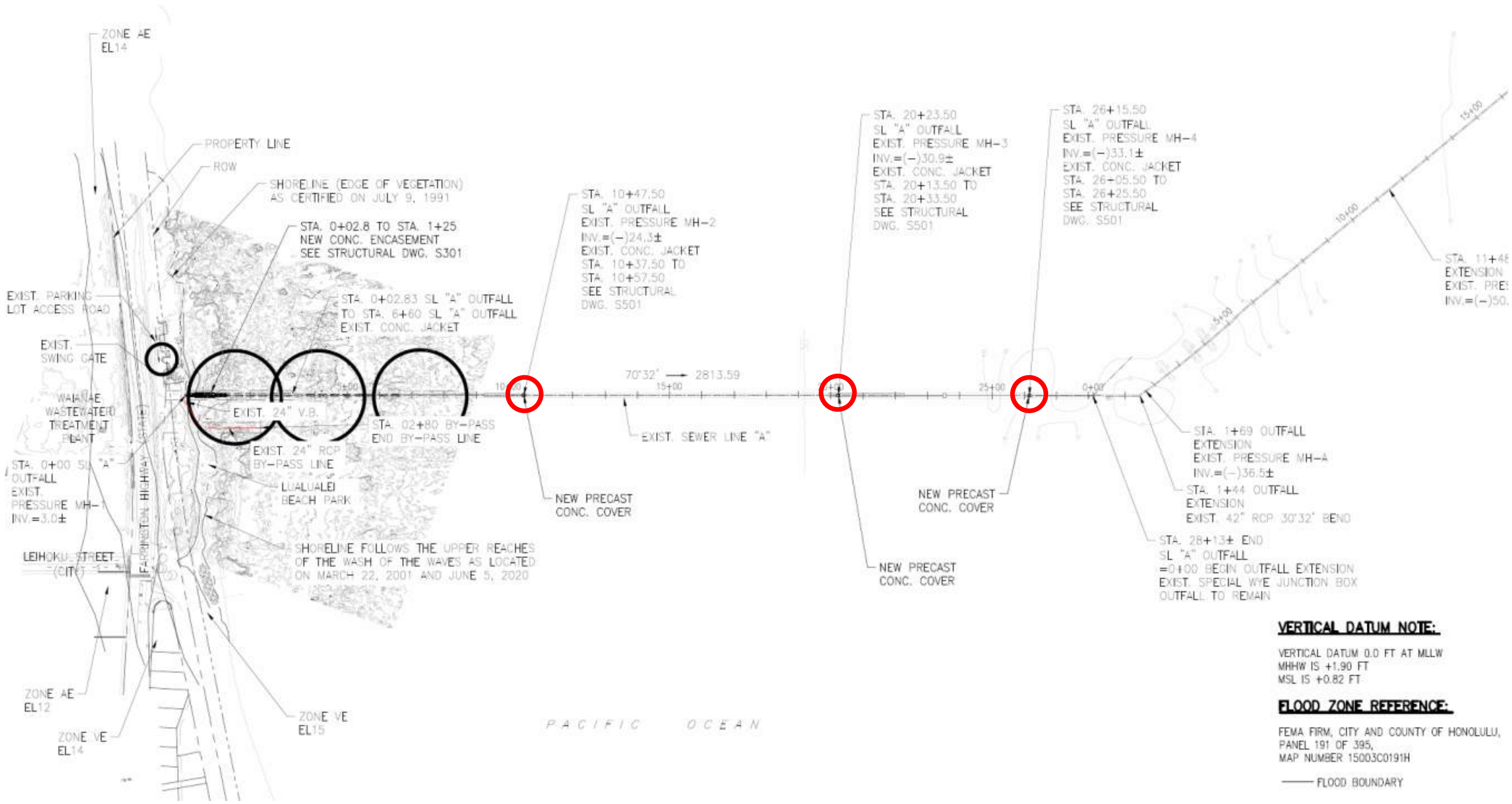


Figure 1-1: Project Site Map



Source: SWCA, 2021

Figure 1-2: Site Plan Showing Boundary of Shoreline Survey Around the Outfall Pipeline Alignment



Source: SWCA, 2021

Figure 1-3: Proposed Manhole Capping Layout

1.3 Marine Environment

The WWTP outfall pipeline is a man-made structure with marine biotic assemblages that have colonized the concrete pipe and casing since its installment and/or subsequent upgrades. Anthropogenic effects on the area are apparent and constantly present, as there were several tents and encampments on the sandy beach at Lualualei Beach Park during the survey. Photos of the project area are shown in Attachment A (Tables A-1 and A-2).

According to the National Oceanic and Atmospheric Administration (NOAA) National Center for Coastal Science, National Centers for Coastal Science, the reef structure in the nearshore survey area is classified as "Land" and "Pavement", while at MH-2 and MH-3, it is "Pavement with Sand Channels". MH-4, located furthest offshore, is characterized as "Pavement" (Figure 1-4). The predominant benthic biological habitat in the nearshore survey area is characterized as "Macroalgae", while the manhole areas are characterized as "Turf Algae" (Figure 1-5). In general, turf algae (30%) and macroalgae (23%) are the predominant cover types in main Hawaiian Island coral reefs (BAE S2 IS, 2007).

Several benthic faunal sampling studies adjacent to the Wai'anae Ocean Outfall Diffuser, approximately 2,000 ft further offshore and south from the project area, have been conducted. In June 2008, the City and County of Honolulu Department of Environmental Services Oceanographic team collected bottom-sediment samples for biological and geochemical analyses within a 34-meter (m) zone of initial dilution in the vicinity of the WWTP outfall. These data, along with results from previous years, suggest that there were no deleterious effects from treated effluent discharge to the biologically indigenous populations near the outfall (UH WRRC, 2008). The current project area is, therefore, unlikely to be affected by the outfall.

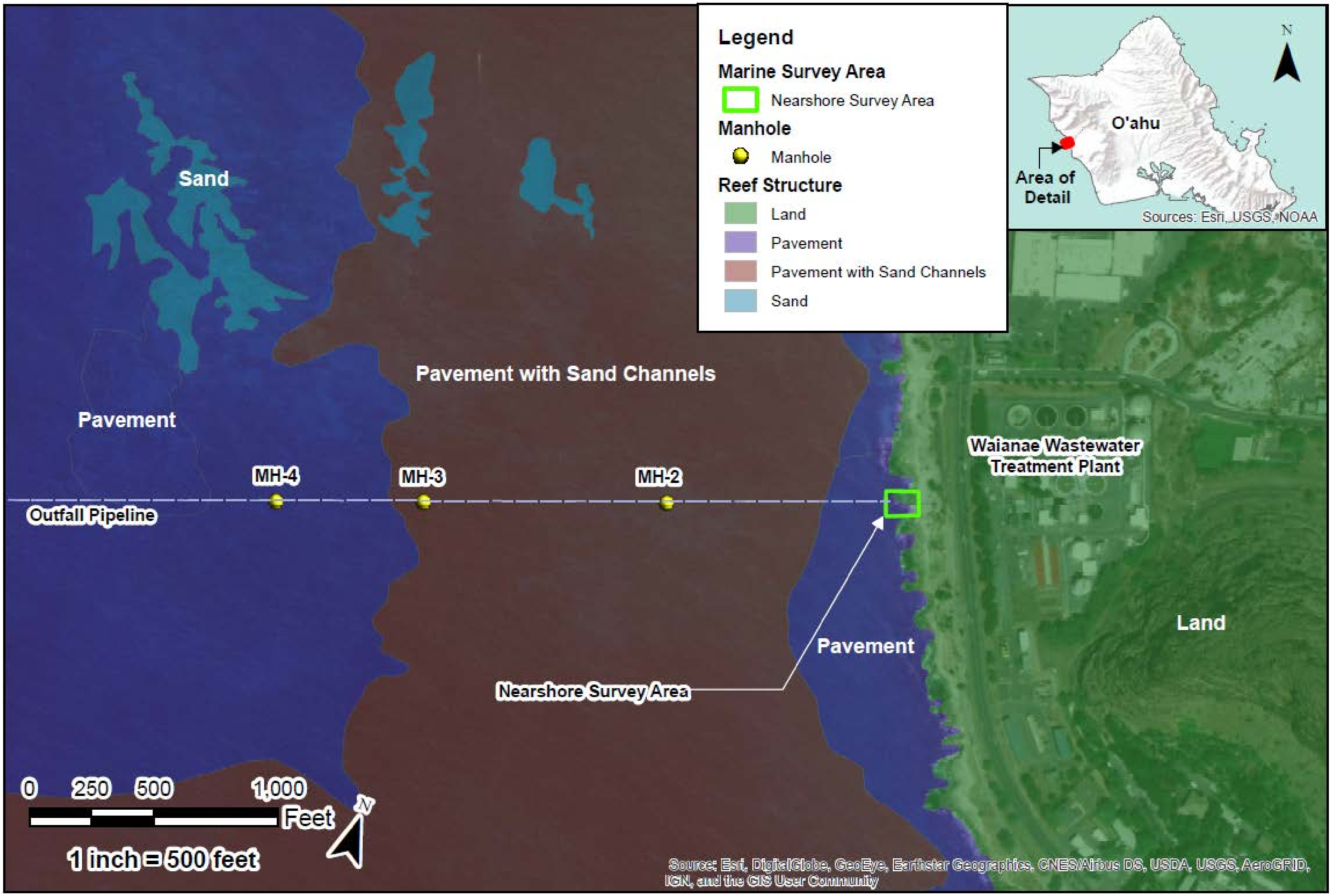


Figure 1-4: NOAA Reef Structure

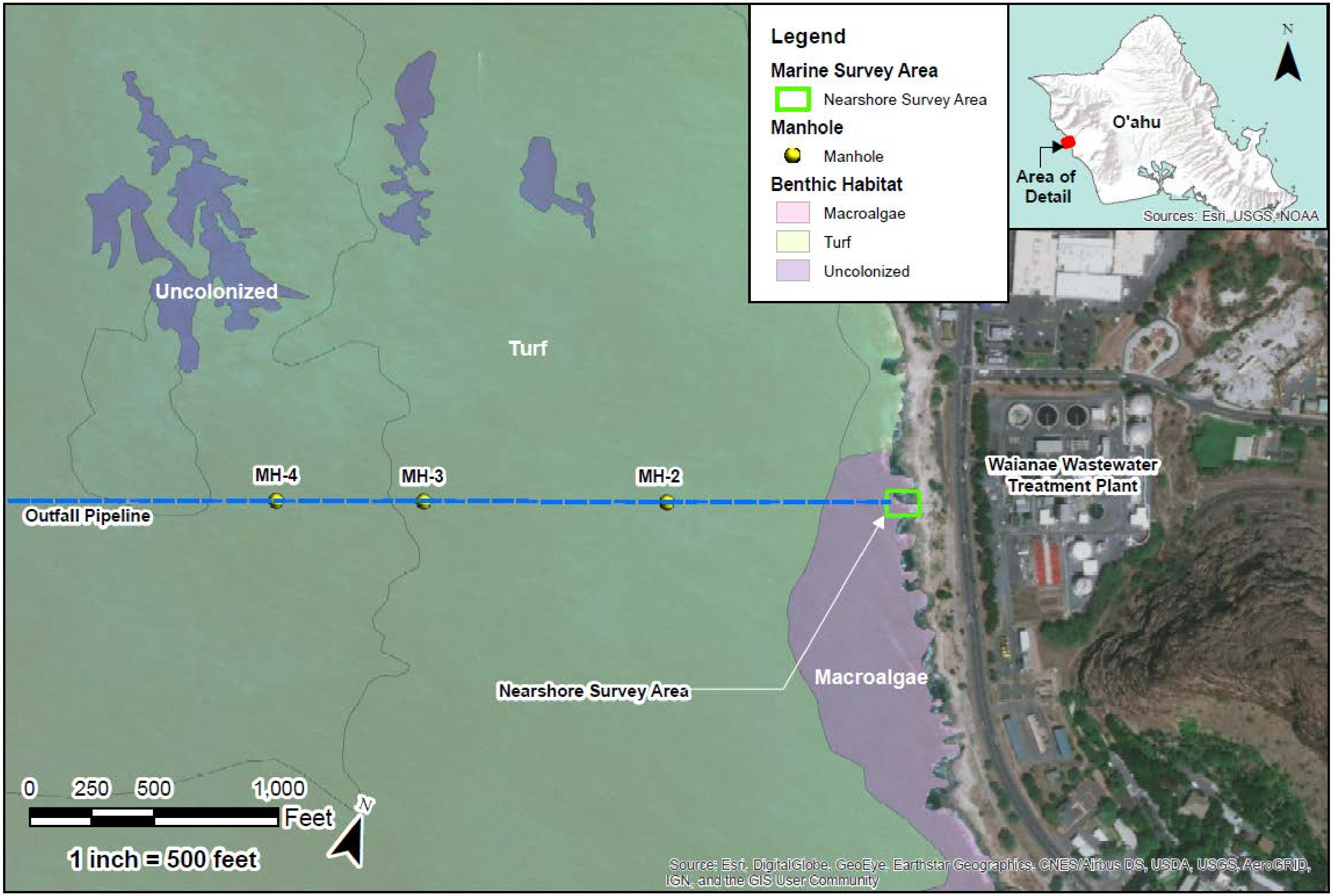


Figure 1-5: NOAA Biological Benthic Cover

2. METHODS

Oceanit personnel conducted all field activities on May 6, 2021. The nearshore survey was performed during low tide in the morning, while the offshore manhole surveys were completed in the afternoon. Low tide was 7:46 AM (-0.2 ft MLLW) and high tide was 2:14 PM (1.0 ft MLLW). Swell conditions ranged between 1-2 ft with westerly winds ranging 10-15 miles per hour (mph) (NOAA, 2021). In additon to the documentation related to the survey methods described below, incidental observations of large marine vertebrates that passed through the area were also recorded. Biologists referenced online databases (Stender, 2021 and USFWS, 2015) and "Hawaii's Sea Creatures: A Guide to Hawaii's Marine Invertebrates, Revised Ed." (Hoover, 2006) to verify the idenfitication of observed species.

2.1 Nearshore Survey

The nearshore survey encompassed a 100 ft x 130 ft area surrounding the pipeline origin. Biologists set up one horizontal transect parallel to the shoreline (100 linear ft) (E) and five transects (A, B, C, D, and F) perpendicular to the shoreline were spaced approximately 20 ft apart and extended 130 ft from the shoreline (Figure 2-1). Transect F ran along the pipeline and was the center perpendicular shoreline transect. The transect distances were estimated based on measurements between reference points. Transects were designed to capture representative bottom type, macroinvertebrates, algae, and fish in the area.

2.1.1 Characterizing Bottom Type

A line-point intercept method was used along each transect to record the bottom nature every five (5) ft. Bottom type was classified into the following categories:

S	Sand
L	Bare Limestone
R	Rubble
CONC	Concrete
CCA	Crustose Coralline Algae (CCA)
C	Live Coral
A	Algal Turf
MA	Macroalgae
MI	Macro-Invertebrate

2.1.2 Marine Species Survey

A 1-m belt survey was conducted to document algae, macroinvertebrates, fish, and corals along each of the established transects. Coral size classes were also noted. Any species encountered within 0.5-m on either side of the transect were recorded along with notes on their relative abundances. Relative abundance was characterized as follows:

R	Rare – Only 1-2 individuals observed
O	Occasional – Several to a dozen individuals observed
C	Common – Observed everywhere, although generally not in large numbers
A	Abundant – Observed in large numbers and widely distributed

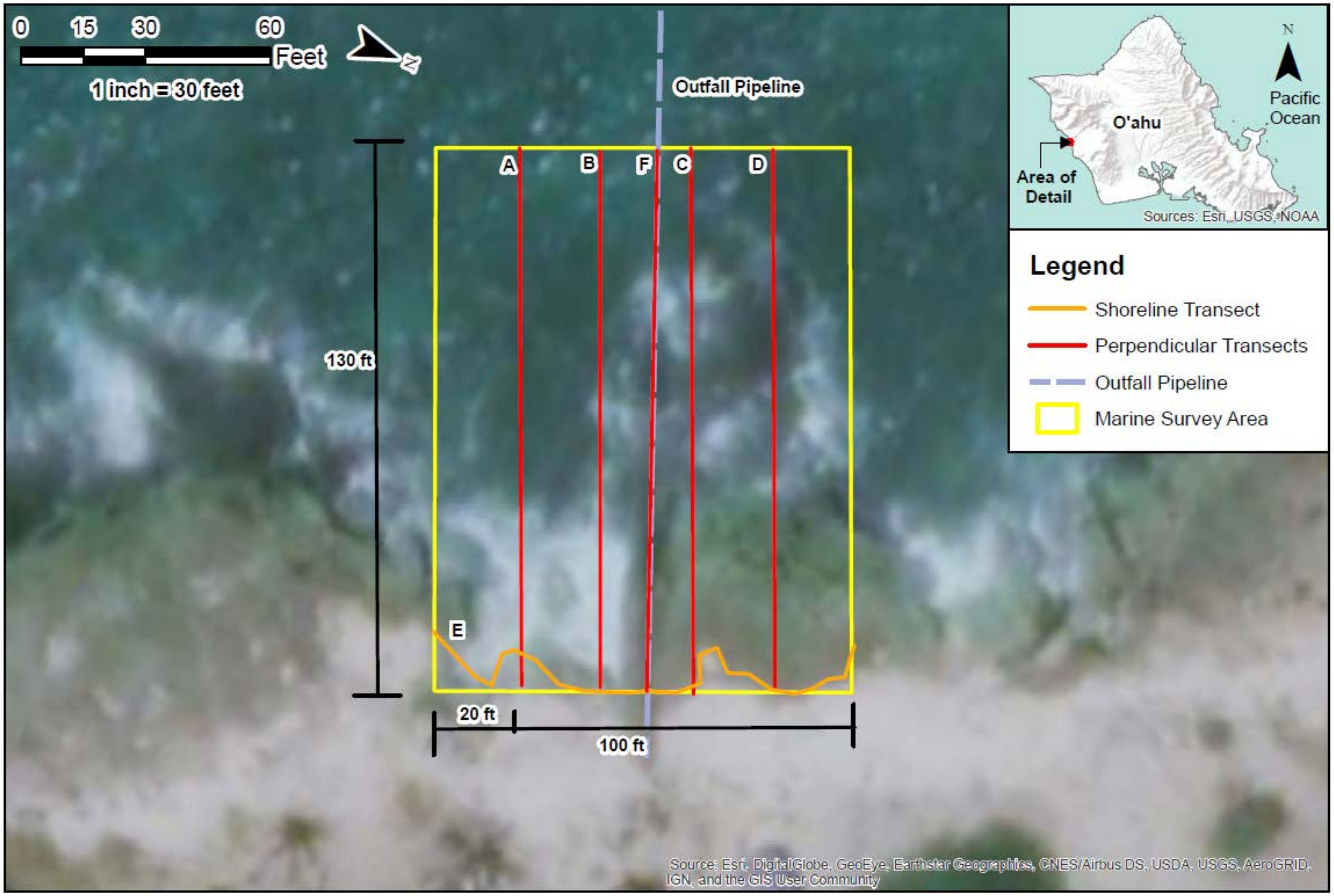


Figure 2-1: Nearshore Marine Biological Survey Transects

2.2 Manhole Covers Survey

A Blue Robotics BlueROV2® remote-operated vehicle (ROV) was used to survey each manhole cover (each 3 ft in diameter) with a surrounding 10-ft radius buffer around each cover. The total area of each manhole survey was approximately 415 ft^2 (38.5 m^2).

The BlueROV2® operates on a lithium-ion battery (14.8V, 19Ah) and has an open frame fitted with associated electronics, battery enclosures, thrusters, buoyancy foam, and ballast weights. The ROV was run using open-source ArduSub subsea vehicle control firmware with an external game controller (Blue Robotics, 2021). A technician operated the ROV and recorded photographs and videos of the manholes directed by a biologist. The biologist later analyzed the ROV images and video.

2.2.1 Coral Abundance and Size-Class Distribution

Coral abundance and size-class distribution were observed in a 10-ft diameter area around each manhole cover. Corals within the transect area were recorded. Coral size class (diameter) was recorded according to the following categories:

(1) 1-5 cm
(2) 6-10 cm
(3) 11-20 cm
(4) 21-40 cm
(5) 41-80 cm
(6) 81-160 cm
(7) >160 cm

2.2.2 Fish and Macroinvertebrates Survey

Fish and macroinvertebrates were observed in the 10-ft diameter area around each manhole cover. The relative abundances of these animals were recorded according to the following categories:

(R) Rare – only 1-2 individuals observed
(O) Occasional – several to a dozen individuals observed
(C) Common – Observed everywhere, although generally not in large numbers
(A) Abundant – observed in large numbers and widely distributed

3. RESULTS

3.1 General Observations

The nearshore area has approximately 20 ft of rocky beach, which merges into a limestone bench with tidepools. Macroinvertebrates such as pipipi (*Nerita picea*), periwinkles (*Littoraria pintado* and *Echinolittorina hawaiiensis*), and hermit crabs (*Calcinus spp.*), are abundant in the surge zone and tidepools. Burrowing urchins *Echinometra oblonga, Echinometra mathaei,* and the helmet urchin *Colobocentrotus atratus* burrow in the submerged concrete pipe as well as the vertical faces along the limestone. A thick mat of macroalgae, consisting mainly of the brown algae *Turbinaria ornata* and *Sargassum spp*., resides in the low intertidal zone and provides cover for various mollusc species, including the cowry (*Monetaria caputophidii*), drupes (*Morula granulata*), and limpets (*Cellana spp.*). Corals are uncommon in the nearshore area, but those that do exist are small (less than 20 cm in diameter). The most common coral species seen were *Pocillopora meandrina* and *Porites lobata.* Complete species lists are included in Attachment B.

Manhole MH-2 had the least amount of marine biota in the area. The manholes further offshore, MH-3 and MH-4, had more associated marine life and corals likely due to the rugosity and topographical relief provided by the piled rocks surrounding the manholes. Photos of each manhole are shown in Table A-2 of Attachment A.

Several green sea turtles (*Chelonia mydas*) were observed swimming approximately 200 ft offshore during the marine biological survey. In addition, a pod of spinner dolphins (*Stenella longirostris*) were observed approximately 2,000 ft offshore during the manhole survey.

3.2 Nearshore Survey

3.2.1 Bottom Type

The percent benthic bottom type along each transect is shown in Figure 3-1. Overall, the rocky beach transitions into beachrock (limestone) with tidepools and a bed of macroalgae in the intertidal zone. Past the beachrock shelf, the nearshore submerged area is rocky with large boulders and rubble with sand interspaces. The transect parallel to the shoreline (E) was comprised of beachrock, sand, and concrete where the outfall pipe and its stabilization exist. Perpendicular to the shoreline, Transect F ran along the pipeline into the water. The landward end of the pipe was bare concrete until the intertidal zone, where it was covered in a thick bed of macroalgae consisting mainly of the brown algae *Turbinaria ornata* and *Sargassum spp.* A few feet further along the pipeline, burrowing urchins *Echinometra oblonga, Echinometra mathaei,* and the helmet urchin *Colobocentrotus atratus* were numerous. The pipeline follows along the seafloor and is covered mainly in algal turf and partially buried as it extends offshore (Attachment A; Table A-1, Photos 1-4).

Four other transects, A, B, C and D were laid parallel to the pipeline (Transect F). The predominant bottom types at Transects A and B, located south of the pipeline, were sand (31%) and algal turf (30%). The transects north of the pipeline, C and D, went over a longer limestone shelf with much more macroalgae (22%). Algal turf (30%) and beachrock (26%) were still the most common bottom types along these transects.

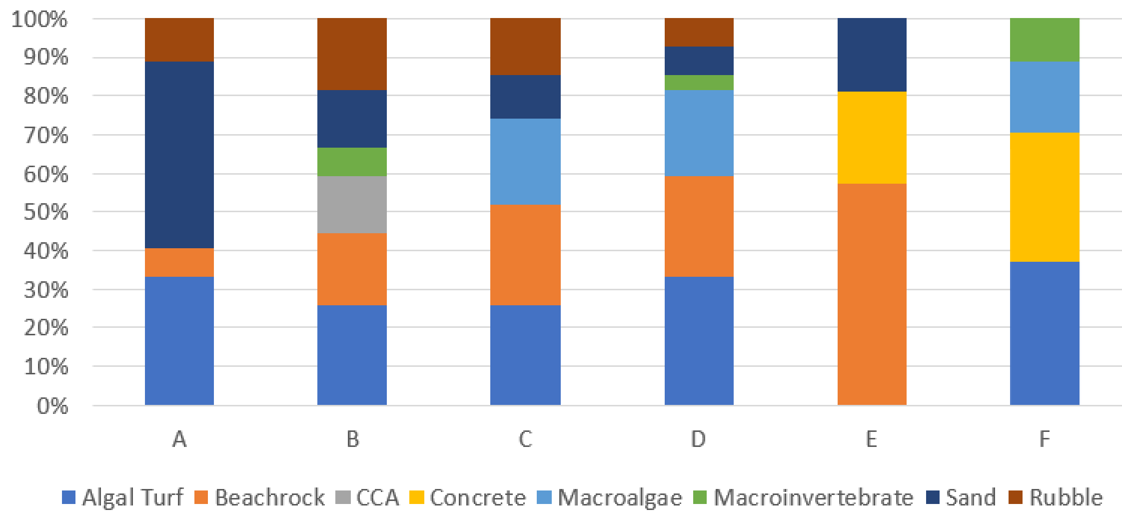


Figure 3-1: Percent Bottom Type by Transect

3.2.2 Corals

Corals were rare in the nearshore area with approximately 0.41 individuals per meter surveyed (Table 3-1). The most abundant coral species was the endemic blue soft coral *Sarcothelia edmondsonii* (32 individuals) and the cauliflower coral *Pocillopora meandrina* (14 individuals). No corals were seen on the pipeline transect (F). Other coral species seen were *Porites lobata, Porites evermanni, Pocillopora acuta, Pocillopora damicornis,* and *Palythoa caesia.* Only 1-2 individuals of these other species were observed in the project area.

Table 3-1: Coral Colony Abundance in Nearshore Benthic Survey

	Size Class (cm)					
Taxa	**1-5**	**6-10**	**11-20**	**21-40**	**41-80**	**Total**
Porites lobata	2	1	2	3		8
Porites evermanni	1					1
Pocillopora meandrina	5		3	6		14
Pocillopora acuta	1					1
Pocillopora damicornis	2					2
Sarcothelia edmondsonii	8	4	4	14	2	32
Palythoa caesia					1	1
Total Count	19	5	9	23	3	59
Area Surveyed	120.8 m^2	120.8 m^2	120.8 m^2	120.8 m^2	120.8 m^2	120.8 m^2
Corals per m^2	0.16	0.04	0.07	0.19	0.02	0.41

3.2.3 Algae

A thick mat of macroalgae, consisting mainly of the brown algae *Turbinaria ornata* and the endemic *Sargassum echinocarpum and Sargassum polyphyllum*, reside in the low intertidal zone. Green algae *Ulva lactuca* and *Cladophora* sp., as well as the hard bubble seaweed *Dictyosphaeria cavernosa* and the ringed finger seaweed *Neomeris annulata* were interspersed in the algal mat. Other brown algae observed included *Padina* spp., *Sphacelaria* spp., and *Dictyota* spp. Two endemic red algal species, *Laurencia* *mcdermidae* and *Gracilaria coronopifolia*, were noted, as well as encrusting coralline species. The introduced hooked seaweed, *Hypnea musciformis,* is a favorite food of green sea turtles and was present in the nearshore area. A complete species list is included in Table B-1 of Attachment B.

3.2.4 Macroinvertebrates

Small macroinvertebrates are abundant in the intertidal zone. The most abundant species include the endemic pipipi (*Nerita picea*), *Littoraria pintado*, and the endemic *Echinolittoria hawaiiensis* that inhabit the beach rock in the splash zone and shallow tidepools. Closer to the surf zone, rock-boring urchins *Echinometra oblonga, Echinometra mathaei,* wana *(Diadema paucispinum),* and the flat helmet urchin (*Colobocentrotus atratus)* have bored into the pipeline concrete and reside on vertical faces along the beachrock and in crevices. Hermit crabs (*Calcinus spp.*), cowries (*Monetaria caputophidii*), and several drupe species (*Morula granulata* and *Thais intermedia*) reside in the tidepool areas. Two species of 'opihi (*Cellana exarata* and *C. sandwicensis*) were occasionally observed in the nearshore area. In the submerged area, a couple of black sea cucumbers (*Holothuria atra*) were observed. A complete species list is included as Table B-2 of Attachment B.

3.2.5 Fish

The most common fish seen in the nearshore area were the brown surgeonfish (*Acanthurus nigrofuscus)* and mamo (*Abudefduf abdominalis*). Several wrasses, one whitemouth moray eel (*Gymnothorax meleagris*), and several boxfish (*Ostracion meleagris*) were also present in the survey area. Endemic blenny species (*Entomacrodus marmoratus*) and gobies (*Opua nephodes*) were commonly seen in shallow tidepools. A complete species list is included as Table B-3 of Attachment B.

3.3 Manhole Covers Survey

The results for each of the three manhole surveys are provided below.

3.3.1 MH-2

MH-2, located approximately 1,050 ft offshore and at 20 ft depth, rests on a slightly raised concrete block, partially covered with sand. Few rocks and rubble are in the vicinity of the manhole, and bathymetry is mostly flat. Photos of MH-2 are included in Table A-1 of Attachment A, and a species list is included as Table B-4 of Attachment B.

Corals - One *Pocillopora meandrina* individual resided directly on the manhole cover. Three other *P. meandrina* individuals were observed in the 10-ft radius around MH-2. The largest individual was about 40 cm in diameter, while the other three are smaller and less than 20 cm in diameter. The density of corals is about 0.01 corals/ft^2. Maps of the approximate coral locations in relation to each manhole covers are included in Attachment C.

Fish - Three species of fish were observed around MH-2. *Acanthurus olivaceus* was seen occasionally, while a few *Acanthus blochii* and *Sufflama fraenatum* individuals were observed.

Invertebrates - One collector urchin (*Tripneustes gratilla*) and one spiny urchin (*Diadema paucispinum*) were observed within the radius of the manhole cover survey area.

3.3.2 MH-3

MH-3 resides on an approximately 9ft x 15ft concrete block and is located approximately 2,000 ft offshore at 26 ft depth. The concrete block is surrounded by piled rocks and rubble that appear to have been placed there. Fish were diverse and abundant around MH-3, likely attributed to the topographical relief and niche interspaces provided by the piled rocks. Corals in the surrounding area are mainly small individuals (less than 10 cm in diameter). A complete species list at MH-3 is included as Table B-5 of Attachment B.

<u>Corals</u> - Corals seen around MH-3 were patchy and small. Six *Porites lobata* individuals, all less than 10 cm in diameter, inhabited the top of the manhole cover. There were about 20 other *Porites lobata* individuals and three (3) *Pocillopora meandrina* individuals residing on the concrete block around the manhole cover (Attachment C). The density of corals is about 0.07 corals/ft^2.

<u>Fish</u> - Schools of bluestripe snapper (*Lutjanus kasmira*) traversed across the MH-3 area. MH-3 had the highest fish species diversity of the three manhole areas surveyed. Twenty-five fish species were observed, and the most common species seen were *Abudefduf abdominalis, Ctenochaetus strigosus, Dascyllus albisella, Parupeneus multifasiatus,* and *Thalassoma duperrey.*

<u>Invertebrates</u> - Two species of spiny urchins, *Echinometra mathaei* and *Echinostrephus arciculatus* occurred occasionally around MH-3. A few collector urchin individuals, *Tripneustes gratilla*, were also seen. The encrusting red algae *Hydrolithon onkodes* was common on the hard concrete surfaces.

3.3.3 MH-4

MH-4 is located furthest offshore (2,600 ft) and at the deepest depth (30 ft) and is also set on a concrete cast block. Large rocks and rubble seemed to be placed around surrounded the manhole, although they were dispersed farther away than those around MH-3. A complete species list at MH-4 is included as Table B-6 of Attachment B.

<u>Corals</u> - MH-4 had the largest coral population of the manhole locations. Three *Porites lobata* individuals were growing directly on the manhole, while two other *Porites lobata* and one *Pocillopora evermanni* individuals were growing on the vertical the side of the manhole cover. Several of the *Pocillopora meandrina* individuals appeared damaged or partially dead. Most of the brown lobe coral *P. evermanni* and *P. lobata* individuals were growing on the sides of large boulders. Within the 10-ft radius, 10 *P. evermanni,* 13 *P. meandrina,* approximately 42 *P. lobata, and* one *Montipora flabellata* were observed (Attachment C). The density of corals is 0.17 corals/ft^2.

<u>Fish</u> - Fish were common around manhole MH-4, although not as abundant as around MH-3. The most abundant species observed were *Dascyllus albisella, Parupeneus multifasciatus,* and *Thalassoma duperrey.* Several types of butterfly fish (*Chaetodon lunula, C. multicinctus,* and *C. quadrimaculatus*), surgeonfish (*Acanthurus blochii* and *Acanthurus nigroris*), goat fish (*Parupeneus multifasciatus*), and big-eye bream *Monotaxis grandoculis.*

<u>Invertebrates</u> - Two species of sea urchins, *Diadema paucispinum* (occasional abundance) and *Echinometra mathaei* (common abundance), were observed.

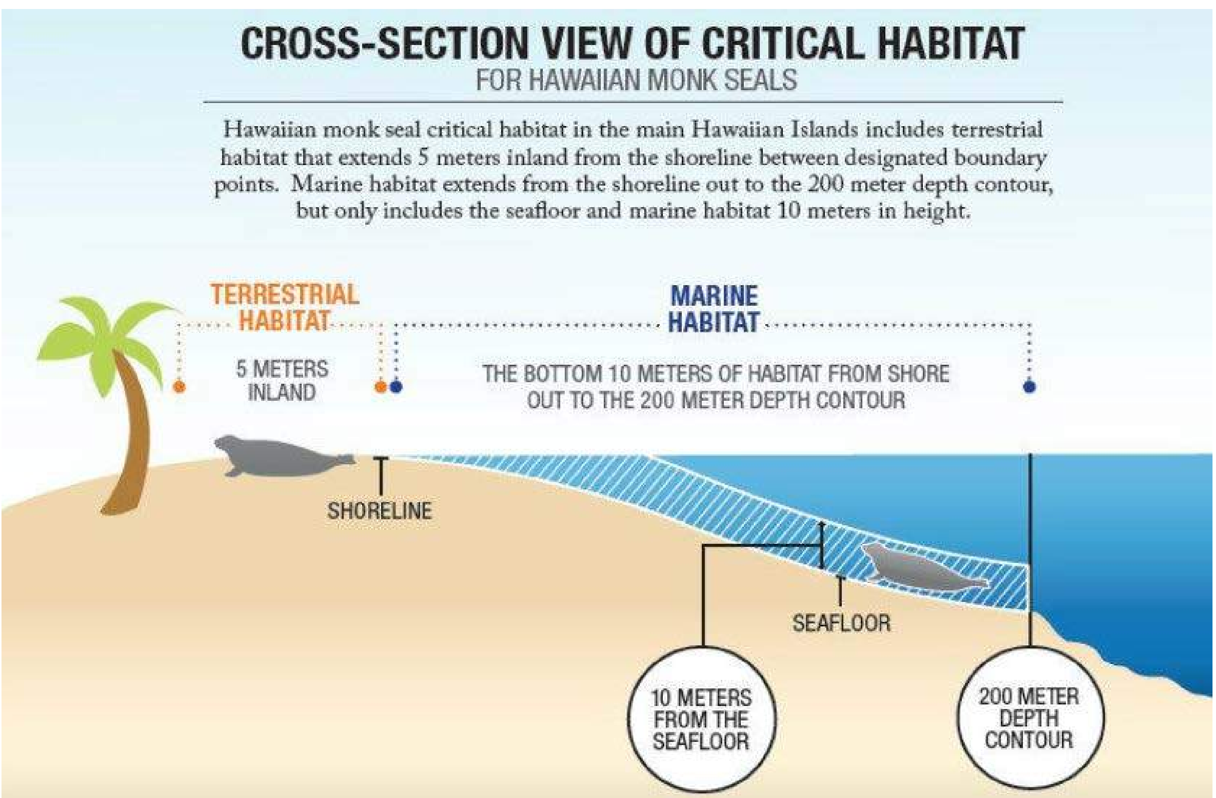
4. DISCUSSION

4.1 Rare, Threatened, Endangered, or Protected Species

No rare, threatened, or endangered (RTE) species were seen in the project vicinities that were surveyed; however, several protected green sea turtles (*Chelonia mydas*) were observed swimming approximately 10-m offshore during the nearshore survey, although an official turtle count was not performed since these animals were located outside the study area.

Adult green sea turtles commonly forage in the shallow nearshore areas and coral reefs. The hawksbill sea turtle is much less common in the Hawaiian Islands than the green sea turtle. Sea turtles use both terrestrial habitats (beaches for nesting and/or basking) and offshore open ocean habitats. Nesting usually occurs between May through September, peaking in June and July, with hatchlings emerging through November and December. Several macroalgal species, including the invasive algae *Acanthophora spicifera*, are known to be grazed by green sea turtles and are present in the project area.

There is a possibility that Hawaiian Monk Seals (*Neomonachus schauinslandi)* may frequent the area or use the beach area to haul out. In 2015, the main Hawaiian Islands and the remote Northwestern Hawaiian Islands were designated as critical habitat for this species (50 CFR 226), published in the NOAA Final Rule (FR) (80 FR 50925). The beach area near the outfall origin is within the critical habitat for Hawaiian Monk Seals, which includes terrestrial habitat that extends five meters inland from the shoreline. Monk seal critical habitat also includes the marine habitat that extends from the shoreline out to 200m (National Oceanic and Atmospheric Administration, 2015) (Figure 4-1). The manholes evaluated in this study extend beyond the critical habitat for the Monk seal.



Source: NOAA Fisheries

Figure 4-1: Critical Habitat for Hawaiian Monk Seals

Humpback whales (*Megaptera novaeangliae*) are transient protected species that frequent Hawaiian waters annually from November to May, with a peak in February and March. Humpback whales may be observed offshore of the project area during this time.

The State protected ʻopihi (*Cellana spp.*) occurs within the project area. ʻOpihi are protected by HAR Title 13, Subtitle 4, Part V, Chapter 92. The rule prohibits harvesting ʻopihi with shells less than 1.25 inches in diameter.

None of the 20 coral species listed as threatened under the August 17, 2017, Final Rule Endangered Species Act (ESA) occur in Hawaiʻi.

5. ASSESSMENT

Construction of the nearshore concrete casing around the outfall pipeline and capping of manhole covers will likely have direct impacts and result in the loss of marine benthos in the immediate nearshore area and within the footprints of the manhole covers. The anchoring of the silt curtains placed in the nearshore waters may also impact marine benthos. The direct impact area was previously disturbed when the outfall pipeline was built or maintained. Corals are rare in the nearshore area and around MH-2, and although corals are more numerous around MH-3 and MH-4, they are mostly small individuals (less than 20cm in diameter). With time, similar coral, algae and macroinvertebrate communities will recruit to the new concrete structures and host similar assemblages seen on the existing structures.

5.1 Recommendations

During construction, best management practices (BMPs) may be implemented to reduce the risk to water quality and minimize disturbances to marine life. The construction materials and equipment used in the marine environment should clean of pollutants that may impact water quality. Vehicle or equipment refueling should be conducted away from the aquatic environment and with spill-prevention measures in place.

Prior to initiating the construction, rare or protected benthos such as corals and ʻopihi may be carefully removed from the substrate and relocated to an equivalent habitat outside of the project site. Before work begins for the day, inspections for protected species (e.g., green sea turtles, Hawaiian Monk Seals) that may have entered the project site may be conducted. Should these animals enter the site while work is in progress, construction should be halted until the animal leaves on its own accord.

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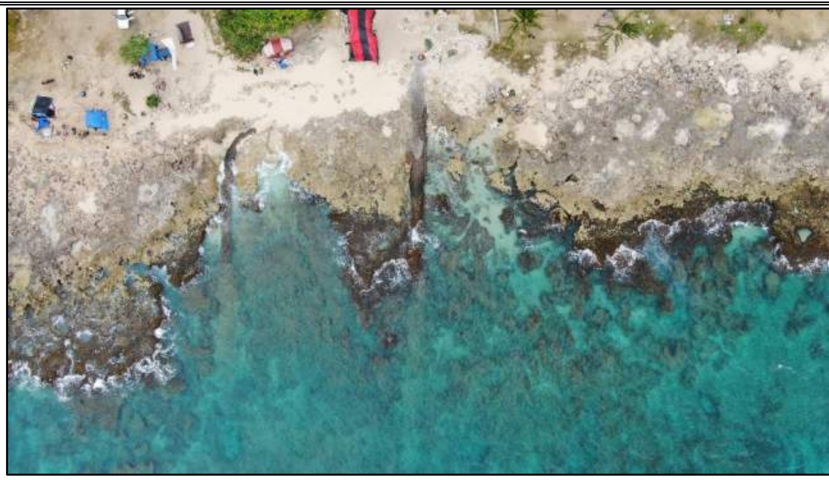
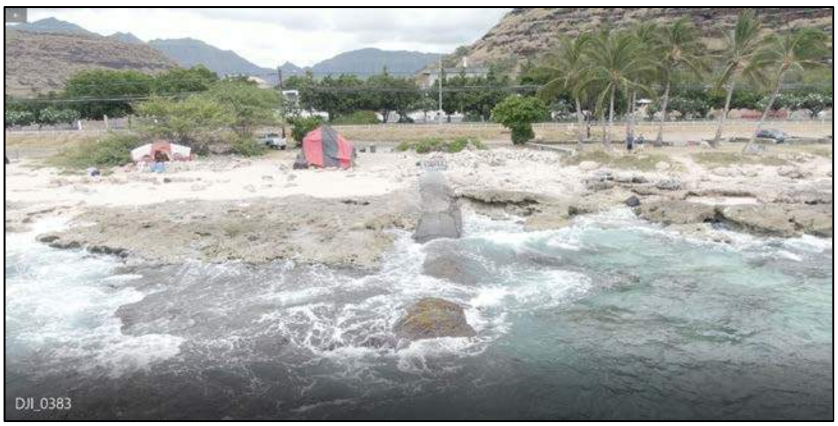
Attachment A:

Site Photographs

Table A-1: Photographs of Nearshore Survey Area

No.	Photograph	Description
1		Aerial drone photograph of nearshore survey area where WWTP outfall pipeline emerges at Lualualei Beach Park.
2		Drone photograph of the nearshore survey area facing mauka (east).
3		Concrete outfall pipe with beach rock visible to the right of the pipe.

4

Macroalgae and invertebrates inhabit the pipeline in the intertidal zone.

5

Macroalgal mat in the tidepool area facing makai (west). Pipeline is on the left side of the photo.

6

Dense macroalgal mats primarily colonized by *Turbinaria* and *Sargassum spp.,* with two helmet urchins (*Colobocentrotus atratus*).

7

Rock boring urchins (*Echinometra spp.)* are abundant in the low tide intertidal area.

8

Two spotted boxfish (*Ostracion meleagris*) at approximately 7 ft depth.

9

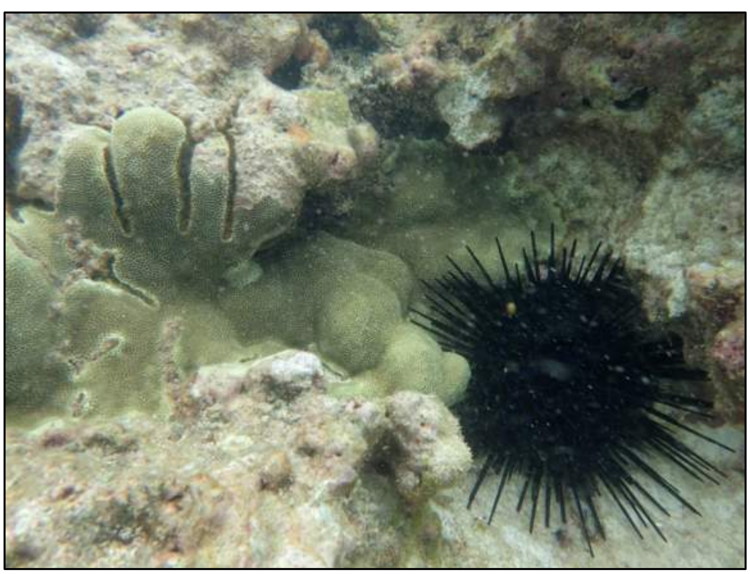
The endemic blue soft coral (*Sarcothelia edmondsonii*) among a vertical rock face at approximately 5ft depth.

10 

Whitemouth Eel hiding in a crevasse, approximately 6 ft depth.

11 

Sea cucumber *(Holothuria atra*) among rocks and rubble along perpendicular transect.

12 

Porites lobata coral with wana (*Diadema paucispinum*)

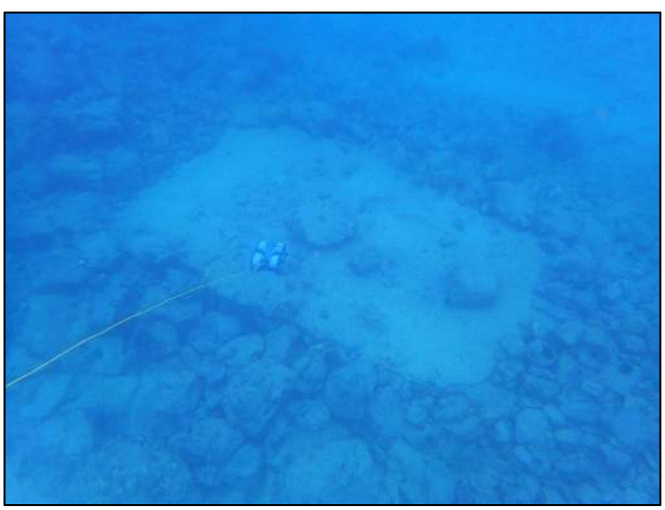
13

Pocillopora meandrina in the nearshore survey area. Depth approximately 10 ft.

14

Rock shelf with fish in the nearshore area.

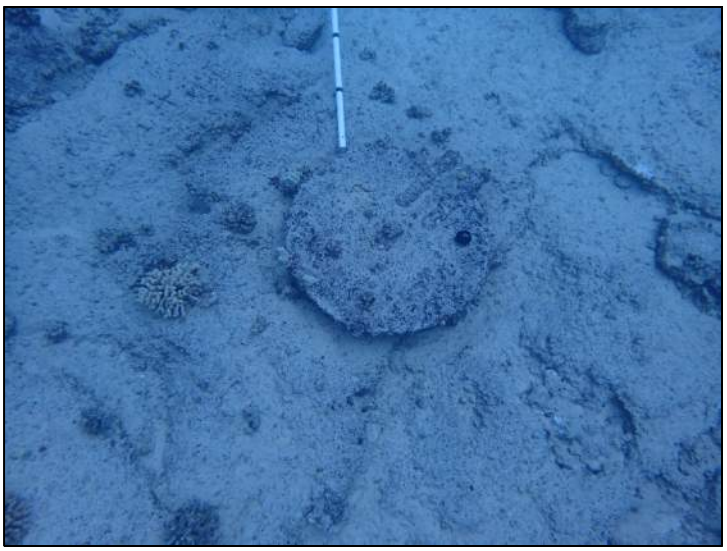
Table A-2: Photographs of Manhole Survey Areas

No.	Photograph	Description
1		Aerial drone photograph of nearshore survey area where WWTP outfall pipeline emerges at Lualualei Beach Park.
2		MH-2, approximately 20 ft. depth.
3		MH –3 with ROV in the foreground.

4

Close up of MH-3 manhole cover at about 26 ft depth. Corals can be seen growing on the manhole cover.

5



MH-4 at approximately 30 ft depth. Several small corals exist on and around the manhole. A collector urchin resides on the manhole.

6

MH-4 with a partially deceased *Pocillopora meandrina*.

Attachment B:

Species List

Table B-1: Nearshore Survey - Algae

	Scientific Name	Common Name	Status	Abundance
Chlorophyta	*Ulva lactuca*	Sea Lettuce	IND	C
	Dictyosphaeria cavernosa	Hard Bubble Seaweed	IND	O
	Cladophora sp.	Filamentous Green Algae	IND	C
	Neomeris annulata	Ringed Finger Seaweed	IND	O
Ochrophyta	*Turbinaria ornata*	Ornate Seaweed	IND	A
	Sargassum echinocarpum	Prickly Sargassum	END	A
	Sargassum polyphyllum	Variable Sargassum	END	A
	Padina sanctae-crucis	St. Croix Padina	IND	O
	Sphacelaria sp.	Black Tufted Seaweed	IND	C
	Dictyota spp.		IND	C
Rhodophyta	*Acanthopora specifera*	Spiny Seaweed	IND	C
	Amphiroa beauvosii	Stiff Amphiroa	IND	O
	Laurencia mcdermidae	Mcdermid's Laurencia	END	O
	Gelidiellia acerosa	Comon Gelidiella	IND	C
	Gracilaria coronopifolia	Ogo	END	O
	Asparagopsis taxiformis	Asparagus seaweed	IND	R
	Hydrolithon onkodes	Encrusting Coralline Algae	IND	A
	Tricleocarpa fragilis	Fragile Galaxaura	IND	C
	Jania pumila	Dwarf Jania	IND	O
	Sporolithon erthraeum	Patchy Red Coralline Algae	IND	O
	Hypnea musciformis	Hooked Seaweed	INVASIVE	C
Cyanobacteria	*Lyngbya majuscula*	Stinging Limu	IND	C

Table B-2: Nearshore Survey - Macroinvertebrates

Phylum	Scientific Name	Common Name	Status	Abundance
Porifera	*Leucetta sp.*	Sponge	IND	R
Mollusca	*Nerita picea*	Pipipi	END	A
	Cellana exarata	Dark Footed Limpet	END	O
	Cellana sandwicensis	Hawaiian Limpet	END	O
	Littoraria pintado	Dotted Periwinkle	IND	A
	Echinolittorina hawaiiensis	Hawaiian Periwinkle	END	A
	Monetaria caputophidii	Snakehead Cowry	END	O
	Morula granulata	Granulated Drupe	IND	C
	Thais intermedia	Drupe	IND	R
	Isognomon perna	Brown Purse Shell	IND	O
	Isognomon californicum	Black Purse Shell	END	O
	Nesochthamalus intertextus	Purple Rock Barnacle	END	R
	Cypraea mauritiana	Humpback Cowry	IND	R
Arthropoda	*Grapsus tenuicrustatus*	Thin-shelled Rock Crab	IND	C
	Calcinus pictus	Painted Hermit Crab	END	A
	Calcinus seurati	Seurat's Hermit Crab	IND	A
Cnidaria	*Zoanthus*	Anthozoans	IND	O
Echinodermata	*Holothuria atra*	Black Sea Cucumber	IND	O
	Holothuria whitmaei	Teated Sea Cucumber	IND	R
	Echinometra oblonga	Black Rock-Boring Urchin	IND	A
	Colobocentrotus atratus	Helmet Urchin	IND	A
	Echinometra mathaei	Pale Rock-Boring Urchin	IND	O
	Diadema paucispinum	Wana	IND	O
	Echinostrephus aciculatus	Needle Spine Urchin	IND	C
	Ophiocoma brevipes	Mottled Brittlestar	IND	R

Table B-3: Nearshore Survey - Fish

Family	Scientific Name	Common Name	Status	Abundance
Acanthuridae	*Ctenochaetus strigosus*	Kole	END	O
	Acanthurus nigrofuscus	Brown Surgeonfish	IND	C
	Acanthurus triostegus	Manini / Convict Tang	IND	O
Balistidae	*Rhinecanthus rectangulus*	Humuhumunukunukuapua'a	IND	R
Blenniidae	*Entomacrodus marmoratus*	Marbled Blenny	END	C
Gobiidae	*Opua nephodes*	Cloudy Goby	END	C
Labridae	*Thalassoma duperrey*	Saddleback Wrasse	END	O
	Halichoeres ornatissimus	Ornate wrasses - Christmas Wrasses	IND	R
	Thalassoma trilobatum	Christmas Wrasse	IND	O
	Thalassoma purpureum	Surge Wrasse	IND	O
Muraenidae	*Gymnothorax meleagris*	Whitemouth Moray Eel	IND	R
Ostraciidae	*Ostracion meleagris*	Spotted Boxfish	IND	R
Pomacentridae	*Abudefduf abdominalis*	Mamo	END	C
	Abudefduf vaigiensis	Seargent Fish	IND	O
	Abudefduf sordidus	Kupipi	IND	O
	Dascyllus albisella	Hawaiian Dascyllus	END	O
	Chromis ovalis	Oval Chromis	END	O
	Plectroglyphidodon imparipennis	Brightye Damselfish	IND	O
Tetraodontidae	*Canthigaster jactator*	Hawaiian Whitespotted Puffer	END	R

Table B-4: MH-2 Species List

Corals

Scientific Name	Common Name	Status	Abundance
Pocillopora meandrina	Cauliflower Coral	IND	R

Invertebrates

Phylum	Scientific Name	Common Name	Status	Abundance
Echinodermata	*Diadema paucispinum*	Wana	IND	R
	Tripneustes gratilla	Collector Urchin	IND	R

Fish

Family	Scientific Name	Common Name	Status	Abundance
Acanthuridae	*Acanthurus olivaceus*	Orangebar Surgeonfish	IND	O
	Acanthurus blochii	Ringtail Surgeonfish	IND	R
Balistidae	*Sufflamen fraenatum*	Bridled Triggerfish	IND	R

Table B-5: MH-3 Species List

Corals

Scientific Name	Common Name	Status	Abundance
Pocillopora meandrina	Cauliflower Coral	IND	R
Porites evermanni	Brown Lobe Coral	END	O
Porites lobata	Lobe Coral	IND	O

Algae

	Scientific Name	Common Name	Status	Abundance
Rhodophyta	*Hydrolithon onkodes*	Encrusting coralline algae	IND	C

Invertebrates

Phylum	Scientific Name	Common Name	Status	Abundance
Echinodermata	*Echinometra mathaei*	Pale Rock-boring Urchin	IND	O
	Echinostrephus aciculatus	Needle-Spined Urchin	IND	O
	Tripneustes gratilla	Collector Urchin	IND	R

Fish

Family	Scientific Name	Common Name	Status	Abundance
Pomacentridae	*Abudefduf abdominalis*	Mamo	END	C
Pomacentridae	*Abudefduf vaigiensis*	Seargent Fish	IND	O
Acanthuridae	*Acanthurus blochii*	Ringtail Surgeonfish	IND	R
Acanthuridae	*Aulostomus chinensis*	Chinese Trumpetfish	IND	R
Chaetodontidae	*Chaetodon fremblii*	Bluestriped Butterflyfish	END	R
Chaetodontidae	*Chaetodon miliaris*	Milletseed Butterflyfish	END	R
Chaetodontidae	*Chaetodon quadrimaculatus*	Fourspot Butterflyfish	IND	R
Acanthuridae	*Ctenochaetus strigosus*	Kole	END	C
Pomacentridae	*Dascyllus albisella*	Hawaiian dascyllus	END	C
Chaetodontidae	*Forcipiger longirostris*	Longnose Butterflyfish	IND	R
Kuhliidae	*Kuhlia sandvicensis*	Reticulated Flagtail	IND	R
Kyphosidae	*Kyphosus hawaiiensis*	Hawaiian Chub	END	R
Lutjanidae	*Lutjanus kasmira*	Bluestripe Snapper	IND	O
Balistidae	*Melichthys niger*	Black Triggerfish	IND	O
Balistidae	*Melichthys vidua*	Pinktail Triggerfish	IND	R
Lethrinidae	*Monotaxis grandoculis*	Bigeye Emperor	IND	O
Holocentridae	*Myripristis berndti*	Hawaiian Squirrelfish	END	R
Cirrhitidae	*Paracirrhites forsteri*	Blackside Hawkfish	IND	R
Mullidae	*Parupeneus multifasciatus*	Manybar Goatfish	IND	C
Pomacentridae	*Stegastes marginatus*	Hawaiian Gregory	END	R
Balistidae	*Sufflamen bursa*	Lei Triggerfish	IND	R
Balistidae	*Sufflamen fraenatum*	Bridled Triggerfish	IND	R
Labridae	*Thalassoma duperrey*	Saddle Wrasse	END	C
Labridae	*Thalsassoma ballieui*	Blacktail Wrasse	END	R

Table B-6: MH-4 Species List

Corals

Scientific Name	Common Name	Status	Abundance
Pocillopora meandrina	Cauliflower Coral	IND	O
Porites evermanni	Brown Lobe Coral	END	R
Porites lobata	Lobe Coral	IND	A
Montipora flabellata	Blue Rice Coral	IND	R

Invertebrates

Phylum	Scientific Name	Common Name	Status	Abundance
Echinodermata	*Echinometra mathaei*	Pale Rock-boring Urchin	IND	C
	Diadema paucispinum	Wana	IND	O

Fish

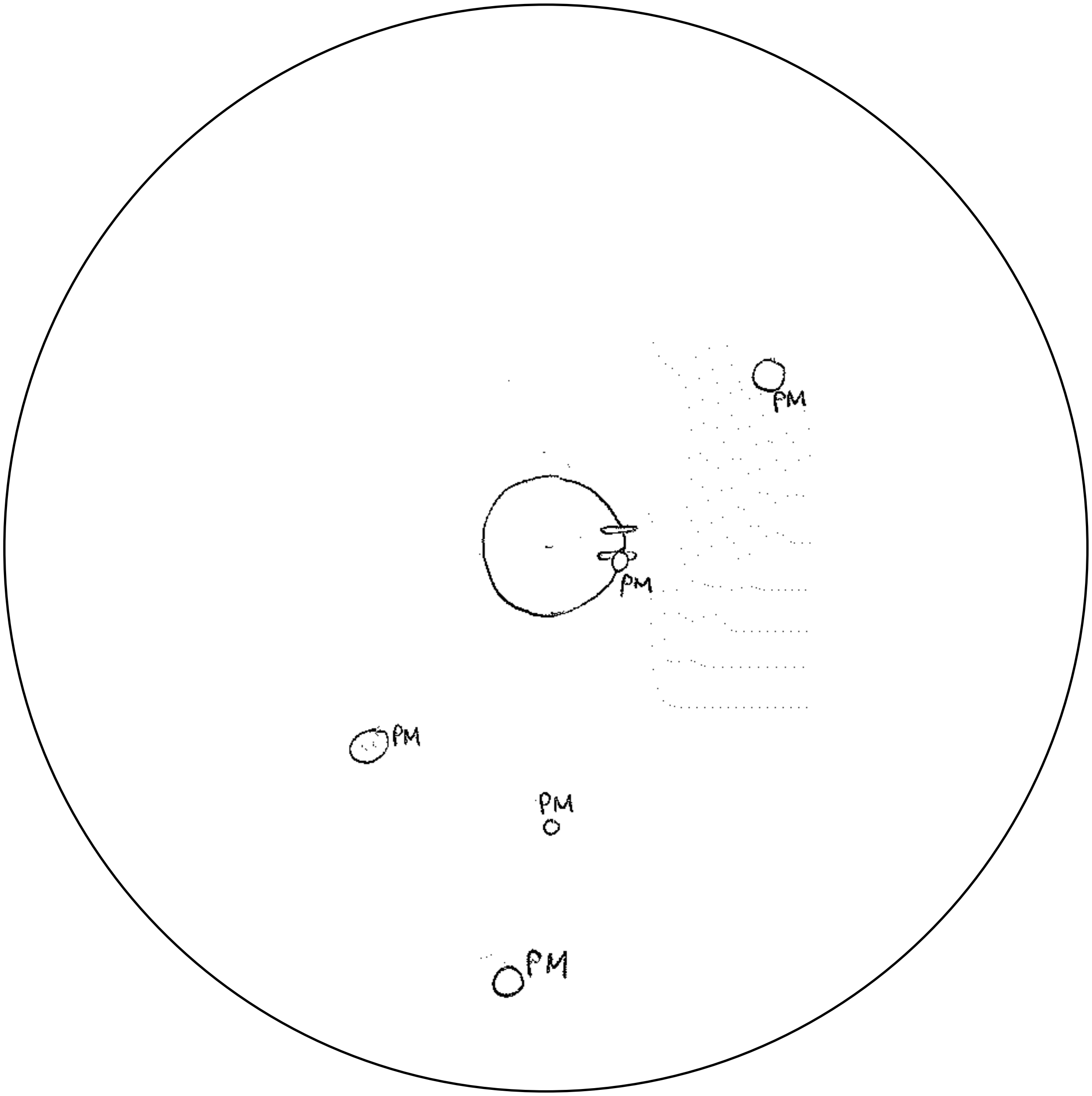
Family	Scientific Name	Common Name	Status	Abundance
Pomacentridae	*Abudefduf abdominalis*	Mamo	END	O
Acanthuridae	*Acanthurus blochii*	Ringtail Surgeonfish	IND	R
Acanthuridae	*Acanthurus nigroris*	Bluelined Surgeonfish	IND	R
Serranidae	*Cephalopholus argus*	Peacock Grouper / Roi	INVASIVE	R
Chaetodontidae	*Chaetodon lunula*	Oval Butterflyfish	IND	R
Chaetodontidae	*Chaetodon multiinctus*	Multibrand Butterflyfish	END	R
Chaetodontidae	*Chaetodon quadrimaculatus*	Fourspot Butterflyfish	IND	R
Pomacentridae	*Chromis vanderbilti*	Blackfin Chromis	IND	R
Acanthuridae	*Ctenochaetus strigosus*	Kole	END	O
Pomacentridae	*Dascyllus albisella*	Hawaiian dascyllus	END	C
Chaetodontidae	*Forcipiger longirostris*	Longnose Butterflyfish	IND	R
Muraenidae	*Gymnothorax flavimarginatus*	Yellowmargined Moray	END	R
Balistidae	*Melichthys niger*	Black Triggerfish	IND	O
Lethrinidae	*Monotaxis grandoculis*	Bigeye Emperor	IND	O
Mullidae	*Parupeneus multifasciatus*	Manybar Goatfish	IND	C
Pomacentridae	*Scarus psittacus*	Hawaiian gregory	END	R
Labridae	*Thalassoma duperrey*	Saddle Wrasse	END	C
Acanthuridae	*Zebrasoma flavescens*	Yellow Tang	IND	R

Attachment C:

Manhole Coral Maps

Manhole 2 (MH-2)

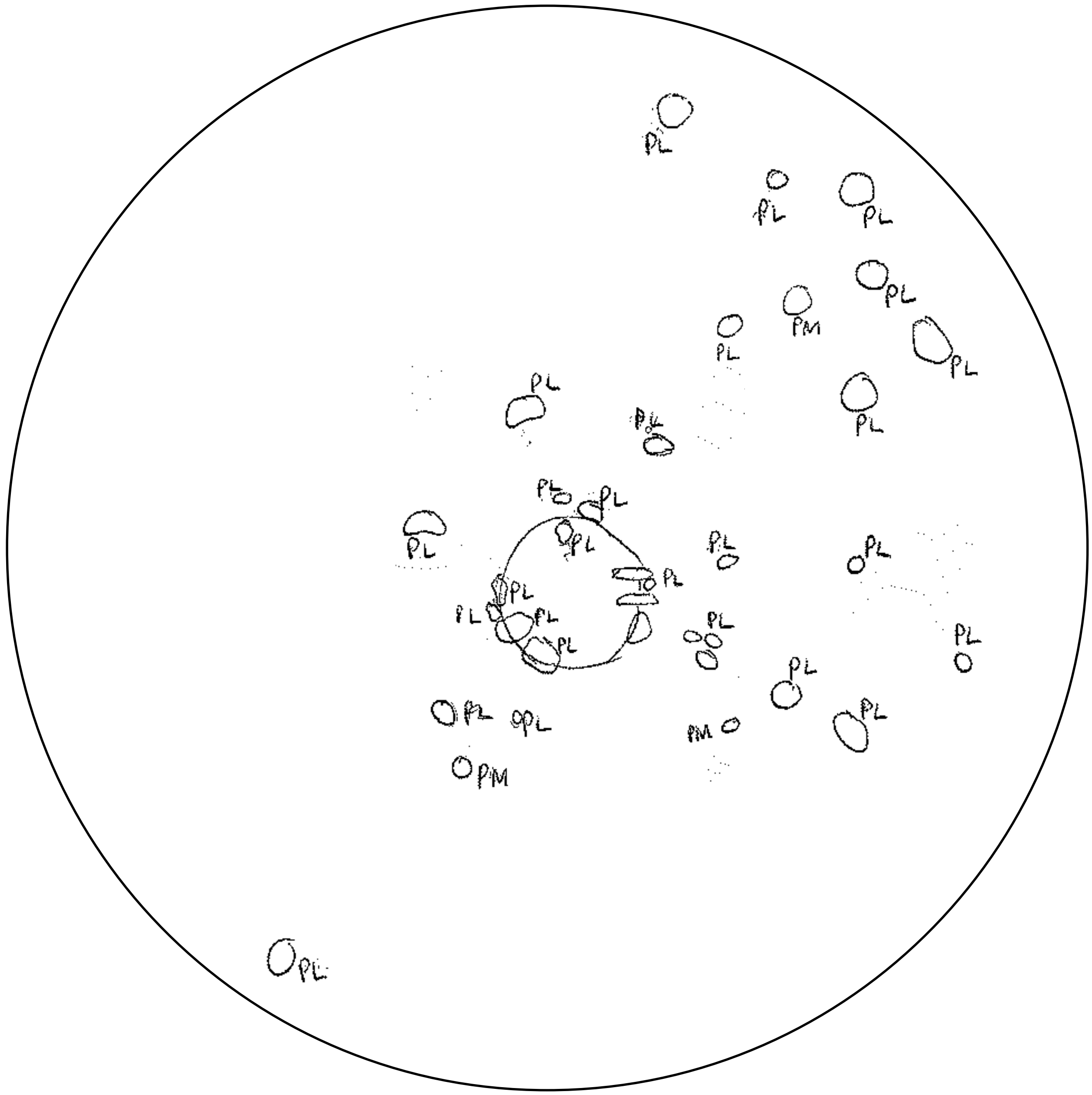
PM – *Pocillopora meandrina*



Manhole 3 (MH-3)

PL – *Porites lobata*

PM – *Pocillopora meandrina*

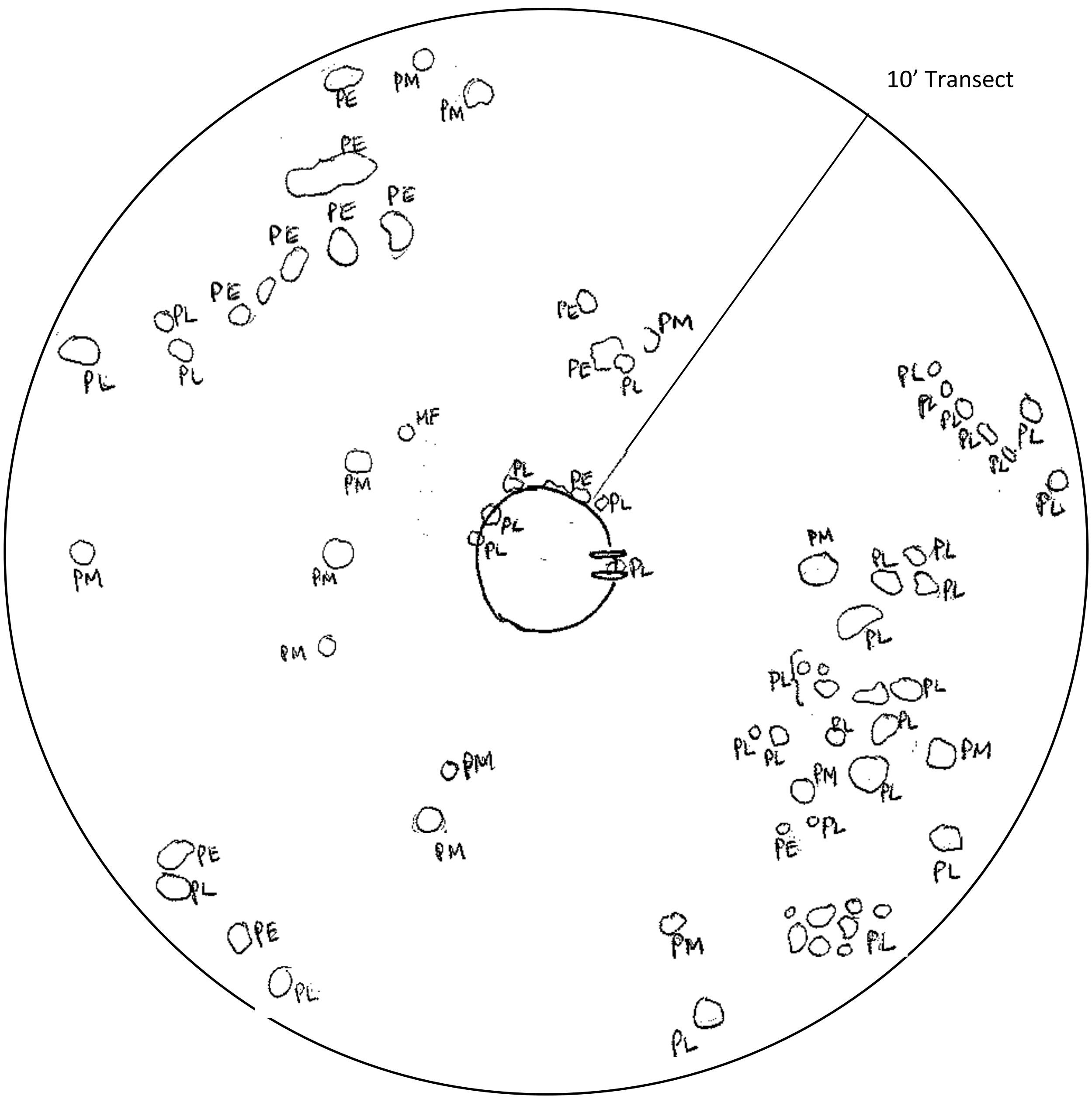


Manhole 4

PE – *Porites evermanni*

PL – *Porites lobata*

PM – *Pocillopora meandrina*



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Appendix E

Archaeological Literature Review Report in Support of the Waianae Wastewater Treatment Plan (WWTP) Outfall Improvements and Rehabilitation Project, Waianae Ahupuaa, Waianae District, Island of Oahu, Hawaii

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PRELIMINARY DRAFT

Archaeological Literature Review Report in Support of the Waianae Wastewater Treatment Plant (WWTP) Outfall Improvements and Rehabilitation Project, Waiʻanae Ahupuaʻa, Waiʻanae District, Island of Oʻahu, Hawaiʻi

TMK: (1) 8-6-001:0007 por.

Prepared for:
SSFM International
501 Sumner Street, Suite 620
Honolulu, Hawaii 96817

April 2021

PACIFIC CONSULTING SERVICES, INC.

720 Iwilei Road, Suite 424, Honolulu Hawaii 96817

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PRELIMINARY DRAFT REPORT

Archaeological Literature Review Report in Support of the Waianae Wastewater Treatment Plant (WWTP) Outfall Improvements and Rehabilitation Project, Waiʻanae Ahupuaʻa, Waiʻanae District, Island of Oʻahu, Hawaiʻi

TMK: (1) 8-6-001:0007 por.

By

Nicole I. Vernon, M.A.

Dennis Gosser, M.A.

Principal Investigator

Prepared For:

SSFM International

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Honolulu, Hawaii 96817

Prepared By:

Pacific Consulting Services, Inc.

720 Iwilei Road, Suite 424

Honolulu, HI 96817

April 2021

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MANAGEMENT SUMMARY

Document Title:	Archaeological Literature Review in Support of the Waianae Wastewater Treatment Plant (WWTP) Ocean Outfall Project, Wai‘anae Ahupua‘a, Wai‘anae District, Island of O‘ahu, Hawai‘i
Date/Revised Date:	Preliminary Draft: September 2020
Archaeological Permit #:	SHPD Permit No. 21-05
Project Location:	WWTP, Wai‘anae Ahupua‘a, Wai‘anae District, Island of O‘ahu, Hawai‘i
Project TMK:	(1) 8-6-001:007
Land Owner:	State of Hawai‘i
Project Proponents:	Department of Design and Construction, City and County of Honolulu
Project Tasks:	Archaeological Literature Review
Project Acreage:	1.4 acres (.57 ha)
Principal Investigator:	Dennis Gosser, M.A.
Regulatory Oversight:	Chapter 6E-7 and 6E-8, Hawaii Revised Statutes (HRS) and Hawaii Administrative Rules (HAR) Chapter 275
Project Background:	The project scope of work includes rehabilitation and improvements to the existing ocean outfall sewer.
SIHP #:	No known sites in the project area; remnants of the OR&L railroad (SIHP Site 50-80-04-09714) are potentially present.
Findings:	During previous archaeological investigations in the vicinity, no historic properties have been recorded. However, the beach location and lack of development in the project area does suggest that traditional Hawaiian human burials may be encountered. Also, based on historical maps a portion of the OR&L railroad (SIHP Site 50-80-04-09714) may be extant in the project area.
Human Skeletal Remains:	None identified with in the project area; traditional Hawaiian burials are potentially present based on beach environment.
Recommendations:	It is recommended that no historic properties will be affected with the condition that archaeological monitoring be conducted with an SHPD-approved AMP.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Under contract to SSFM International, Pacific Consulting Services, Inc. (PCSI) has prepared this Archaeological Literature Review (ALR) and Field Inspection Report in support of the Waianae Wastewater Treatment Plant (WWTP) Ocean Outfall project in Wai‘anae on O‘ahu Island (Figure 1). The project proponent is the Department of Design and Construction, City and County of Honolulu (CCH) and the land owner is the State of Hawai‘i. The project scope of work includes rehabilitation and improvements to the existing ocean outfall sewer. A field inspection and a historical, cultural, and archaeological background study was conducted in order to evaluate any potential effect on historic properties and to recommend mitigation of any adverse effect, if warranted. This work was carried out in accordance with Hawaii Revised Statutes (HRS) Chapter 6E, and Title 13 of the Hawaii Administrative Rules (HAR), Subtitle 13 (State Historic Preservation Division Rules), Chapter 275 (*Rules Governing Procedures for Historic Preservation Review for Governmental Projects Covered Under Sections 6E-7 and 6E-8, HRS*).

PROJECT AREA LOCATION AND DESCRIPTION

The proposed project is located at the Waianae WWTP ocean outfall sewer site, which is on the west side of Farrington Highway, across from the main facility at 86-220 Farrington Highway. The project area is in a portion of Tax Map Key (TMK) parcel (1) 8-6-001:007. Work is limited to a 1.4-acre (.57-ha) portion of the parcel. The plat map for the parcel is shown in Figure 2. Site plans for the existing ocean outfall are provided in Appendix A.

Proposed work will involve rehabilitation and improvements to the existing 36-inch ocean outfall sewer pipeline, which discharges treated effluent 6,180 feet offshore from the WWTP; in addition, three manholes on the pipeline will be capped. It has been anticipated that the existing outfall will experience reduced flow capacity due to the effects of sea level rise and damage may be caused by shoreline erosion (CH2M Hill 2016:28).

ENVIRONMENTAL SETTING

Wai‘anae Ahupua‘a is located on the leeward side of O‘ahu. It is bordered on the north by Mākaha Ahupua‘a and the south by Nānākuli Ahupua‘a. The current undertaking is situated on the shoreline, just outside the mouth of Lualualei Valley. This amphitheater-headed valley is defined by Kāne‘īlio Point and the edge of Pu‘uheleakalā on the coast and extends five miles inland. The current study area immediately north of Kalaeokakao, also known as Goat Point, and west of Pu‘umā‘ili‘ili (see Figure 1). The coastal area of this region contains white sand beaches and old, uplifted coral reefs and limestone flats.

TOPOGRAPHY AND SOILS

The project area is situated on the shoreline of Lualualei beach Park. The area is underlain by karstic flats of raised limestone reef lands (Stearns 1939:plate 1). The project area is underlain by Mokuleia clay (Mtb), as shown in Figure 4. The Mokuleia series are shallow, well-drained soils that formed in recent alluvium deposited over coral sand and are found on the coastal plains (Foote et al. 1972:95).

RAINFALL, HYDROLOGY, AND VEGETATION

Mean annual rainfall in this portion of west O‘ahu averages 553.0 millimeters (mm) (21.77 inches[in]) annually, with most of the rainfall occurring between November and March (Giambelluca et al. 2013). The channelized Mā‘ili‘ili Stream is approximately 550 meters south of the project area (see Figure 4). Vegetation includes *‘aki‘aki* (seashore rush grass, *Sporobolus virginicus*), *kiawe* (*Prosopis pallida*), *milo* (portia tree, *Thespesia populnea*), *niu* (coconut, *Cocos nucifera*), *pōhuehue* (beach morning glory, *Ipomea pes-caprae subsp. brasiliensis*).

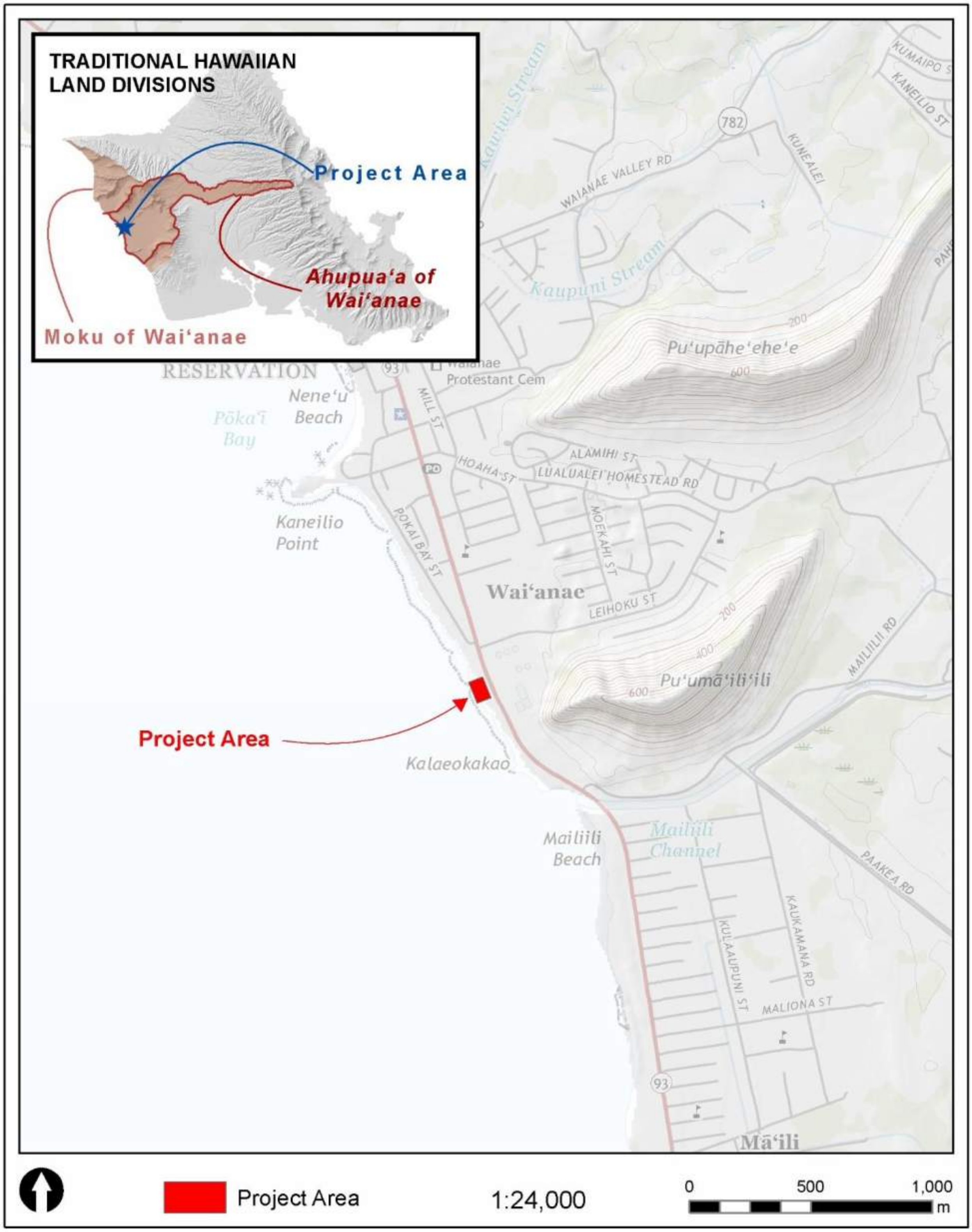

Figure 1. Project Area Shown on USGS 2017 Waianae Topographical Quadrangle (USGS 2017).

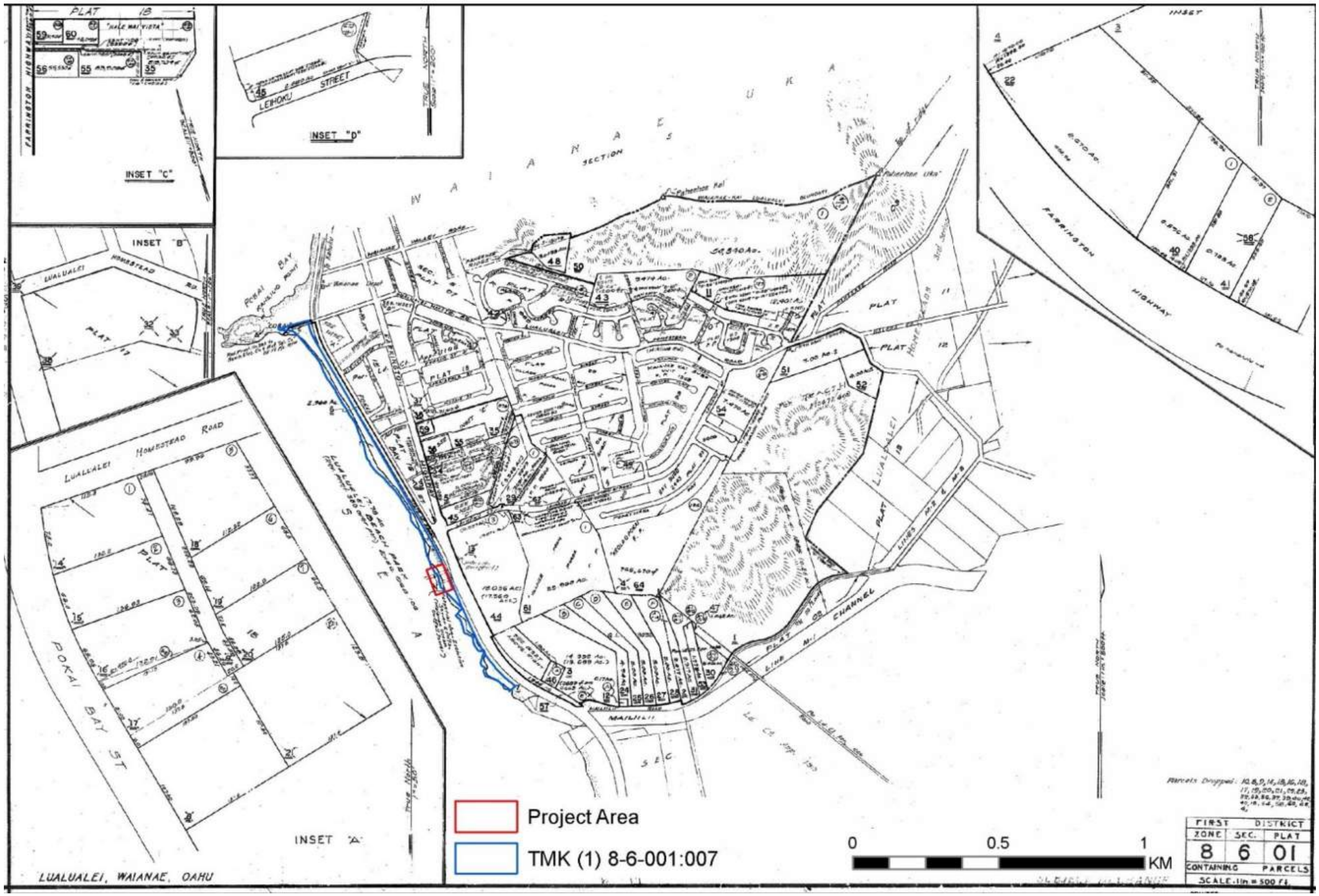

Figure 2. Tax Map for Plat (1) 8-6-01 Showing the Project Area (Tax Maps Bureau and Survey Department 1933).

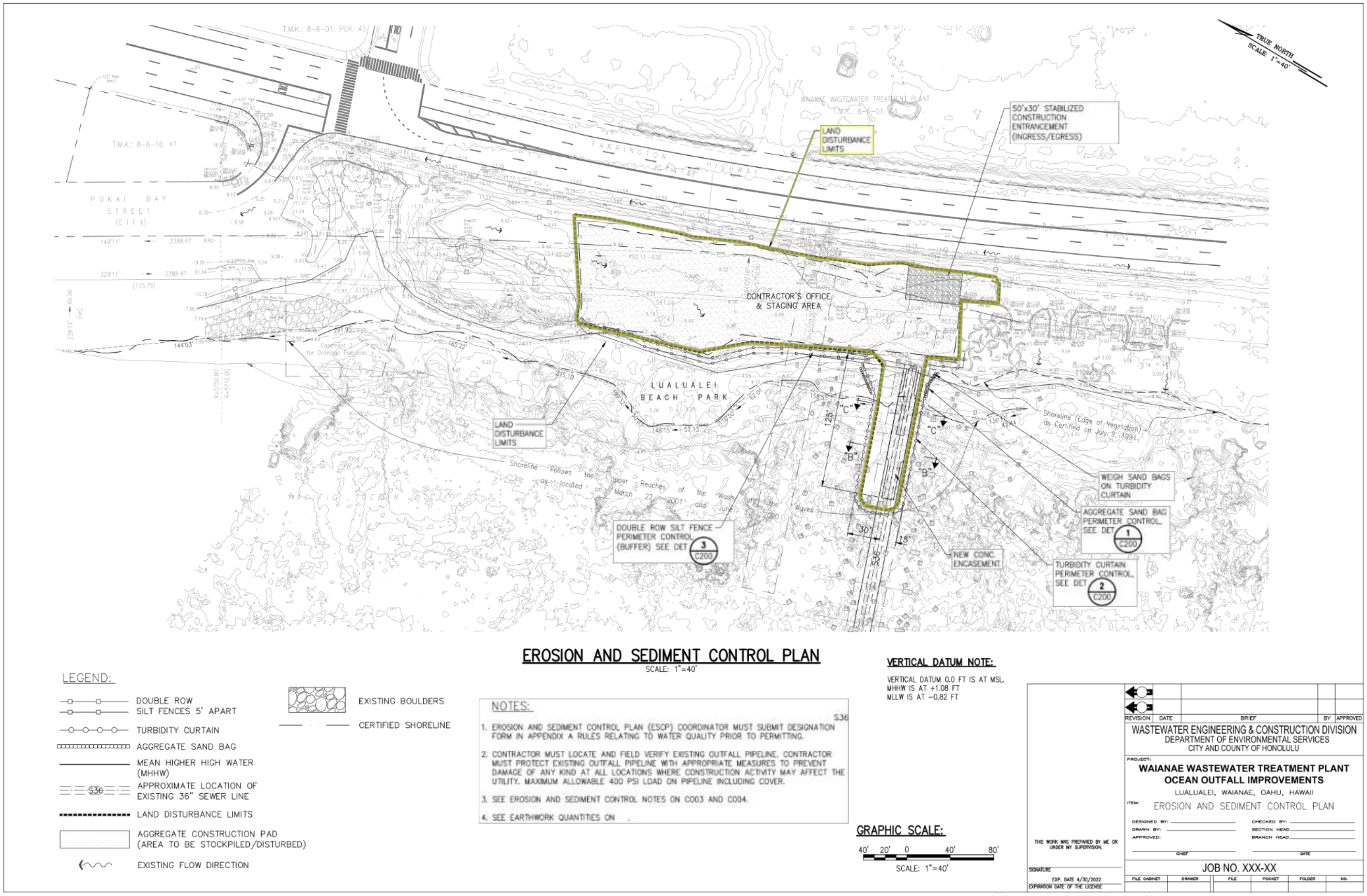

Figure 3. Design Plan Showing Project Area and the Land Disturbance Limit.

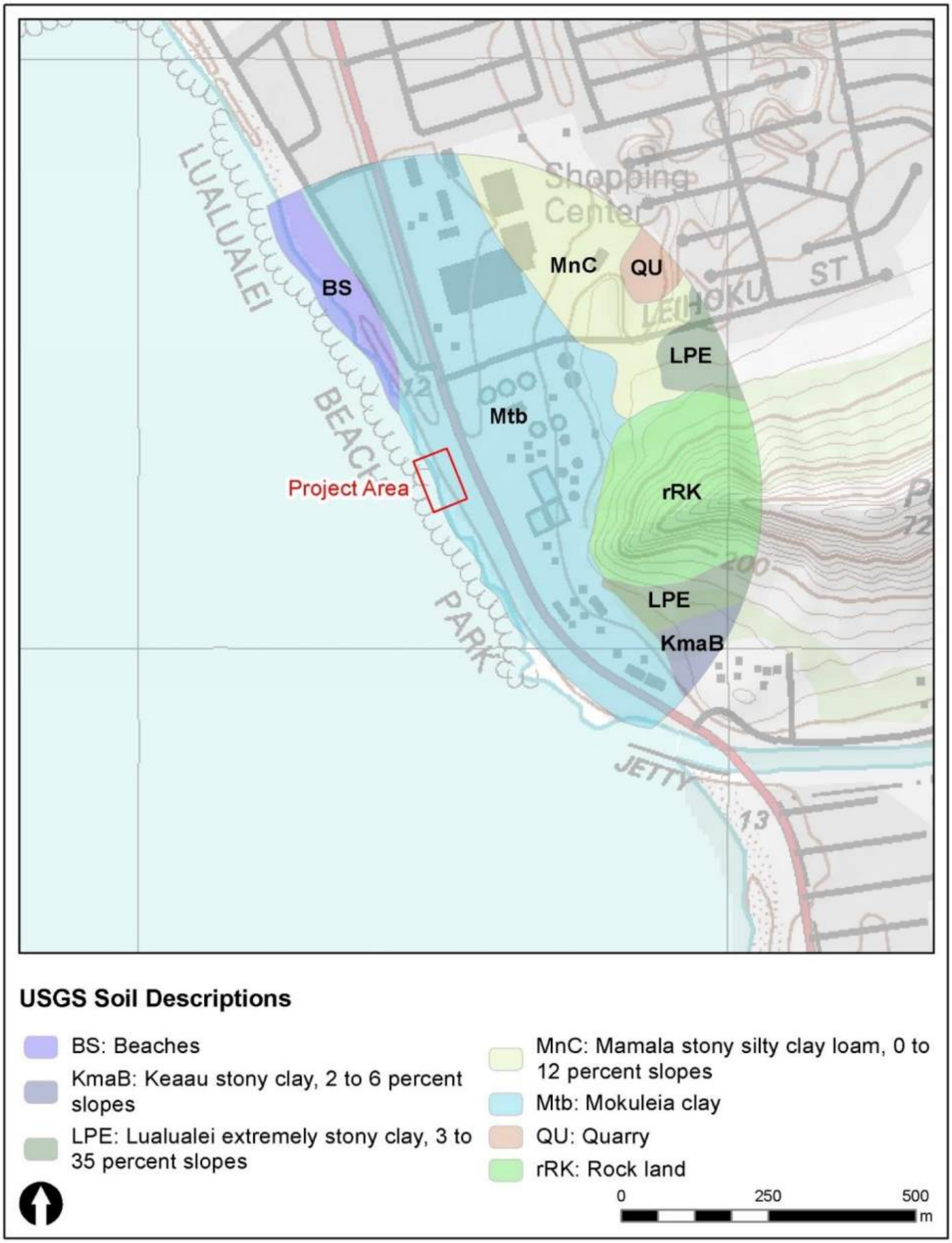

Figure 4. Soil Units in the Vicinity of the Project Area (Soil Survey Staff, NRCS, USDA 2020).

HISTORICAL BACKGROUND

Archival background research and literature review examined maps, historical and archival documents, and previous archaeological studies in the vicinity of the project area. Relevant historical maps were georeferenced to determine where traditional Hawaiian or historic features may fall within the project area. The information obtained from these sources was synthesized to present data findings and to evaluate the potential for archaeological and cultural resources in the project area.

PLACE NAMES

Lualualei can be translated as “flexible wreath,” which refers to a battle formation used by Māʻilikūkahi against four invading armies in the 1400s during the battle of Kīpapa (McGrath et al. 1973:11; Sterling and Summers 1978:68). Hawaiian historian John Papa ʻĪʻī offers another interpretation and translated the name as “beloved one spared.” He relates a story of a relative accused of wearing the king’s *malo*, or loincloth, which was punishable by death:

> The company, somewhat in the nature of prisoners, spent a night at Lualualei. There was a fishpond there on the plain and that was where the night was spent. After several days had passed, the proclamation from the king was given by Kulaʻinamoku, that there was no death and that Kalakua did not wear the king’s loincloth. Thus was the family of Luluku spared a cruel death. For that reason, a child born in the family later was named Lualualei [ʻĪʻī 1959:23].

TRADITIONAL HISTORY AND LAND USE

Waiʻanae Moku has a wealth of associated myths and legends, many concerning kings and gods. For example, King Kamehamaha I is said to have lost the battle for Kauaʻi in 1796 because he failed to pay homage to the Waiʻanae gods. According to Kamakau: “The fleet went on to Waiʻanae and the war god [Kū-kaʻili-moku] was carried ashore that evening” (1992:173). Kamakau asserts that Kamehameha and his fleet sailed before midnight, but according to the traditional stories of Waiʻanae, he stayed longer to rededicate two heiau (temple) to his own war god (McGrath et al. 1973:14). This action angered the gods of Waiʻanae, who then caused the storm that ended the expedition called Kaʻieʻiewaho to Kauaʻi.

In contrast to the dearth of land resources in Waiʻanae Moku during the pre-Contact period, marine resources were abundant. The ancient chief Kewalo is said to have distinguished himself as a fisherman in the waters off Kaʻena Point, while there are also stories from Waiʻanae that tell of the kupua1 Māui as a fisherman (Beckwith 1940:232–3; Handy and Handy 1972:467).

According to traditional accounts from Wai’anae, Lualualei is the birthplace of Māui and his brothers (Beckwith 1940:226). Several stories (see Sterling and Summers 1978:64–66) tell of events that occurred when Maui was living at Ulehawa in southern Lualualei. The following is a version of a story from Kamakau (1991:135) that tells of Māui in Waiʻanae:

> Akaalana lived with Hinakawea, and Mauimua, Maui-waena, Maui-ikiiki, and Maui-a-kalana, all boys were born.
>
> At Ulehawa and Kaolae on the south side of Waianae was their birthplace. There are pointed out the things left by Maui. Among other famous things to be seen are the cave in which Hina made her tapa, the fishhook Manaiakalani, the snare for catching the sun, the places where Maui's adzes were made, and all his other implements. But Maui-a-kalana went to Kahiki after the birth of his son in Hawaiʻi and the last of his children born of Hina-a-kealoha was Hina-akeka, and these became came the ancestors of all lands in the ocean as far as the country which foreigners call New Zealand. There in the islands of the ocean

[1] A demigod or cultural hero in Hawaiian.

> Maui performed those famous exploits which are ever held in remembrance among this people [Kamakau 1991:135].

Archaeological and historical documentation suggest that Wai‘anae was first occupied around AD 1200 when population pressure on the windward coast and in the Kona Moku pushed people to expand across O‘ahu. A shift from temporary to permanent settlement likely began in the coastal and well-watered areas by the 1300s. Archaeological evidence indicates that the upper valleys followed this permanent settlement pattern by the 1400s (Cordy 2002a). The arid climate of Wai‘anae Moku, particularly from Mākua to Nānākuli, would have made the well-watered valleys the most attractive locations for settlement on the west side of O‘ahu.

Archaeological evidence indicates that early habitation in the upper valley of Lualualei dates to the AD 1300s–1500s, while temporary habitation and dryland fields in the lower upper valley indicated dates of AD 1400s–1600s, which according to Cordy (2002a:20) suggests earlier settlement down near the shore. By the 1600s, permanent houses in the upper portion of the valley had increased, and *lo‘i* were present along the upper Pūhawai and Kolekole streams (Cordy 2002a:32). When Europeans arrived in the area, permanent settlements were present on the coast and the in the upper valley (Cordy 2002a:90).

In upper Lualualei Valley, there were several *heiau*: at Pāhoa was Nioi‘ula Heiau (SIHP Site 50-80-08-00149), which is believed to have been associated with Kākuihihewa (ruled AD 1640–1660); Kakioe Heiau (State Inventory of Historic Places [SIHP] Site 50-80-08-00151), near a spring at Pūhāwai; and several small *heiau* within the navy land of Lualualei (Cordy 2002a:91–93). Archaeological work has also documented numerous house sites in the upper valley, along with evidence of dryland agriculture. As for the lower valley, only evidence of temporary habitation has been recorded, with the exception sites along Mā‘ili‘ili Stream (Cordy 2002a:94).

Coastal archaeological sites are sparse. McAllister (1933:112) noted that Pu‘upahe‘ehe‘e (SIHP Site 50-80-08-00152), situated at the seaward end of the ridge had been destroyed. Ruins of Kū‘īlioloa Heiau (SIHP Site 50-80-07-00153) on Kāne‘ilio Point are extant today.

During the late pre-Contact and early history periods many political changes transpired in Wai‘anae Moku (Shefcheck and Spear 2007:9). Maui Chief Kahekili successfully battled O‘ahu warriors in 1784, with the final battle occurring at Pu‘u Kawiwi in Wai‘anae Valley. Ten years later, Kahekili died and his son, Ka-lani-kū-pule took control of the island. In 1794, Ka-lani-kū-lani, ruler of Maui, Moloka‘i, and Lāna‘i, recruited warriors from Waialua and Wai‘anae and battled Ka-‘eo-kū-pule, but they were defeated (Kamakau 1992:168). The next year Kamehameha invaded the island and took control following the Battle of Nu‘uanu in April 1795 (Kuykendall 1938:47).

When European explorers first arrived in the Hawaiian Islands in the late 18th century, the population of Wai‘anae was concentrated in Wai‘anae and Mākaha valleys. According to archaeologist Ross Cordy, the area was a “political and religious center of the district in the late 1600s–1700s” (2002a:47). After Kamehameha I took power, Wai‘anae Moku was no longer considered a political center. Many people from other parts of O‘ahu fled to Wai‘anae for refuge. The following is an account of this event by A. Mouritz (1934 in Sterling and Summers 1978:68):

> After the rout of the army of Kalanikupule, the king of Oahu at Nuuanu, April 29, 1795 by the invading army of Kamehameha Nui, the conquered Oahuans were driven from the ir homes, their lands seized and divided amongst the friends of Kamehameha--the despoiled people in large numbers fled to Waianae and settled there. This part of Oahu being hot, arid, isolated, with little water, was not coveted by the invaders; the sea off the coast of Waianae has always supplied an abundance of fish, hence the name --wai, water; anae, large mullet [Mouritz 1934 in Sterling and Summers 1978:68].

Immediately south of the project area is the area known as Mā‘ili, between Pu‘umā‘il‘ili and Pu‘uohulu. The origin of the two ridges is told of in the following story:

> Puu o Hulu was said to be a chief who was in love with Maʻiliilii, one of twin sisters, but he could never tell, whenever he saw them which of the two was his beloved. A moʻo changed them all mountains so he is still there watching and trying to distinguish his loved one [Victoria Holt, Nov. 1954 in Sterling and Summers 1978:67].

Hawaiian historian John Papa ʻĪʻī wrote of traditional trails on Oʻahu. The portion of the trail from Mākaha to Puʻu o Kapolei, described below, would have passed through coastal Lualualei:

> It was customary to have dwelling places along the mountain trails that led downward from here [Puu Kawiwi] into Kamaile, as well as along the beach trail of Makaha. There were many houses at Makaha were a fine circle of sand provided a landing places for fleets of fishing canoes. The trail which passes by this sandy bar was one from Puu o Kapolei, which had joined the beach trail from Puuloa and from Waimanalo. It then went along the shore all around this island [ʻĪʻī 1959:97].

POST-CONTACT HISTORY AND LAND USE

Beginning in 1811, Kamehameha I commenced intensive sandalwood logging on Oʻahu. The trade was strictly under the control of the *aliʻi* (chiefs) and harvesting was conducted by the *makaʻāinana* (commoners). After a famine in 1821 due to the intensive logging, Kamehameha reversed the order to log so that the *makaʻāinana* were not overworked to the extent that farming was neglected. He also instituted conservation measures that spared young trees (Cottrell 2002:10). Upon Kamehameha's death in 1819, Liholiho (Kamehameha II) opened the sandalwood trade to his *aliʻi*, which caused the island to revert to intensive harvesting.

One of the *aliʻi* involved in the trade was Boki Kamaʻuleʻule, chief of Waiʻanae, who later became governor of Oʻahu (Kirch and Sahlins 1992:59). The diary of Don Francisco de Paula Marin documents many of Boki's trips from Honolulu to Waiʻanae, which were thought to be for procuring goods. In 1829, he sailed to the New Hebrides searching for more sandalwood and his ship was lost at sea (Jones and Hammatt 2009:13).

During the last years of the sandalwood trade, journal entries from Stephen Reynolds indicate that availability of sandalwood from Waiʻanae was sporadic. In 1840, forest privatization measures were introduced by King Kauikeaouli, just before the Mahele. At this point, relations between the *makaʻāinana* and *aliʻi* were strained and the land was suffering from the ecological consequences of deforestation (Cottrell 2002:164).

Traditional land divisions of the fifteenth and sixteenth centuries persisted until the 1848 Mahele, which introduced private property into Hawaiian society (Kamakau 1991:54). During the Mahele, the Land Commission required the Hawaiian chiefs and *konohiki* (land agent for the *aliʻi*) to present their claims to the Land Commission. In return they were granted Land Commission Awards (LCAs) for the land quit-claimed to them by Kamehameha III. Land was divided into Crown Lands, Government Lands, and Konohiki Lands. The remaining unclaimed land was then sold publicly, "subject to the rights of the native tenants" (Chinen 1958:29).

In the case of land claims made for Konohiki lands, approval by the Land Commissioners was required before the award was made. If approved, then the awardee obtained a Royal Patent (RP) from the Minister of the Interior, which indicated that the government's interest in the land had been settled with a commutation fee. This fee was typically no more than one-third of the value of the unimproved land. This fee was paid either with cash, or, more commonly, the return of one-third of the awardee's lands (or total value of the lands awarded) (Hammatt 2013:A-3).

The Kuleana Act of 1850 allowed *hoaʻāina* (common people of the land, native tenants) to make claims to the Land Commission. The new western system of ownership resulted in many losing their land.

Often claims would be made for discontiguous cultivated plots with varying crops, but only one parcel would be awarded.

The Crown Lands became Government Lands when the Hawaiian Government was overthrown in 1895, making them public domain for sale by fee simple (Hammatt 2013:A-5). Patents were the certificates issued for the sale of such lands. Beginning in 1900, when Hawaiʻi became a U.S. territory, the certificates were called Land Patents, or Land Patent Grants (Hammatt 2013:A-5).

Following the Kuleana Act of 1850 that granted individual *kuleana* (commoner) lots; no awards were made near the current project area. Lualualei was set aside as Crown Land and in 1894 was described as "one of the best and most valuable of the Crown lands on the Island of Oahu . . . surpassing any of the other lands for richness and great fertility of the soil" (Commissioner of Public Lands 1894:36 in Blahut and Hammatt 2017:17). Obviously, this referred to other parts of the valley and not the arid coastal plain where the project area is situated.

During the mid-19th century, Waiʻanae Moku became dominated by cattle grazing. William Jarrett leased around 17,000 acres of land from Kamehameha III in 1851, much of which was in Lualualei (B.C. Liber 4:616–618 in Tulchin et al. 2007:16). Later his operation became Lualualei Ranch. In 1880, George Bowser visited the area on noted the cattle grazing:

> Leaving Waiʻanae, a ride of about two miles brought me to the Lualualei Valley, another romantic place opening to the sea and surrounded in every direction by high mountains. This valley is occupied as a grazing farm by Messrs, Dowsett & Galbraith, who lease some sixteen thousand acres from the Crown. Its dimensions do not differ materially from those of the Waiʻanae Valley, except that it is broader – say, two miles in width by a length of six or seven miles. The hills which enclose it, however, are not so precipitous as those at Waiʻanae, and have, therefore, more grazing land on their lower slopes, a circumstance which adds greatly to the value of the property as a stock farm. Although only occupied for grazing purposes at present, there is nothing in the nature of the soil to prevent the cultivation of the sugar cane, Indian corn, etc. Arrangements for irrigation, however, will be a necessary preliminary to cultivation [Bowser 1880:493-494].

Specific to the current project area, available historical maps show few features in the vicinity of the project area. In Figure 5, an 1884 map simply labels the area "sand stone plain" and notes one "solitary coconut" to the east of the project area. Between the coconut tree and the shoreline is the O.R.&L railway (SIHP Site 50-80-04-07597) and a the "Government Road" or "Old Waiʻanae Road" (SIHP Site 50-80-04-07520). The road was unpaved and lacked bridges, so prior to the highway construction travel to Waianae from Honolulu was either by ship of (Blahut and Hammatt 2017:17).

In Figure 6, the project area falls within publics lands, with Waianae Plantation and former ranching land inland, the latter of which is outlined in dark orange. The 1914 Lualualei Homestead map, shown in Figure 7, indicates the project area was near Land Grant 5006 to Willard E. Brown and Land Grant 5263 to the Makaha Coffee Co Ltd. Brown was a stockbroker in Honolulu. The Makaha Coffee Company was an early grower of coffee on O'ahu and around 1896 the company purchased 200 acres in the back of Mākaha Valley (Commercial Advertiser 1896). It can be speculated that the parcel in Lualualei was used for storage or administration.

On subsequent maps the land continues to appear desolate until the 1920s. A 1913 topographical map in Figure 8 shows the project area in scrubland, with only the road and O.R.&L railway along the coast. On 27 June 1921, the project area became a public park following the governors executive order No. 106. By the late 1920s, a railway spur led branched inland near project area, as shown on topographical maps dated 1928 and 1936 in Figures 9 and 10. The spur led to Waiʻanae Lime Company quarry and would have transported raw materials (Land Court 1934; Persinski et al. 2002:13). The railway was used until the O.R.&L company went out of business. In 1939, the Lenakona Development, LTD, a branch of the former

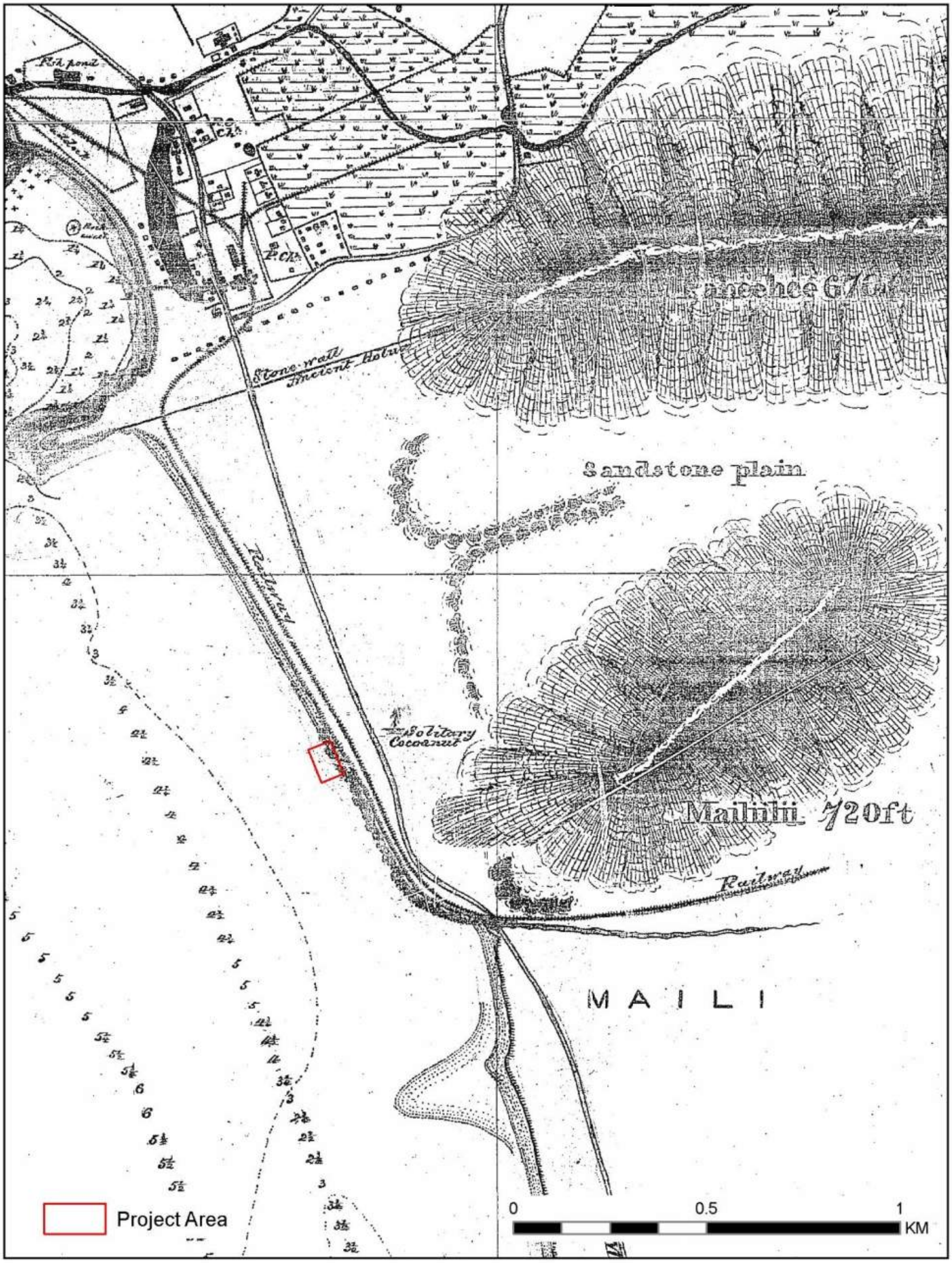

Figure 5. Project Area on 1884 Hawaiian Government Survey Map (Jackson 1884).

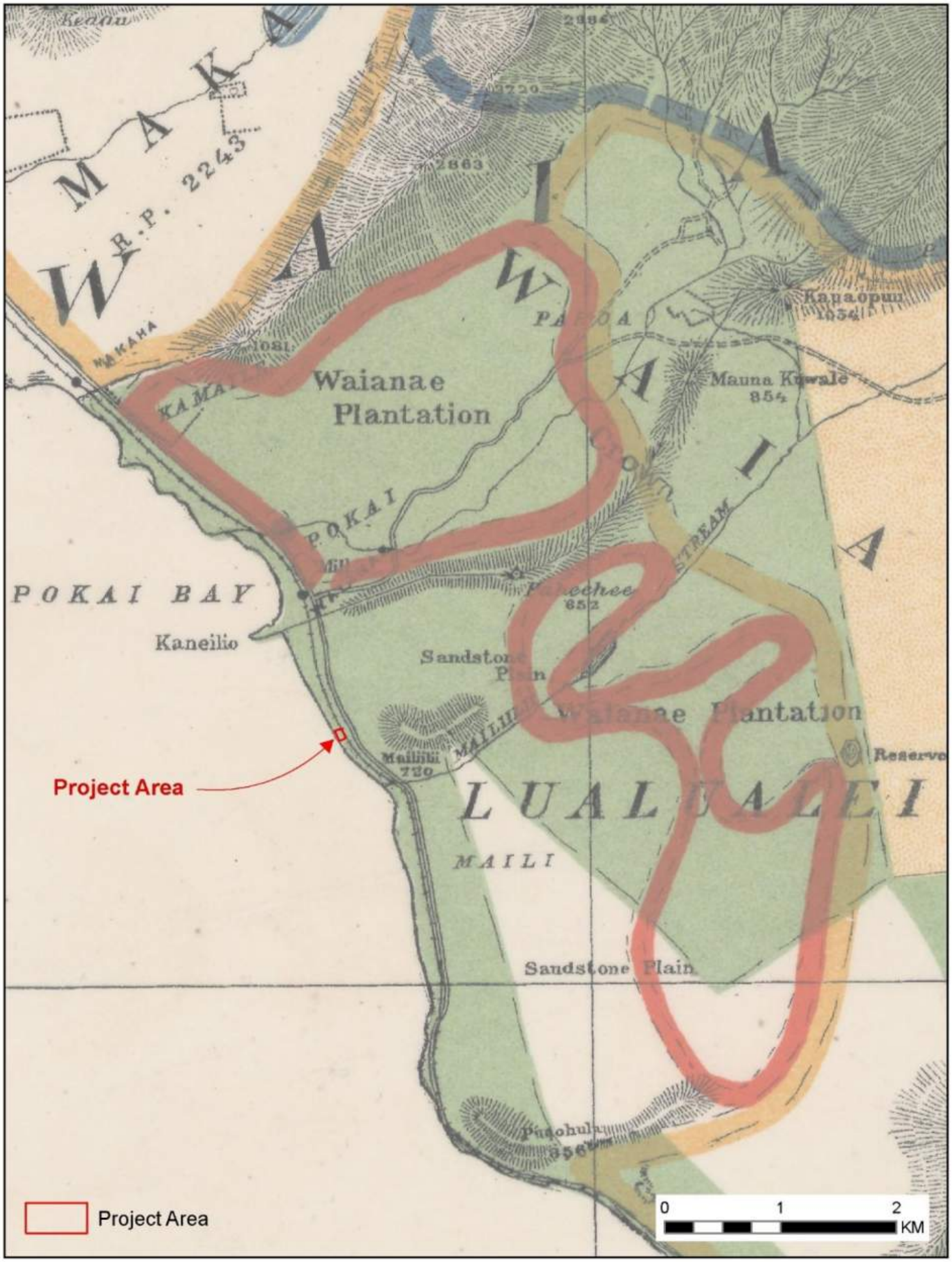

Figure 6. Historical Map Showing Waianae Plantation, Ranching Land Outlined in Dark Orange, and Public Land in Green (Donn 1902).

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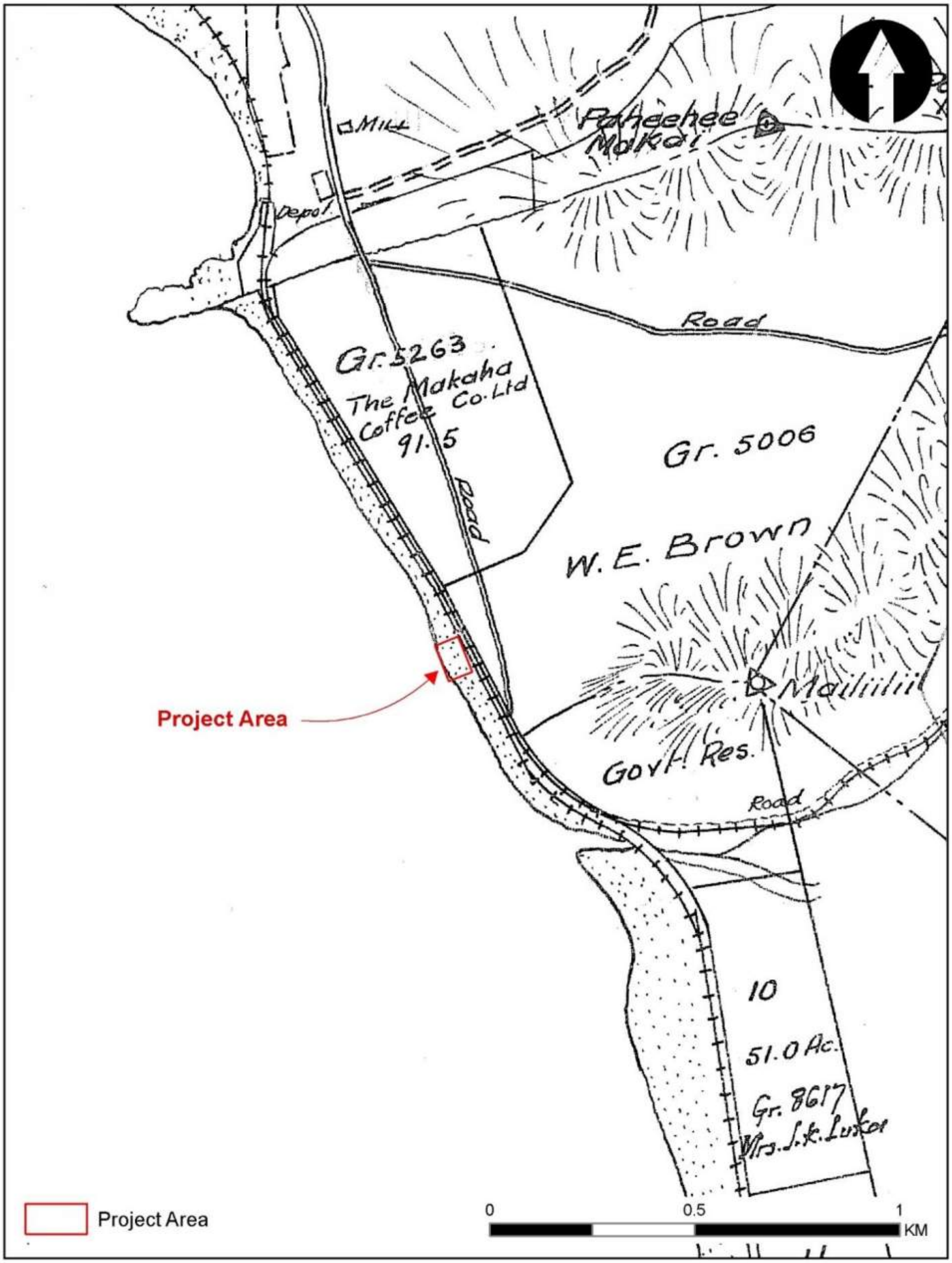

Figure 7. Historical Map Showing Land Grants (Iao 1914).

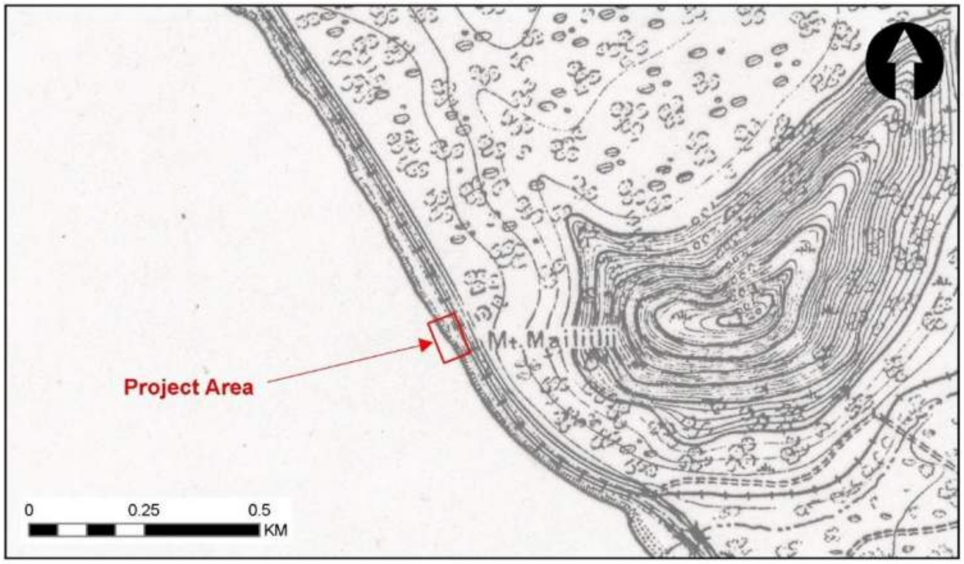

Figure 8. Portion of 1913 Topographical Map Showing Project Area Location (Cos. A. G. and I. Engineers, U.S. Army 1913).

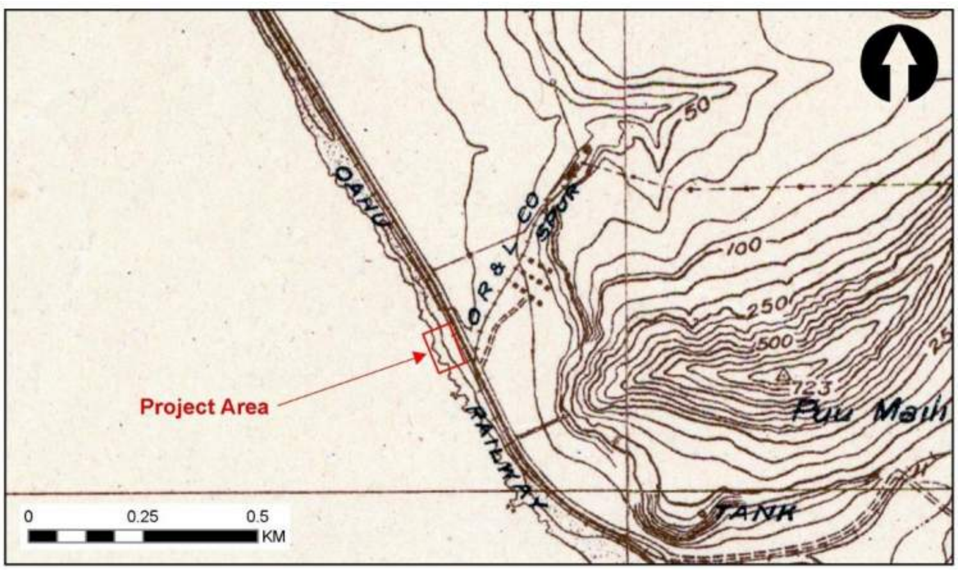

Figure 9. Portion of 1928 Topographical Map Showing Project Area Location (USGS 1928).

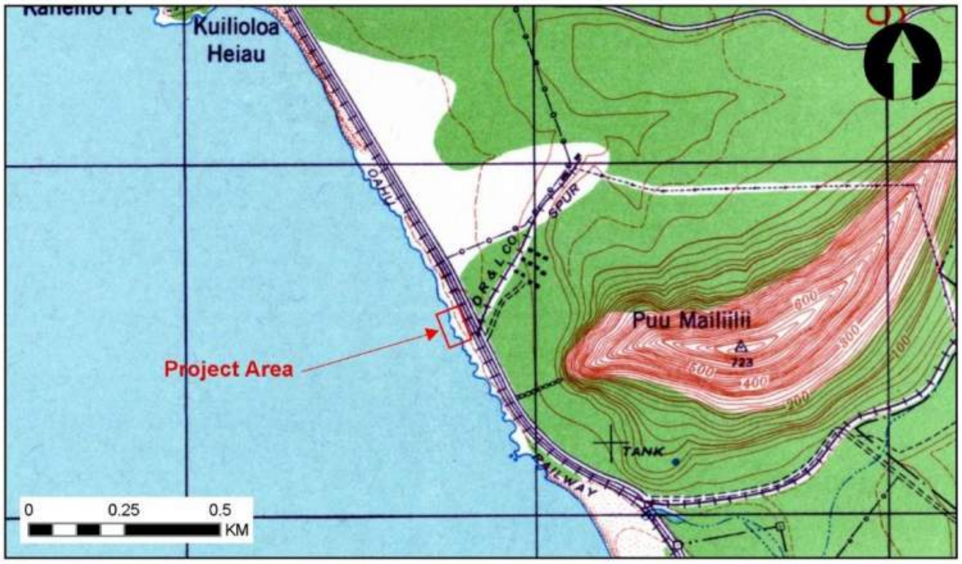

Figure 10. Portion of 1936 Topographical Map Showing Project Area Location (USACOE 1936).

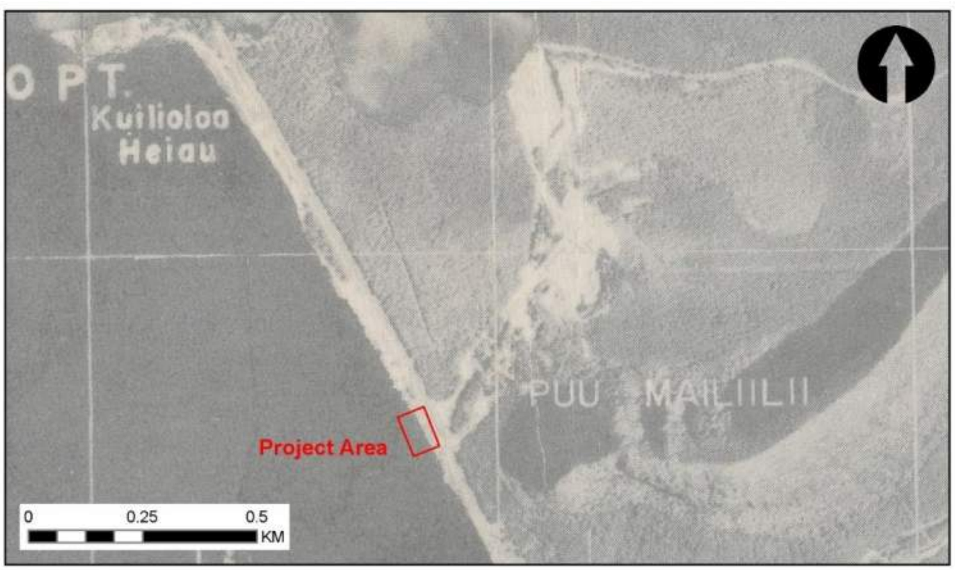

Figure 11. Portion of 1944 Topographical Map Showing Project Area Location (USAFCPBC 1944).

Hawaiian Gas Products, acquired a 301-acre parcel inland of the current project area; at the time, a cement and lime plant were in operation at the site (Persinski et al. 2002:13). After the acquisition, Hawaiian Gas Products changed its name to Gaspro and then partnered with the American Cement Company to form the Hawaiian Cement Company in 1950. The lime plant ceased operation 1976 due to complaints of noise and dust.

A 1944 photomap (see Figure 11) shows a swath of unvegetated land extending inland from the project area, which corresponds to the location of the quarry and access road on a 1956 topographical map in Figure 12. On a 1962 aerial photograph in Figure 13, the WWTP had not yet been constructed. Figure 14 shows WWTP on the east side of the highway in 1976, while the Village Pokai Bay subdivision was under construction at the former quarry site. By 1993, parking stalls were present in project area, as shown in Figure 15.

PREVIOUS ARCHAEOLOGY

Previous archaeological investigations in Waiʻanae Moku have documented *heiau*, temporary and permanent habitation sites, human burials, and historic sites. Investigations first began over a century ago with the work of Thrum (1907) and continued with McAllister during his island-wide survey (1933). In the modern era, archaeological work has shifted to systematic identification of cultural resources and the development of a settlement model for the *moku*. Some of the most notable studies include the Bishop Museum's Mākaha Valley project conducted from 1968 to 1970, which documented pre-Contact agricultural areas, permanent habitations, *heiau,* and various other structures dating from AD 1400s to 1700s (Green 1969;1970;1980); investigations in Nānākuli by the State Historic Preservation Division (SHPD) from 1988 to 1992 (Cordy 2002a); investigations in Waiʻanae Valley beginning in 1997 by SHPD, Waiʻanae High School's Hawaiian Studies Program, and the University of Hawaiʻi-West Oʻahu (Cordy 2002b;2003); and intensive survey at the back of Lualualei Valley by AMEC (Dixon et al. 2003).

None of the previous archaeological investigations within 500 meters of the project area, which are listed in Table 1, have recorded historic properties (Figure 16). Most relevant to the current undertaking are three archaeological monitoring projects conducted either along or seaward of Farrington Highway.

Along the beach near the WWTP, archaeological monitoring was conducted at two locations for comfort station construction: one to the north and one to the south of the current project area (Thruman and Hammatt 2009). No cultural deposits were encountered. The soil stratigraphy was limited to landscaping and construction fills.

The second project involved archaeological monitoring for the Makaha Interceptor Sewer Rehabilitation/Replacement Project (Stine et al. 2012), which extended along the coast from Pōkaʻī Bay to the WWTP. No historic properties were recorded near the WWTP project area. A stratigraphic soil profile recorded 400 meters north of the current project area documented three layers of fill to a depth of 60 cmbs.

Nearest to the current project area was archaeological monitoring along Farrington Highway from Ala Poko Street to the south end of the WWTP, which was conducted for the Kahe-Permanente 46kV Reconductoring and Pole Replacements Project (Blahut and Hammatt 2017). There was potential for the presence of two historic properties: SIHP Site 50-80-04-09714, which is the OR&L railroad, and traditional Hawaiian cultural layers due the project's beach location; however, no historic properties were encountered. Near the current project area, two stratigraphic soil profiles were recorded. At 200 meters south of the current project area, Profile 1 documented a 30 cm thick layer of fill underlain by a 25 cm thick layer of loamy sand. The coral shelf was encountered at 60 cmbs. Along the west border of the current project area, Profile 2 documented a 7 cm thick A horizon underlain by a 13 cm thick layer of fill, followed by a 6 cm thick buried A horizon, which was underlain by 42 cm thick layer of sand to loamy sand. The coral shelf was encountered at 88 cmbs. No cultural materials were observed.

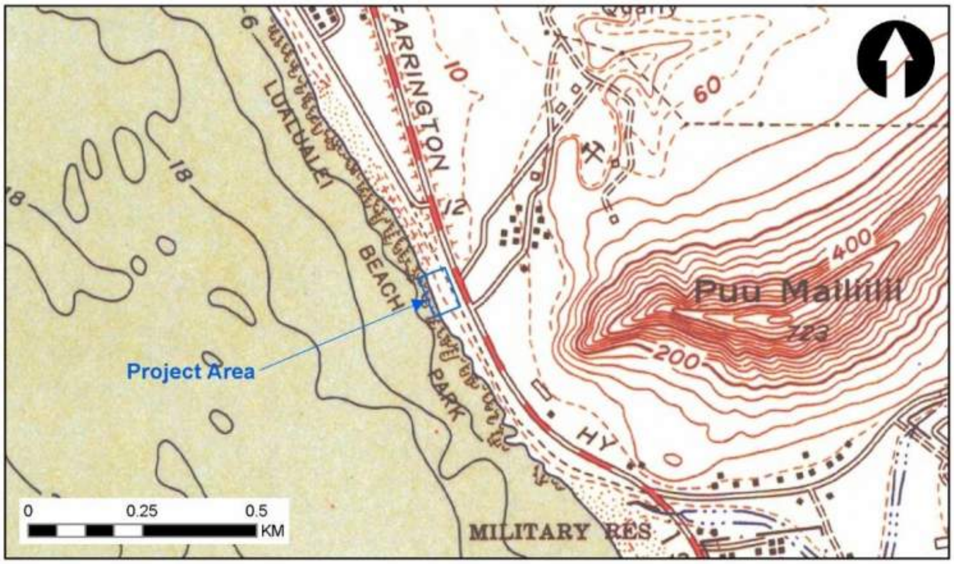

Figure 12. Portion of 1954 Topographical Map Showing Project Area Location (USGS 1954).

Figure 13. Portion of 1965 Aerial Photograph Showing Project Area Location (USDA 1962).

Figure 15. Portion of 1976 Aerial Photograph Showing Project Area Location (USGS 1976).

Figure 14. Portion of 1990 Aerial Photograph Showing Project Area Location (NOAA 1993).

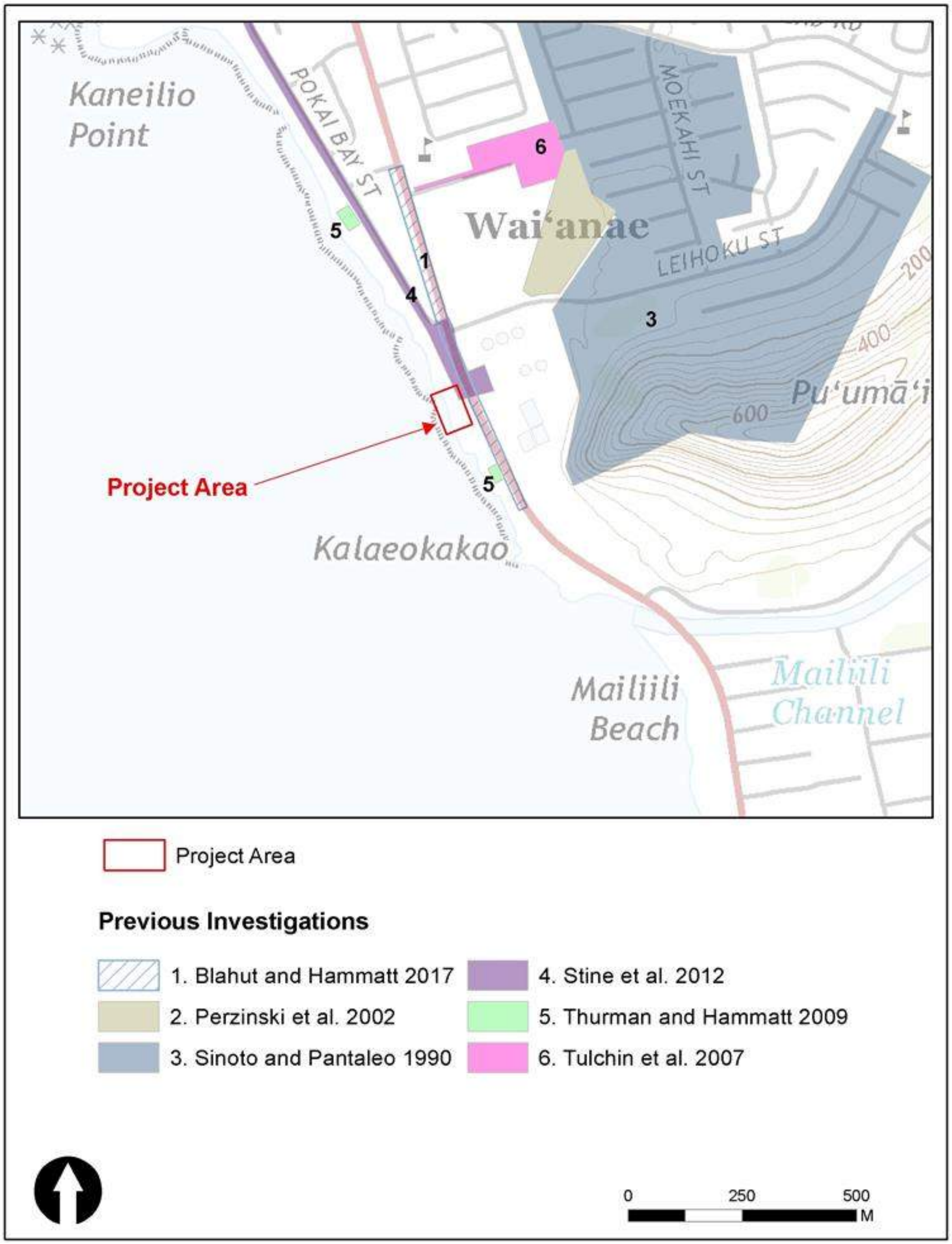

Figure 16. Locations of Previous Archaeological Investigations Near the Project Area.

Table 1. Previous Archaeological Studies in the Vicinity of the Project Area.

Reference	TMK(s) (1)	Nature of Study	Results
McAllister 1933	Island-wide	Archaeological Reconnaissance Survey	No sites recorded near the current project area
Sinoto and Pantaleo 1990	Pōka'ī Bay Subdivision	Archaeological Reconnaissance Survey	No significant finds
Perzinski et al. 2002	8-6-001:029/ Wai'anae Transit Center	Archaeological Assessment	No significant finds
Tulchin et al. 2007	8-7-023:060/ Wai'anae Sustainable Communities Plan project	Archaeological Assessment	No significant finds
Thurman and Hammatt 2009	8-6-001:007/ Lualualei Beach Park	Archaeological Monitoring	No significant finds
Stine et al. 2014	8-5, 8-6/ Mākaha Interceptor Sewer Rehabilitation/Replacement Project	Archaeological Monitoring	No sites recorded near the current project area
Blahut and Hammatt 2017	8-6-001, 013/ Farrington Hwy	Archaeological Monitoring	No significant finds

*State Inventory of Historic Places

ANTICIPATED FINDS

In view of the prior archaeological findings and past land use, there is low potential for the presence of traditional Hawaiian subsurface cultural layers or features in the project area. There have been no historic properties, including human burials, identified near the project area (see Figure 16). However, the beach location and lack of development in the project area does suggest that traditional Hawaiian human burials may be encountered. Also, based on historical maps (see Figures 5–10), a portion of the OR&L railroad (SIHP Site 50-80-04-09714) may be extant in the project area.

FIELD INSPECTION

An archaeological field inspection was conducted by PCSI archaeologist Dennis Gosser, M.A., on 10 September 2020. The purpose of the field inspection was to ensure that no traditional Hawaiian pre-Contact or historical archaeological materials or features were present on the surface.

The portion WWTP Outfall project area consists of an approximately 100-meter-wide swath of beach that extends from Farrington Highway to the shoreline. On the opposite side of the highway is the WWTP. At the northeast corner is a parking lot for beach access. A campsite is present to the north, outside the project area. Surrounding the outfall sewer large is undeveloped beach scattered with large rocks or small boulders. Photographs of the project are shown in Figures 17–19. No traditional Hawaiian pre-Contact or historical archaeological materials were observed in the project area. Only four modern features were present, all of which consisted of stacked or intentionally arranged rocks, including one memorial. These four modern features are shown in Figures 20–24.

Figure 17. Overview Photograph of the Project Area, Facing North.

Figure 18. Overview Photograph of the Project Area, Facing South.

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Figure 19. Overview Photograph of the Project Area, Facing Northwest

Figure 20. Modern Feature 1 With Memorial, Facing Northwest

Figure 21. Modern Feature 2, Facing West.

Figure 22. Modern Feature 2 With Rubbish, Facing Southeast.

Figure 23. Modern Feature 3, Facing North.

Figure 24. Modern Feature 4, Facing East.

SUMMARY AND ASSESSMENT

The proposed Waianae Wastewater Treatment Plant (WWTP) Ocean Outfall project is within the TMK parcel (1) 8-6-001:007 in Lualualei, Wai‘anae Ahupua‘a, Wai‘anae Moku on O‘ahu Island (see Figure 1). The project area measures 1.4-acre (.57-ha). The project proponent and land owner is State of Hawai‘i. The project scope of work ehabilitation and improvements to the existing 36-inch ocean outfall sewer, which discharges treated effluent 6,180 feet offshore from the WWTP. A field inspection and an archaeological literature review that addresses historical, cultural, and archaeological background were conducted in order to evaluate any potential effect on historic properties in the project area, and to recommend mitigation of any adverse effect, if warranted. This work was carried out in accordance with Hawaii Revised Statutes (HRS) Chapter 6E, and Title 13 of the Hawaii Administrative Rules (HAR), Subtitle 13 (State Historic Preservation Division Rules), Chapter 275 (*Rules Governing Procedures for Historic Preservation Review for Governmental Projects Covered Under Sections 6E-7 and 6E-8, HRS*).

Background research indicates that project area was not intensively used during the pre-Contact or early historic periods. Previous land use in the project area includes construction of the ocean outfall sewer in the mid-1960s and recreation and camping in the modern era. Based on previous archaeological investigations in the vicinity, there is low potential for traditional Hawaiian subsurface cultural deposits; however, the lack of development and the beach location does suggest the possibility of for encountering traditional Hawaiian human burials. Also, historical maps indicate that a portion of the OR&L railroad (SIHP Site 50-80-04-09714) may be present in the project area.

RECOMMENDATIONS

Results of the field inspection and literature review conducted for the WWTP Ocean Outfall project indicate that there are no known historic properties within the project area. However, based on the project’s beach environment, there is potential for traditional Hawaiian burials in subsurface sand deposits. Additionally, buried remnants of the OR&L railroad (SIHP Site 50-80-04-09714) may be extant. It is recommended that no historic properties will be affected with the condition that archaeological monitoring be conducted with an SHPD-approved AMP. Pursuant to HRS, Chapter 6E-8 and its implementing regulations at HAR §13-275-7(2), the recommended project effect determination for the project area, based on the research presented herein, is “effect, with proposed mitigation commitments” as the proposed project has the potential to adversely impact any subsurface historic properties that may be present.

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APPENDIX A: PROJECT SITE PLANS

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JOB NO. 25-65

WAIANAE OCEAN OUTFALL SEWER

WAIANAE, OAHU, HAWAII

DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

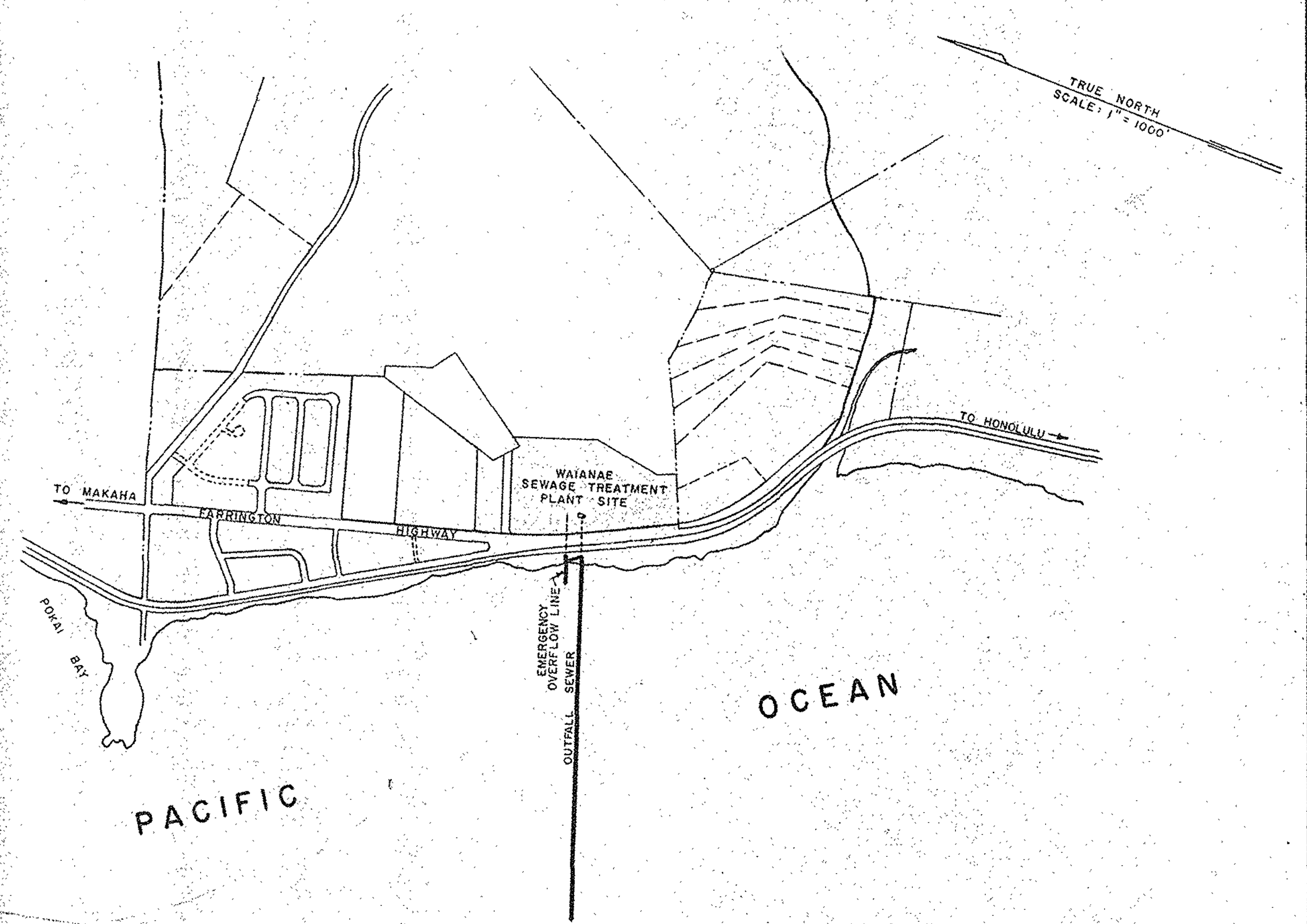
DIVISION OF SEWERS

INSPECTOR'S COPY
Wye Book No.
Res. Engr.
Inspector
Date Final Inspection 11/14/67

SUNN, LOW, TOM & HARA, INC. — CONSULTING ENGINEERS
195 SOUTH KING STREET — HONOLULU, HAWAII

ALBERT O. Y. TOM — REGISTERED PROFESSIONAL ENGINEER — No. 713 — HAWAII, U.S.A.

FRANKLIN Y. K. SUNN — REGISTERED PROFESSIONAL ENGINEER — No. 531 — HAWAII, U.S.A.



LOCATION PLAN

1000' 500' 0' 1000' 2000'

SCALE: 1" = 1000'

TAX MAP KEY: 8-6-01

WN 36/18

INDEX TO DRAWINGS

APPROVED:

Yoshio Kunimoto — 2/21/66
REGISTERED PROFESSIONAL ENGINEER No. 291-E, HAWAII — DATE
DEPARTMENT OF PUBLIC WORKS
CITY & COUNTY OF HONOLULU, HAWAII

Francis Aona — 2/18/66
REGISTERED PROFESSIONAL ENGINEER No. 492-E, HAWAII — DATE
DIVISION OF SEWERS
CITY & COUNTY OF HONOLULU, HAWAII

Francis J. Coito — 2/21/66
REGISTERED PROFESSIONAL ENGINEER No. 820-E, HAWAII — DATE
ENVIRONMENTAL HEALTH DIVISION
DEPARTMENT OF HEALTH

WAIANAE OCEAN OUTFALL

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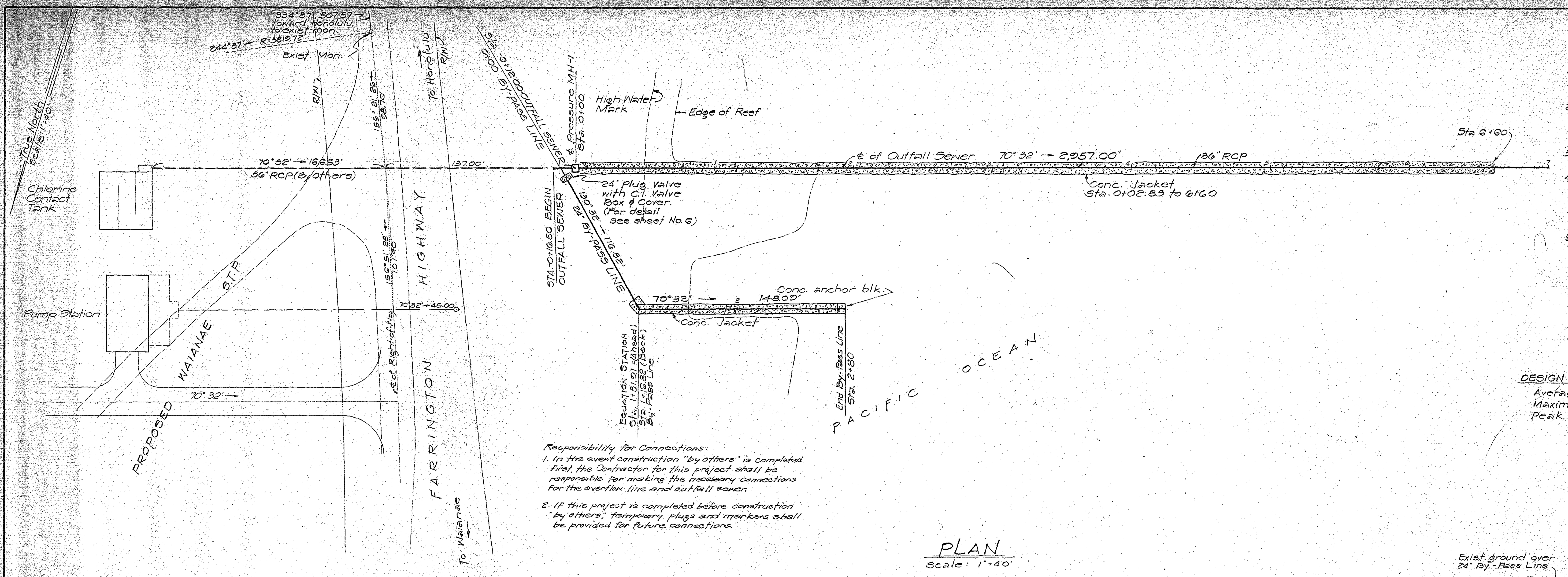
FILE	POCKET	FOLDER	NO.
			57



PLAN
Scale: 1"=40'

GENERAL NOTES

1. Bench Mark and Reference Points at beginning of construction shall be furnished by the Engineer. Datum is mean sea level.
2. The elevations shown on the Profiles are P.I. (inv.) elevations. Maximum deflection per joint for all horizontal and vertical deflections shall be 0 degree 45 minutes (0°45'). Bends are acceptable.
3. 30" and 36" RCP and fittings test requirement shall be 50 ft. of hydrostatic head.
4. The Borings shown on the sheets are for design purposes only. The Borings and Soundings are believed to be reliable but the City and County of Honolulu does not guarantee the accuracy of same. Borings taken by Nat Whiton, Jan. 3, 1964.
5. Ocean bottom shown on profile at outfall ℄ is plotted schematically only. Contractor shall make his own verification of the profile. No extra payment shall be made to the contractor for any variations in the profile. Soundings were taken on February 17, 1965 along ℄.

DESIGN DATA

DESIGN FLOWS	INITIAL PHASE	ULTIMATE PHASE
Average	1.72 mgd	7.02 mgd
Maximum	3.68 mgd	15.10 mgd
Peak	4.60 mgd	19.28 mgd

PROFILES

OUTFALL SEWER
Scale: Horiz: 1"=40' Vert: 1"=4'

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.
A. Tom 4/20/65
OFFICER DATE

REVISION	DATE	BRIEF	BY	APPR'D
1	7/12/66	Deleted 24" Overflow Line		

SUNN, LOW, TOM & HARA, INC.
CONSULTING ENGINEERS
195 S. KING ST. HONOLULU 13, HAWAII

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
DIVISION OF SEWERS
WAIANAE OCEAN OUTFALL SEWER
WAIANAE, OAHU, HAWAII
PLAN & PROFILE
OCEAN OUTFALL,
BY-PASS & OVERFLOW LINES

DRAWN BY C. Won ENGINEER G. Taguchi
APPROVED BY
DIR., DIVISION OF SEWERS 2/18/66 DATE
DATE DATE

FILE	POCKET	FOLDER	NO.

REVISION	DATE	BRIEF	BY	APPR'D

SUNN, LOW, TOM & HARA, INC.
CONSULTING ENGINEERS
195 S. KING ST. HONOLULU 13, HAWAII

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
DIVISION OF SEWERS

WAIANAE OCEAN OUTFALL SEWER
WAIANAE, OAHU, HAWAII

PLAN & PROFILE OCEAN OUTFALL SEWER

DRAWN BY C. Non ENGINEER B. Taguchi

REGISTERED PROFESSIONAL ENGINEER No. 713 — HAWAII, U.S.A.

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A. Tom 4/20/65
OFFICER DATE

DIR., DIVISION OF SEWERS 2/18/66 DATE

DATE

DATE

DATE

SHEET 3 OF 6 SHEETS

FILE	POCKET	FOLDER	NO.
11	11	3	59

202-4
TRUE NORTH
NOTE:
1-Stones shall be 12" to 24" in diameter and shall weigh at least 200#
2-Quarry Run & Rock Fill From: Sta. 20+50 to 22+60 Sta. 25+60 to 25+90
Stones with filler
36" R.C.P.
Quarry Run 6" To Fine
Sand
Crushed Coral Cradle
Approximate Coral Surface
QUARRY RUN & ROCK FILL DETAIL
NOZZLE LAYOUT-PLAN
NO SCALE
NOTE: Outfall sewer stationing at diffusers based on constant 10'-0" o.c. spacing. Corresponding adjustment will be necessary for diffuser spacing exceeding 10'-0".
Sta. 1+70.27
Sta. 0+26.32
Sta. 1+52.32
Sta. 1+63.27 to 1+69.27 Conc. Anchor Block
30" RCP Plug with C.I. Cover. Provide 12" dia. opening with temporary plug @ bottom. For details see shts. 5 & 6
End Ocean Outfall
6" P of
8" P
36" RCP Plug With Concrete Reaction Block
Sta. 20+13.50 to 20+33.50 Conc. Jacket
Sta. 20+23.50 Pressure MH-3
℄ 36" Pipe
70° 32'
Sta. 20+33.50 to 22+60 Quarry Run & Rock Fill For Detail - See Above
Sta. 25+60 to 25+90 Quarry Run & Rock Fill For Detail - See Above
Boring B-2 Sta. 24+04
Sta. 26+05.50 - 26+25.50 Conc. Jacket
Sta. 26+15.50 Pressure MH-4 For details, see sht. 5 & 6
Sta. 28+03.02 P.I. Special Wye Structure (For details - See This Sht.) 0+00 (Diffuser Line)
NOTE: Furnish One (1) 1" Thick Fiberglass Gate.
1½" Slot Opening For Fiberglass Gate
36" I.D.
18-¾" x 6" Stainless Steel Bolts ¼" Thick Stainless Steel Cover Plate For Both Slots
Sta. 28+03.02 P.I. Special Wye
7'-10½"
9'-0"
36"x36" SPECIAL WYE STRUCTURE
SCALE: 3/8"=1'-0"
SECTION "A-A"
SCALE: 3/8"-1'-0"
PLAN
Scale: 1"=40'
36"x36" Special Wye
Plug
Concrete Reaction Block Poured In-Place
DETAIL OF 36" PLUG AND REACTION BLOCK
Not To Scale
2' Dia. min. rockfill continuous over RCP For details see sht. 5 Sta. 20+50 to 25+90
Exist. ocean floor @ ℄ pipe
Conc. Jacket
Medium Coral Rock
Soft and Medium Coral Rock
36" RCP 485.00' @ 0.24%
36" RCP 800.00' @ 0.40%
30" RCP 170.27' @ 0.00%
2' dia. min. rockfill continuous over RCP Sta. 26+10 to Sta. 28+00
8 Diffusers @ 18'-0" o.c. min. (20'-0" o.c. max.) For Details see sht. 5
This Section Proposal Item 8
Excavate to Sta. 29+03.27 Cut at 2:1 to meet ocean floor
30" RCP plug with cast iron cover. Provide 12" dia. opening with temporary plug @ bottom. For details see sheets 5 & 6
-30.73
-33.13
-33.03
-32.93
PROFILE
Scale: Horiz. 1"=40' Vert. 1"=4'
18+00 19+00 20+00 21+00 22+00 23+00 24+00 25+00 26+00 27+00
-20 -30 -40
9-8-67 Added Quarry Run & Rock Fill Det. - Sta. 20+50 & 26+60
8-31-67 Revised Diffuser Slope & Ground Profile
7-31-67 Changed 30" to 36" Pipe Realigned Diffuser Line
6-10-66 Revised Diffuser & Plug notes.
REVISION DATE BRIEF BY APPR'D
SUNN, LOW, TOM & HARA, INC.
CONSULTING ENGINEERS
195 S. KING ST. HONOLULU 13, HAWAII
DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
DIVISION OF SEWERS
WAIANAE OCEAN OUTFALL SEWER
WAIANAE, OAHU, HAWAII
PLAN & PROFILE
OCEAN OUTFALL SEWER
DRAWN BY C. Hon
ENGINEER B. Taguchi
APPROVED BY
DIR., DIVISION OF SEWERS
DATE 2/18/66
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION
OFFICER 4/20/65 DATE
SHEET 4 OF 6 SHEETS
FILE 11 POCKET 11 FOLDER 3 NO. 60

Appendix F

Cultural Impact Assessment in Support of the Waianae Wastewater Treatment Plant (WWTP) Outfall Improvements and Rehabilitation Project, Waianae Ahupuaa, Waianae District, Island of Oahu, Hawaii

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DRAFT REPORT

Cultural Impact Assessment in Support of the Waianae Wastewater Treatment Plant (WWTP) Outfall Improvements and Rehabilitation Project, Wai‘anae Ahupua‘a, Wai‘anae District, Island of O‘ahu, Hawai‘i

TMK: (1) 8-6-001:0007 por.

Prepared for:
SSFM International
501 Sumner Street, Suite 620
Honolulu, Hawaii 96817

August 2021

PACIFIC CONSULTING SERVICES, INCORPORATED
720 IWILEI ROAD, HONOLULU HAWAI‘I 96817

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DRAFT REPORT

Cultural Impact Assessment in Support of the Waianae Wastewater Treatment Plant (WWTP) Outfall Improvements and Rehabilitation Project, Waiʻanae Ahupuaʻa, Waiʻanae District, Island of Oʻahu, Hawaiʻi

TMK: (1) 8-6-001:0007 por.

By
Dennis Gosser, M.A.
Principal Investigator

Prepared For:
SSFM International
501 Sumner Street, Suite 620
Honolulu, Hawaii 96817

Prepared By:
Pacific Consulting Services, Inc.
720 Iwilei Road, Suite 424
Honolulu, HI 96817

August 2021

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MANAGEMENT SUMMARY

Document Title:	Cultural Impact Assessment in Support of the Waianae Wastewater Treatment Plant (WWTP) Ocean Outfall Project, Waiʻanae Ahupuaʻa, Waiʻanae District, Island of Oʻahu, Hawaiʻi
Date/Revised Date:	Preliminary Draft: August 2021
Archaeological Permit #:	SHPD Permit No. 21-05
Project Location:	WWTP, Waiʻanae Ahupuaʻa, Waiʻanae District, Island of Oʻahu, Hawaiʻi
Project TMK:	(1) 8-6-001:007
Land Owner:	State of Hawaiʻi
Project Proponents:	Department of Design and Construction, City and County of Honolulu
Project Tasks:	Archaeological Literature Review
Project Acreage:	1.4 acres (.57 ha)
Principal Investigator:	Dennis Gosser, M.A.
Regulatory Oversight:	Chapters 373 and 6E-8, Hawaii Revised Statutes (HRS) and Hawaii Administrative Rules (HAR) Chapter 275
Project Background:	The project scope of work includes rehabilitation and improvements to the existing ocean outfall sewer.
SIHP #:	No known sites in the project area; remnants of the OR&L railroad (SIHP Site 50-80-04-09714) are potentially present.
Findings:	During previous archaeological investigations in the vicinity, no historic properties have been recorded. However, the beach location and lack of development in the project area does suggest that traditional Hawaiian human burials may be encountered. Also, based on historical maps a portion of the OR&L railroad (SIHP Site 50-80-04-09714) may be extant in the project area. Community consultation resulted in the identification of modern uses such as camping, day gatherings, and fishing as well as the generalized possibility of human burials along the Waiʻanae coast. No cultural or traditional practices were identified within the project area.
Human Skeletal Remains:	None identified with in the project area; traditional Hawaiian burials are potentially present based on beach environment.
Recommendations:	Pursuant to HRS, Chapter 6E-8 and its implementing regulations at HAR §13-275-7(2), the project effect determination for the project area, based on the research presented herein, is “No Historic Properties Affected.” The project will not affect any significant architectural historic properties and at this time no significant archaeological historic properties have been identified within the project area. Because the proposed project has the potential to adversely impact subsurface historic properties that may be present, archaeological monitoring should be conducted for identification purposes with an SHPD-approved AMP.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Under contract to SSFM International, Pacific Consulting Services, Inc. (PCSI) has prepared this Cultural Impact Assessment (CIA) in support of the Waianae Wastewater Treatment Plant (WWTP) Ocean Outfall project in Waiʻanae on Oʻahu Island (Figure 1). The project proponent is the Department of Design and Construction, City and County of Honolulu (CCH) and the land owner is the State of Hawaiʻi. The project scope of work includes rehabilitation and improvements to the existing ocean outfall sewer. A field inspection and a historical, cultural, archaeological background study, as well as community consultation was conducted in order to evaluate any potential effect on historic properties and to recommend mitigation of any adverse effect, if warranted. This work was carried out in accordance with Hawaii Revised Statutes (HRS) Chapters 6E (*Historic Preservation*) and Chapter 343 (*Environmental Impact Statements*), and Title 13 of the Hawaii Administrative Rules (HAR), Subtitle 13 (State Historic Preservation Division Rules), Chapter 275 (*Rules Governing Procedures for Historic Preservation Review for Governmental Projects Covered Under Sections 6E-7 and 6E-8, HRS*).

PROJECT AREA LOCATION AND DESCRIPTION

The proposed project is located at the Waianae WWTP ocean outfall sewer site, which is on the west side of Farrington Highway, across from the main facility at 86-220 Farrington Highway. The project area is in a portion of Tax Map Key (TMK) parcel (1) 8-6-001:007. Work is limited to a 1.4-acre (.57-ha) portion of the parcel. The plat map for the parcel is shown in Figure 2. Site plans for the existing ocean outfall are provided in Appendix A.

Proposed work will involve rehabilitation and improvements to the existing 36-inch ocean outfall sewer pipeline, which discharges treated effluent 6,180 feet offshore from the WWTP; in addition, three manholes on the pipeline will be capped. It has been anticipated that the existing outfall will experience reduced flow capacity due to the effects of sea level rise and damage may be caused by shoreline erosion (CH2M Hill 2016:28).

ENVIRONMENTAL SETTING

Waiʻanae Ahupuaʻa is located on the leeward side of Oʻahu. It is bordered on the north by Mākaha Ahupuaʻa and the south by Nānākuli Ahupuaʻa. The current undertaking is situated on the shoreline, just outside the mouth of Lualualei Valley. This amphitheater-headed valley is defined by Kāneʻīlio Point and the edge of Puʻuheleakalā on the coast and extends five miles inland. The current study area immediately north of Kalaeokakao, also known as Goat Point, and west of Puʻumāʻiliʻili (see Figure 1). The coastal area of this region contains white sand beaches and old, uplifted coral reefs and limestone flats.

TOPOGRAPHY AND SOILS

The project area is situated on the shoreline of Lualualei beach Park. The area is underlain by karstic flats of raised limestone reef lands (Stearns 1939:plate 1). The project area is underlain by Mokuleia clay (Mtb), as shown in Figure 4. The Mokuleia series are shallow, well-drained soils that formed in recent alluvium deposited over coral sand and are found on the coastal plains (Foote et al. 1972:95).

RAINFALL, HYDROLOGY, AND VEGETATION

Mean annual rainfall in this portion of west Oʻahu averages 553.0 millimeters (mm) (21.77 inches[in]) annually, with most of the rainfall occurring between November and March (Giambelluca et al. 2013). The channelized Māʻiliʻili Stream is approximately 550 meters south of the project area (see Figure 4). Vegetation includes *ʻakiʻaki* (seashore rush grass, *Sporobolus virginicus*), *kiawe* (*Prosopis pallida*), *milo* (portia tree, *Thespesia populnea*), *niu* (coconut, *Cocos nucifera*), *pōhuehue* (beach morning glory, *Ipomea pes-caprae subsp. brasiliensis*).

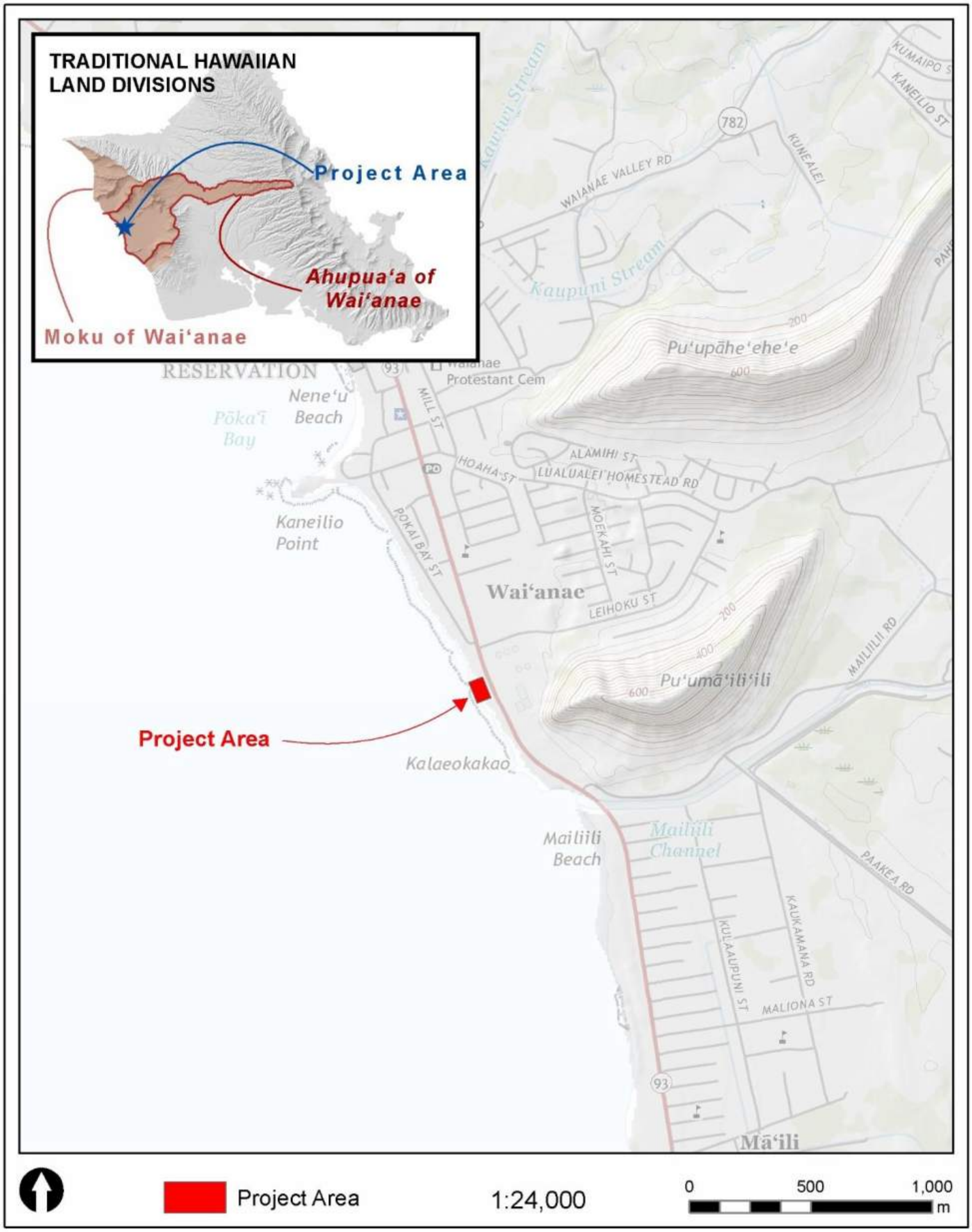

Figure 1. Project Area Shown on USGS 2017 Waianae Topographical Quadrangle (USGS 2017).

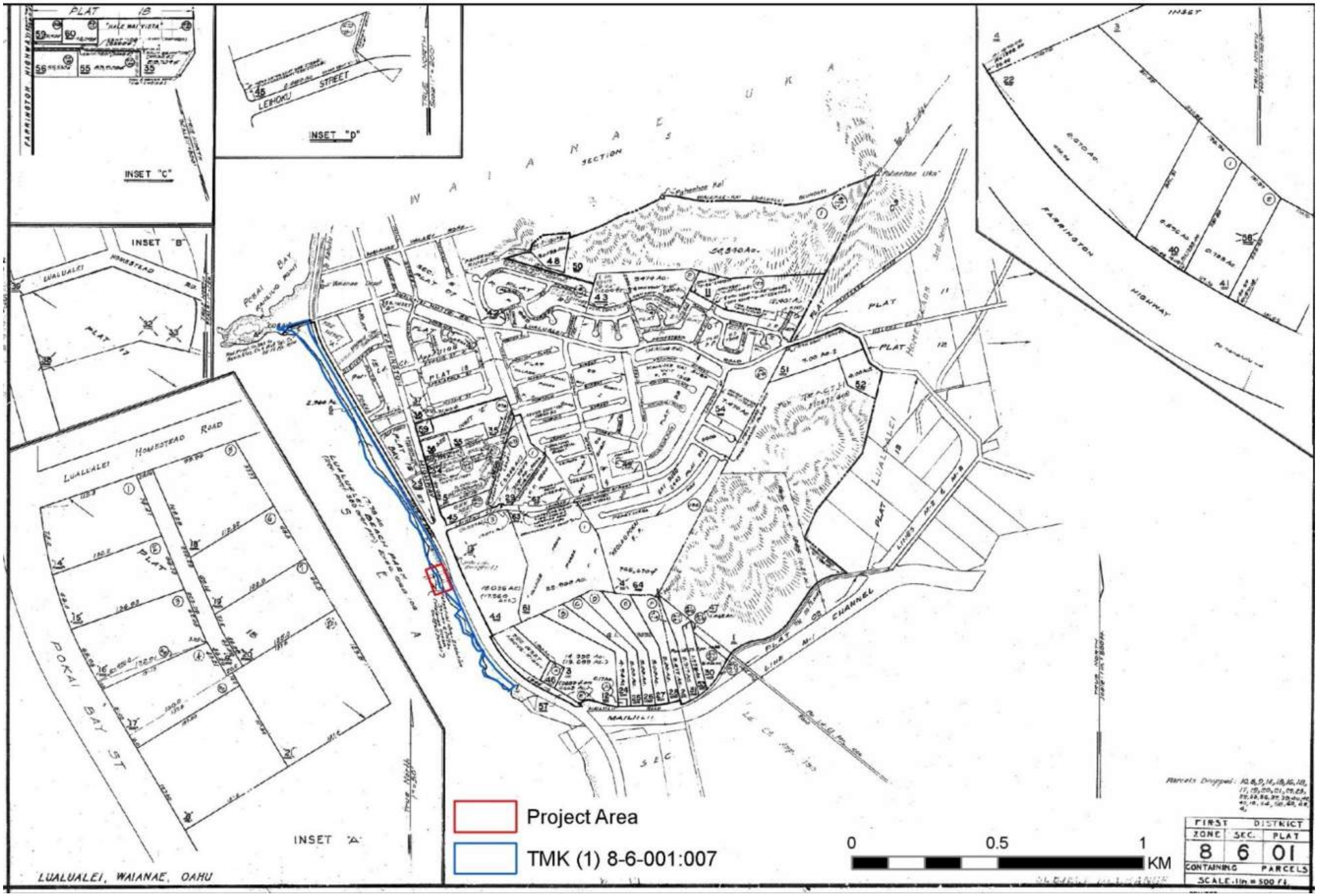

Figure 2. Tax Map for Plat (1) 8-6-01 Showing the Project Area (Tax Maps Bureau and Survey Department 1933).

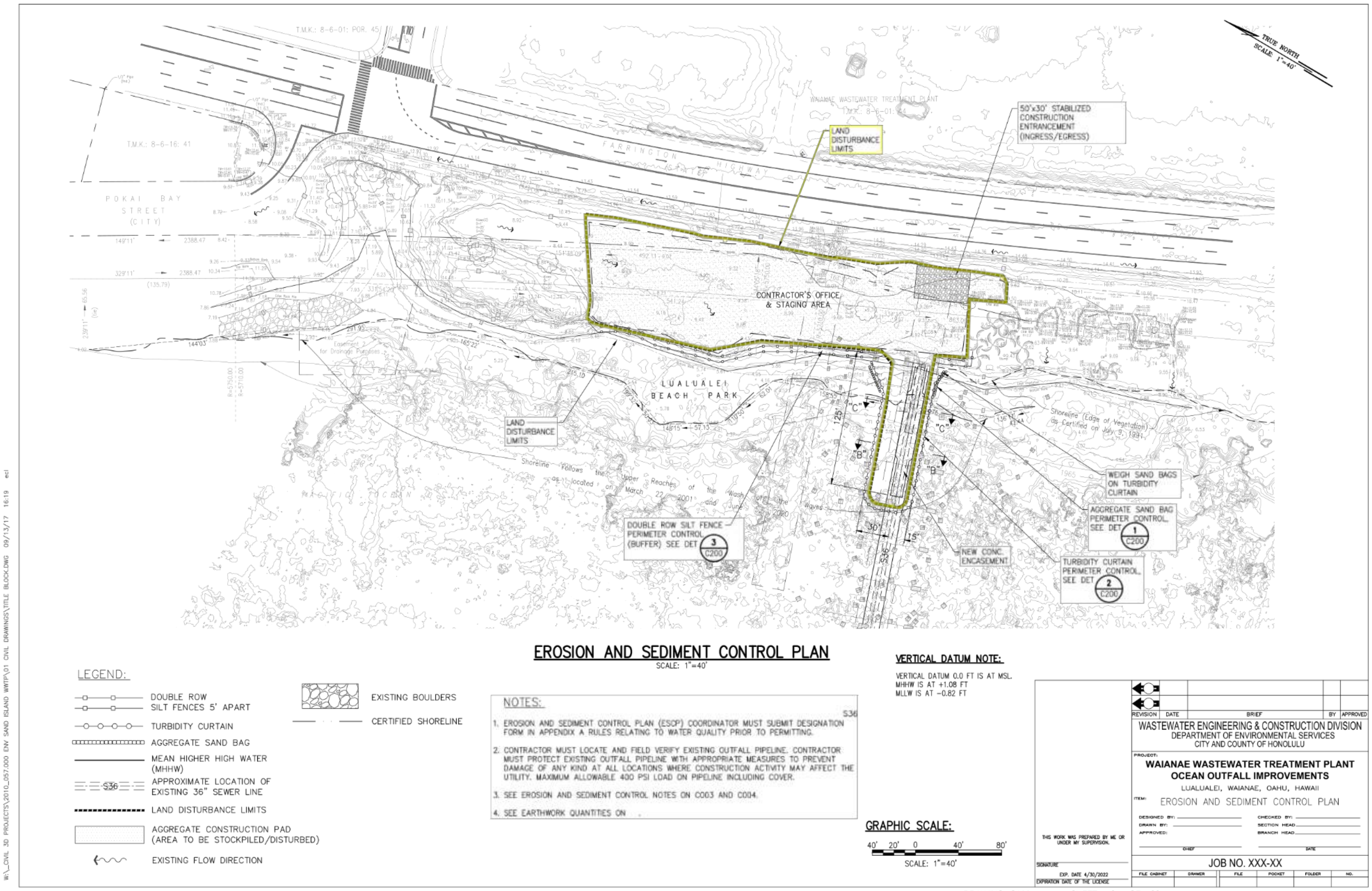

Figure 3. Design Plan Showing Project Area and the Land Disturbance Limit.

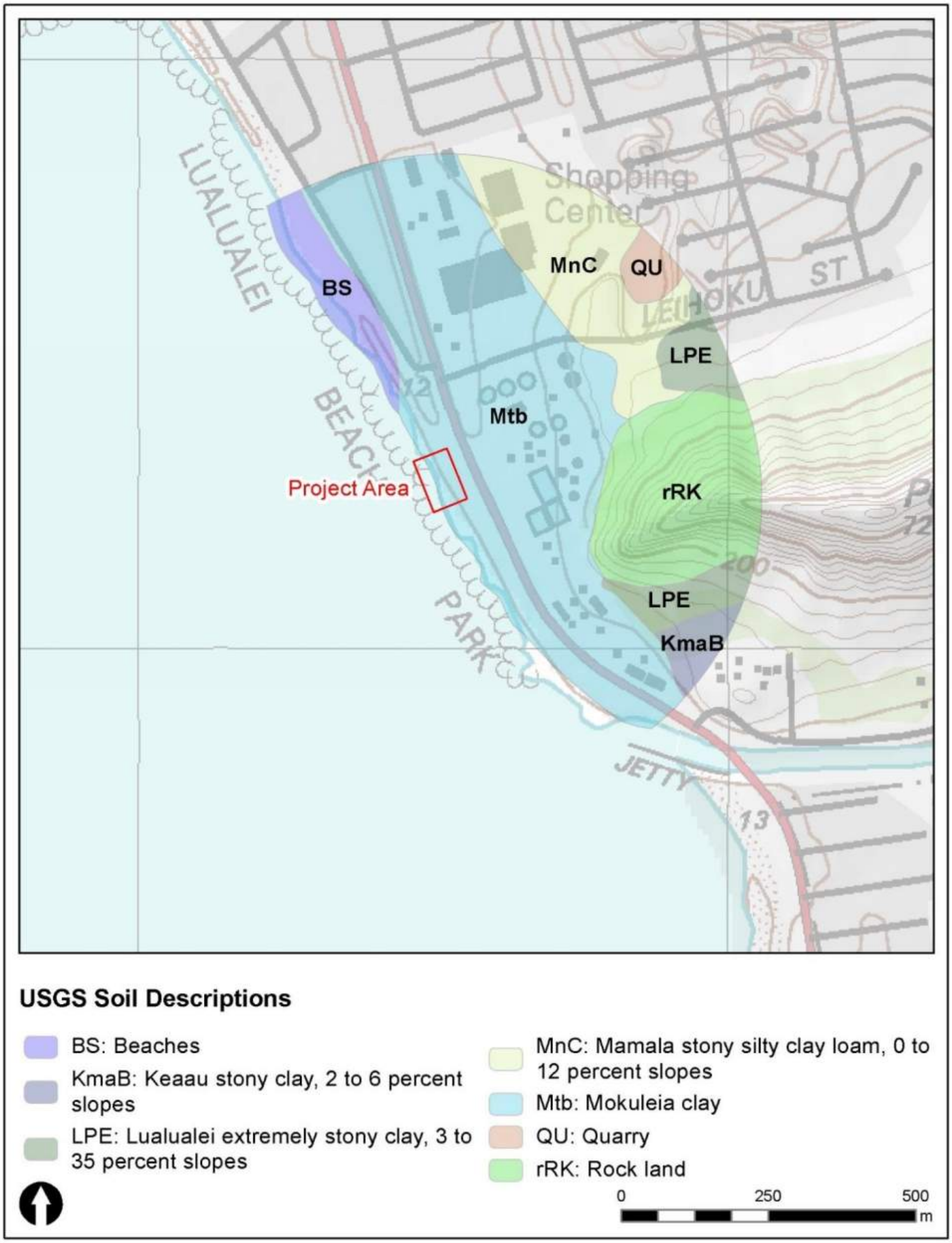

Figure 4. Soil Units in the Vicinity of the Project Area (Soil Survey Staff, NRCS, USDA 2020).

HISTORICAL BACKGROUND

Archival background research and literature review examined maps, historical and archival documents, and previous archaeological studies in the vicinity of the project area. Relevant historical maps were georeferenced to determine where traditional Hawaiian or historic features may fall within the project area. The information obtained from these sources was synthesized to present data findings and to evaluate the potential for archaeological and cultural resources in the project area.

PLACE NAMES

Lualualei can be translated as "flexible wreath," which refers to a battle formation used by Māʻilikūkahi against four invading armies in the 1400s during the battle of Kīpapa (McGrath et al. 1973:11; Sterling and Summers 1978:68). Hawaiian historian John Papa ʻĪʻī offers another interpretation and translated the name as "beloved one spared." He relates a story of a relative accused of wearing the king's *malo*, or loincloth, which was punishable by death:

> The company, somewhat in the nature of prisoners, spent a night at Lualualei. There was a fishpond there on the plain and that was where the night was spent. After several days had passed, the proclamation from the king was given by Kulaʻinamoku, that there was no death and that Kalakua did not wear the king's loincloth. Thus was the family of Luluku spared a cruel death. For that reason, a child born in the family later was named Lualualei [ʻĪʻī 1959:23].

TRADITIONAL HISTORY AND LAND USE

Waiʻanae Moku has a wealth of associated myths and legends, many concerning kings and gods. For example, King Kamehamaha I is said to have lost the battle for Kauaʻi in 1796 because he failed to pay homage to the Waiʻanae gods. According to Kamakau: "The fleet went on to Waiʻanae and the war god [Kū-kaʻili-moku] was carried ashore that evening" (1992:173). Kamakau asserts that Kamehameha and his fleet sailed before midnight, but according to the traditional stories of Waiʻanae, he stayed longer to rededicate two heiau (temple) to his own war god (McGrath et al. 1973:14). This action angered the gods of Waiʻanae, who then caused the storm that ended the expedition called Kaʻieʻiewaho to Kauaʻi.

In contrast to the dearth of land resources in Waiʻanae Moku during the pre-Contact period, marine resources were abundant. The ancient chief Kewalo is said to have distinguished himself as a fisherman in the waters off Kaʻena Point, while there are also stories from Waiʻanae that tell of the kupua1 Māui as a fisherman (Beckwith 1940:232–3; Handy and Handy 1972:467).

According to traditional accounts from Wai'anae, Lualualei is the birthplace of Māui and his brothers (Beckwith 1940:226). Several stories (see Sterling and Summers 1978:64–66) tell of events that occurred when Maui was living at Ulehawa in southern Lualualei. The following is a version of a story from Kamakau (1991:135) that tells of Māui in Waiʻanae:

> Akaalana lived with Hinakawea, and Mauimua, Maui-waena, Maui-ikiiki, and Maui-a-kalana, all boys were born.
>
> At Ulehawa and Kaolae on the south side of Waianae was their birthplace. There are pointed out the things left by Maui. Among other famous things to be seen are the cave in which Hina made her tapa, the fishhook Manaiakalani, the snare for catching the sun, the places where Maui's adzes were made, and all his other implements. But Maui-a-kalana went to Kahiki after the birth of his son in Hawaiʻi and the last of his children born of Hina-a-kealoha was Hina-akeka, and these became came the ancestors of all lands in the ocean as far as the country which foreigners call New Zealand. There in the islands of the ocean

[1] A demigod or cultural hero in Hawaiian.

> Maui performed those famous exploits which are ever held in remembrance among this people [Kamakau 1991:135].

Archaeological and historical documentation suggest that Wai‘anae was first occupied around AD 1200 when population pressure on the windward coast and in the Kona Moku pushed people to expand across O‘ahu. A shift from temporary to permanent settlement likely began in the coastal and well-watered areas by the 1300s. Archaeological evidence indicates that the upper valleys followed this permanent settlement pattern by the 1400s (Cordy 2002a). The arid climate of Wai‘anae Moku, particularly from Mākua to Nānākuli, would have made the well-watered valleys the most attractive locations for settlement on the west side of O‘ahu.

Archaeological evidence indicates that early habitation in the upper valley of Lualualei dates to the AD 1300s–1500s, while temporary habitation and dryland fields in the lower upper valley indicated dates of AD 1400s–1600s, which according to Cordy (2002a:20) suggests earlier settlement down near the shore. By the 1600s, permanent houses in the upper portion of the valley had increased, and *lo‘i* were present along the upper Pūhawai and Kolekole streams (Cordy 2002a:32). When Europeans arrived in the area, permanent settlements were present on the coast and the in the upper valley (Cordy 2002a:90).

In upper Lualualei Valley, there were several *heiau*: at Pāhoa was Nioi‘ula Heiau (SIHP Site 50-80-08-00149), which is believed to have been associated with Kākuihihewa (ruled AD 1640–1660); Kakioe Heiau (State Inventory of Historic Places [SIHP] Site 50-80-08-00151), near a spring at Pūhāwai; and several small *heiau* within the navy land of Lualualei (Cordy 2002a:91–93). Archaeological work has also documented numerous house sites in the upper valley, along with evidence of dryland agriculture. As for the lower valley, only evidence of temporary habitation has been recorded, with the exception sites along Mā‘ili‘ili Stream (Cordy 2002a:94).

Coastal archaeological sites are sparse. McAllister (1933:112) noted that Pu‘upahe‘ehe‘e (SIHP Site 50-80-08-00152), situated at the seaward end of the ridge had been destroyed. Ruins of Kū‘īlioloa Heiau (SIHP Site 50-80-07-00153) on Kāne‘ilio Point are extant today.

During the late pre-Contact and early history periods many political changes transpired in Wai‘anae Moku (Shefcheck and Spear 2007:9). Maui Chief Kahekili successfully battled O‘ahu warriors in 1784, with the final battle occurring at Pu‘u Kawiwi in Wai‘anae Valley. Ten years later, Kahekili died and his son, Ka-lani-kū-pule took control of the island. In 1794, Ka-lani-kū-lani, ruler of Maui, Moloka‘i, and Lāna‘i, recruited warriors from Waialua and Wai‘anae and battled Ka-‘eo-kū-pule, but they were defeated (Kamakau 1992:168). The next year Kamehameha invaded the island and took control following the Battle of Nu‘uanu in April 1795 (Kuykendall 1938:47).

When European explorers first arrived in the Hawaiian Islands in the late 18th century, the population of Wai‘anae was concentrated in Wai‘anae and Mākaha valleys. According to archaeologist Ross Cordy, the area was a “political and religious center of the district in the late 1600s–1700s” (2002a:47). After Kamehameha I took power, Wai‘anae Moku was no longer considered a political center. Many people from other parts of O‘ahu fled to Wai‘anae for refuge. The following is an account of this event by A. Mouritz (1934 in Sterling and Summers 1978:68):

> After the rout of the army of Kalanikupule, the king of Oahu at Nuuanu, April 29, 1795 by the invading army of Kamehameha Nui, the conquered Oahuans were driven from the ir homes, their lands seized and divided amongst the friends of Kamehameha--the despoiled people in large numbers fled to Waianae and settled there. This part of Oahu being hot, arid, isolated, with little water, was not coveted by the invaders; the sea off the coast of Waianae has always supplied an abundance of fish, hence the name --wai, water; anae, large mullet [Mouritz 1934 in Sterling and Summers 1978:68].

Immediately south of the project area is the area known as Mā‘ili, between Pu‘umā‘il‘ili and Pu‘uohulu. The origin of the two ridges is told of in the following story:

> Puu o Hulu was said to be a chief who was in love with Maʻiliilii, one of twin sisters, but he could never tell, whenever he saw them which of the two was his beloved. A moʻo changed them all mountains so he is still there watching and trying to distinguish his loved one [Victoria Holt, Nov. 1954 in Sterling and Summers 1978:67].

Hawaiian historian John Papa ʻĪʻī wrote of traditional trails on Oʻahu. The portion of the trail from Mākaha to Puʻu o Kapolei, described below, would have passed through coastal Lualualei:

> It was customary to have dwelling places along the mountain trails that led downward from here [Puu Kawiwi] into Kamaile, as well as along the beach trail of Makaha. There were many houses at Makaha were a fine circle of sand provided a landing places for fleets of fishing canoes. The trail which passes by this sandy bar was one from Puu o Kapolei, which had joined the beach trail from Puuloa and from Waimanalo. It then went along the shore all around this island [ʻĪʻī 1959:97].

POST-CONTACT HISTORY AND LAND USE

Beginning in 1811, Kamehameha I commenced intensive sandalwood logging on Oʻahu. The trade was strictly under the control of the *aliʻi* (chiefs) and harvesting was conducted by the *makaʻāinana* (commoners). After a famine in 1821 due to the intensive logging, Kamehameha reversed the order to log so that the *makaʻāinana* were not overworked to the extent that farming was neglected. He also instituted conservation measures that spared young trees (Cottrell 2002:10). Upon Kamehameha's death in 1819, Liholiho (Kamehameha II) opened the sandalwood trade to his *aliʻi*, which caused the island to revert to intensive harvesting.

One of the *aliʻi* involved in the trade was Boki Kamaʻuleʻule, chief of Waiʻanae, who later became governor of Oʻahu (Kirch and Sahlins 1992:59). The diary of Don Francisco de Paula Marin documents many of Boki's trips from Honolulu to Waiʻanae, which were thought to be for procuring goods. In 1829, he sailed to the New Hebrides searching for more sandalwood and his ship was lost at sea (Jones and Hammatt 2009:13).

During the last years of the sandalwood trade, journal entries from Stephen Reynolds indicate that availability of sandalwood from Waiʻanae was sporadic. In 1840, forest privatization measures were introduced by King Kauikeaouli, just before the Mahele. At this point, relations between the *makaʻāinana* and *aliʻi* were strained and the land was suffering from the ecological consequences of deforestation (Cottrell 2002:164).

Traditional land divisions of the fifteenth and sixteenth centuries persisted until the 1848 Mahele, which introduced private property into Hawaiian society (Kamakau 1991:54). During the Mahele, the Land Commission required the Hawaiian chiefs and *konohiki* (land agent for the *aliʻi*) to present their claims to the Land Commission. In return they were granted Land Commission Awards (LCAs) for the land quit-claimed to them by Kamehameha III. Land was divided into Crown Lands, Government Lands, and Konohiki Lands. The remaining unclaimed land was then sold publicly, "subject to the rights of the native tenants" (Chinen 1958:29).

In the case of land claims made for Konohiki lands, approval by the Land Commissioners was required before the award was made. If approved, then the awardee obtained a Royal Patent (RP) from the Minister of the Interior, which indicated that the government's interest in the land had been settled with a commutation fee. This fee was typically no more than one-third of the value of the unimproved land. This fee was paid either with cash, or, more commonly, the return of one-third of the awardee's lands (or total value of the lands awarded) (Hammatt 2013:A-3).

The Kuleana Act of 1850 allowed *hoaʻāina* (common people of the land, native tenants) to make claims to the Land Commission. The new western system of ownership resulted in many losing their land.

Often claims would be made for discontiguous cultivated plots with varying crops, but only one parcel would be awarded.

The Crown Lands became Government Lands when the Hawaiian Government was overthrown in 1895, making them public domain for sale by fee simple (Hammatt 2013:A-5). Patents were the certificates issued for the sale of such lands. Beginning in 1900, when Hawaiʻi became a U.S. territory, the certificates were called Land Patents, or Land Patent Grants (Hammatt 2013:A-5).

Following the Kuleana Act of 1850 that granted individual *kuleana* (commoner) lots; no awards were made near the current project area. Lualualei was set aside as Crown Land and in 1894 was described as "one of the best and most valuable of the Crown lands on the Island of Oahu . . . surpassing any of the other lands for richness and great fertility of the soil" (Commissioner of Public Lands 1894:36 in Blahut and Hammatt 2017:17). Obviously, this referred to other parts of the valley and not the arid coastal plain where the project area is situated.

During the mid-19th century, Waiʻanae Moku became dominated by cattle grazing. William Jarrett leased around 17,000 acres of land from Kamehameha III in 1851, much of which was in Lualualei (B.C. Liber 4:616–618 in Tulchin et al. 2007:16). Later his operation became Lualualei Ranch. In 1880, George Bowser visited the area on noted the cattle grazing:

> Leaving Waiʻanae, a ride of about two miles brought me to the Lualualei Valley, another romantic place opening to the sea and surrounded in every direction by high mountains. This valley is occupied as a grazing farm by Messrs, Dowsett & Galbraith, who lease some sixteen thousand acres from the Crown. Its dimensions do not differ materially from those of the Waiʻanae Valley, except that it is broader – say, two miles in width by a length of six or seven miles. The hills which enclose it, however, are not so precipitous as those at Waiʻanae, and have, therefore, more grazing land on their lower slopes, a circumstance which adds greatly to the value of the property as a stock farm. Although only occupied for grazing purposes at present, there is nothing in the nature of the soil to prevent the cultivation of the sugar cane, Indian corn, etc. Arrangements for irrigation, however, will be a necessary preliminary to cultivation [Bowser 1880:493-494].

Specific to the current project area, available historical maps show few features in the vicinity of the project area. In Figure 5, an 1884 map simply labels the area "sand stone plain" and notes one "solitary coconut" to the east of the project area. Between the coconut tree and the shoreline is the O.R.&L railway (SIHP Site 50-80-04-07597) and a the "Government Road" or "Old Waiʻanae Road" (SIHP Site 50-80-04-07520). The road was unpaved and lacked bridges, so prior to the highway construction travel to Waianae from Honolulu was either by ship of (Blahut and Hammatt 2017:17).

In Figure 6, the project area falls within publics lands, with Waianae Plantation and former ranching land inland, the latter of which is outlined in dark orange. The 1914 Lualualei Homestead map, shown in Figure 7, indicates the project area was near Land Grant 5006 to Willard E. Brown and Land Grant 5263 to the Makaha Coffee Co Ltd. Brown was a stockbroker in Honolulu. The Makaha Coffee Company was an early grower of coffee on O'ahu and around 1896 the company purchased 200 acres in the back of Mākaha Valley (Commercial Advertiser 1896). It can be speculated that the parcel in Lualualei was used for storage or administration.

On subsequent maps the land continues to appear desolate until the 1920s. A 1913 topographical map in Figure 8 shows the project area in scrubland, with only the road and O.R.&L railway along the coast. On 27 June 1921, the project area became a public park following the governors executive order No. 106. By the late 1920s, a railway spur led branched inland near project area, as shown on topographical maps dated 1928 and 1936 in Figures 9 and 10. The spur led to Waiʻanae Lime Company quarry and would have transported raw materials (Land Court 1934; Persinski et al. 2002:13). The railway was used until the O.R.&L company went out of business. In 1939, the Lenakona Development, LTD, a branch of the former

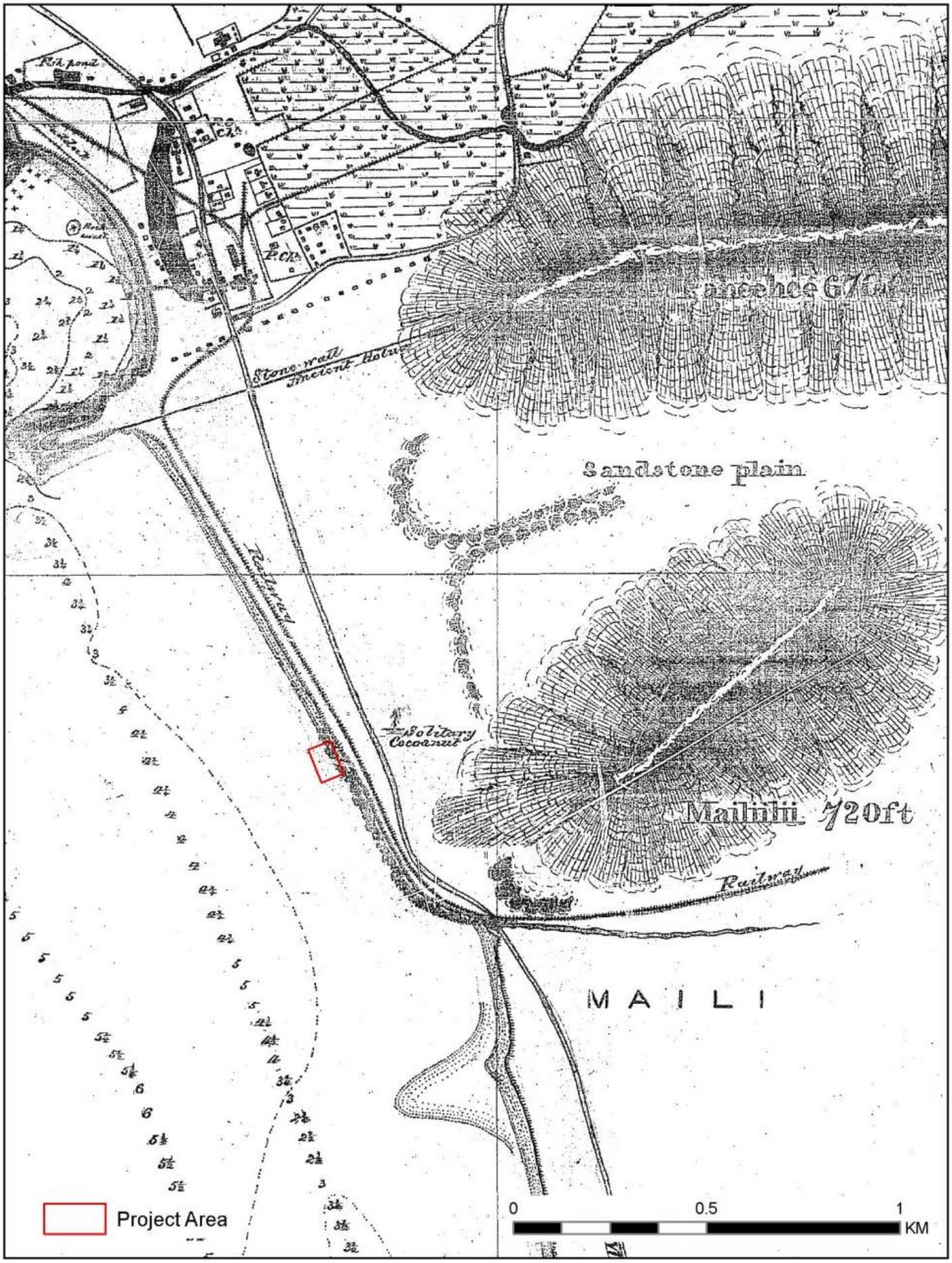

Figure 5. Project Area on 1884 Hawaiian Government Survey Map (Jackson 1884).

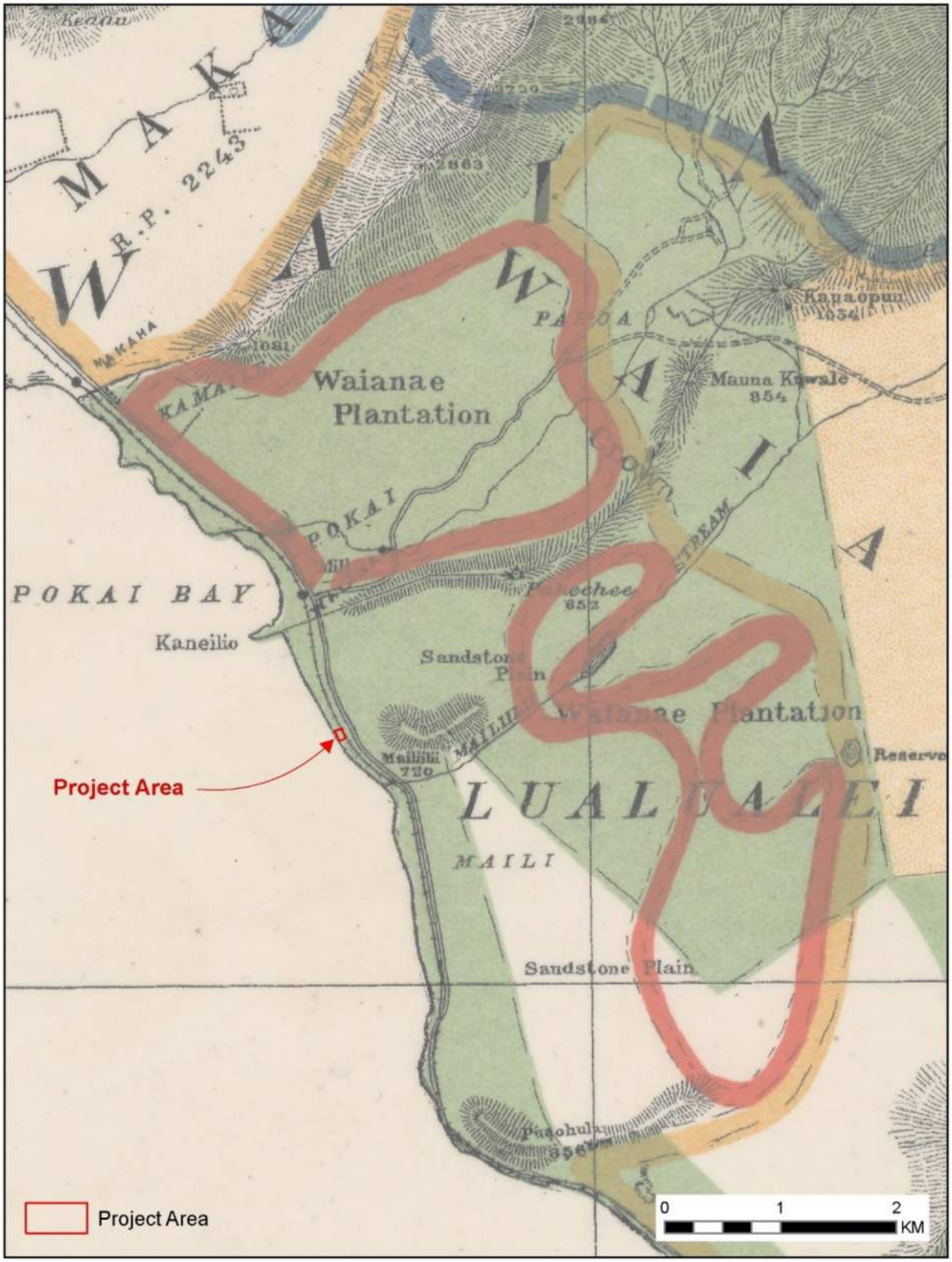

Figure 6. Historical Map Showing Waianae Plantation, Ranching Land Outlined in Dark Orange, and Public Land in Green (Donn 1902).

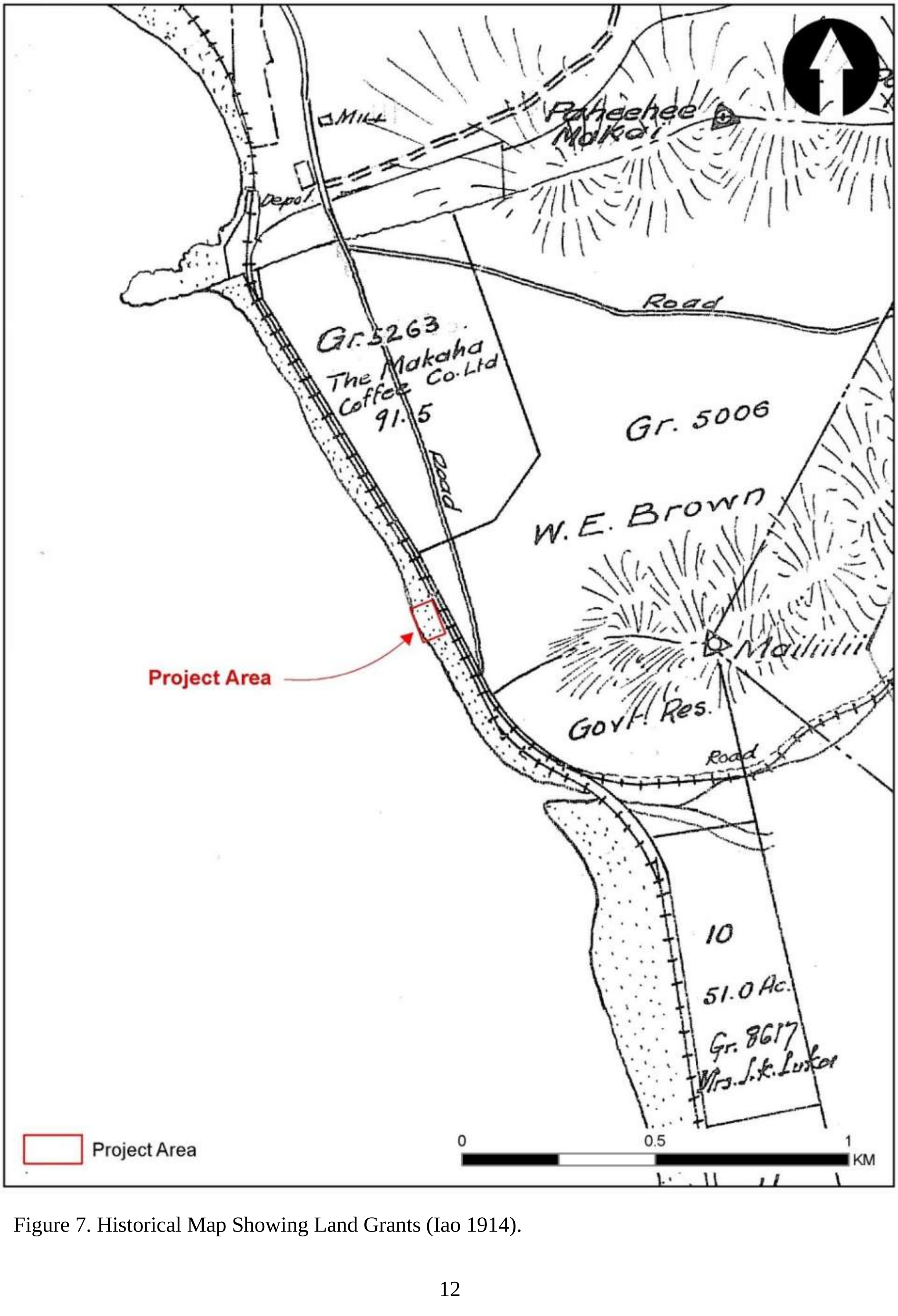

Figure 7. Historical Map Showing Land Grants (Iao 1914).

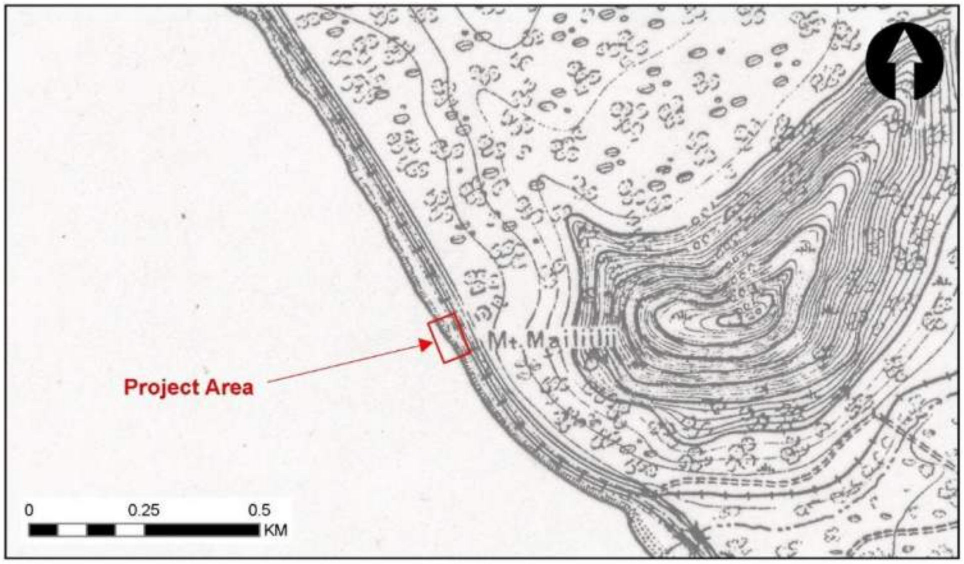

Figure 8. Portion of 1913 Topographical Map Showing Project Area Location (Cos. A. G. and I. Engineers, U.S. Army 1913).

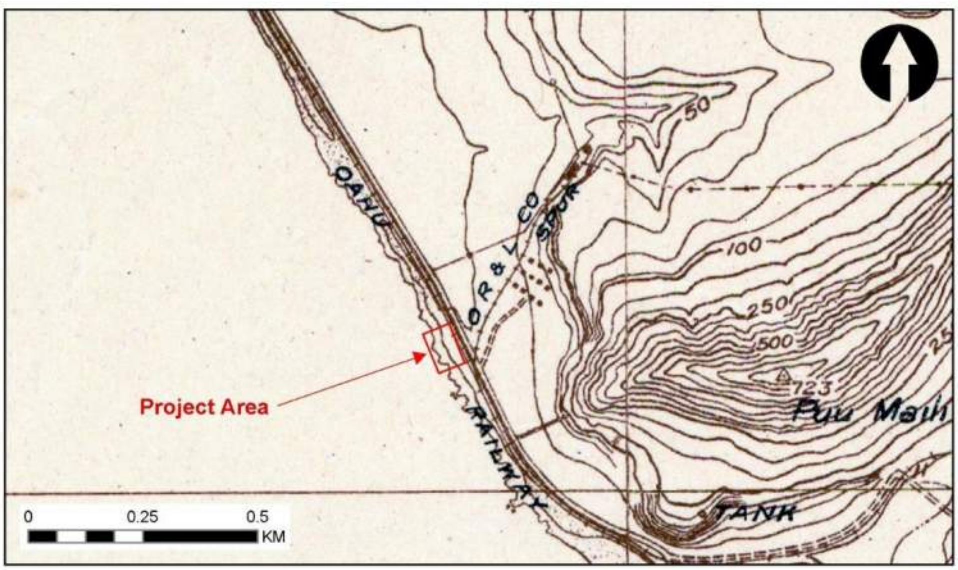

Figure 9. Portion of 1928 Topographical Map Showing Project Area Location (USGS 1928).

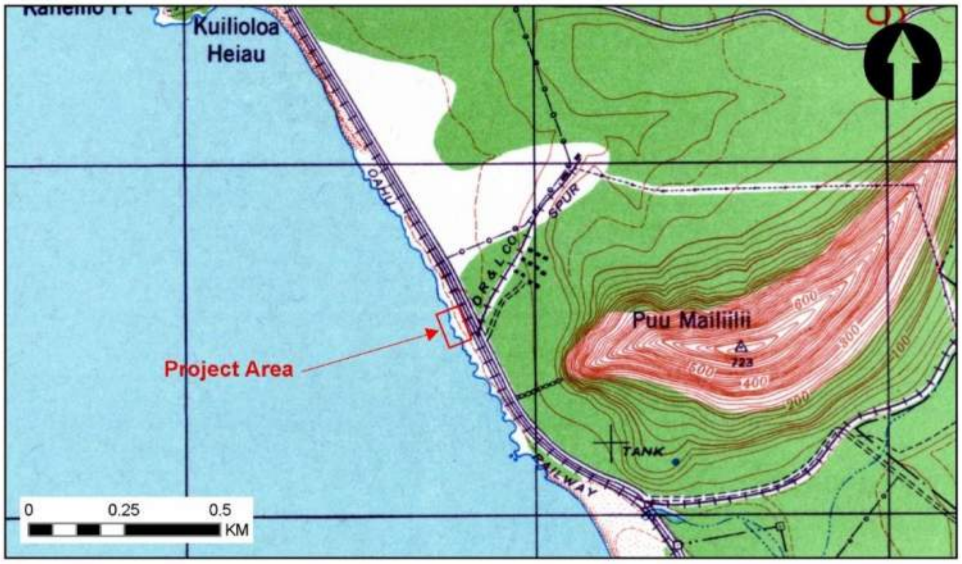

Figure 10. Portion of 1936 Topographical Map Showing Project Area Location (USACOE 1936).

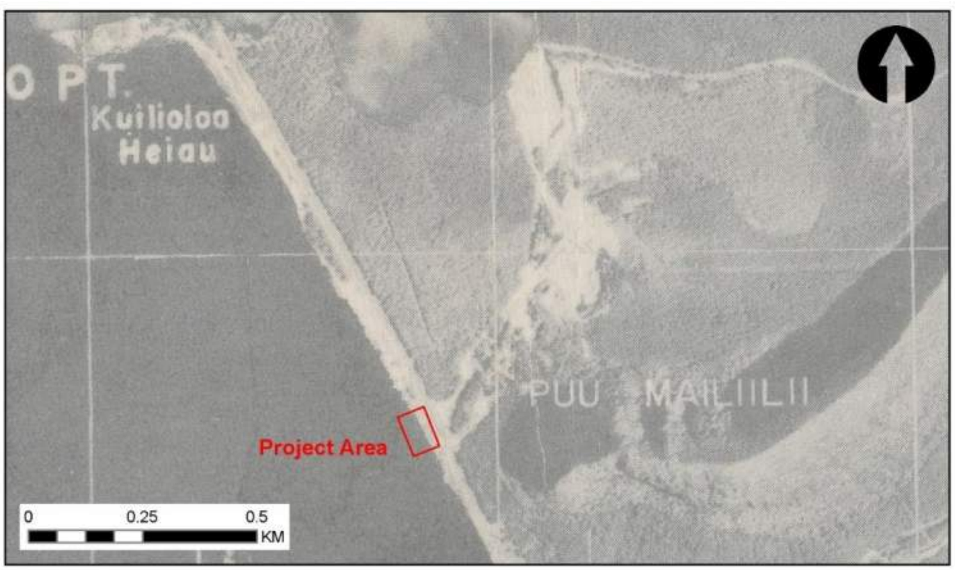

Figure 11. Portion of 1944 Topographical Map Showing Project Area Location (USAFCPBC 1944).

Hawaiian Gas Products, acquired a 301-acre parcel inland of the current project area; at the time, a cement and lime plant were in operation at the site (Persinski et al. 2002:13). After the acquisition, Hawaiian Gas Products changed its name to Gaspro and then partnered with the American Cement Company to form the Hawaiian Cement Company in 1950. The lime plant ceased operation 1976 due to complaints of noise and dust.

A 1944 photomap (see Figure 11) shows a swath of unvegetated land extending inland from the project area, which corresponds to the location of the quarry and access road on a 1956 topographical map in Figure 12. On a 1962 aerial photograph in Figure 13, the WWTP had not yet been constructed. Figure 14 shows WWTP on the east side of the highway in 1976, while the Village Pokai Bay subdivision was under construction at the former quarry site. By 1993, parking stalls were present in project area, as shown in Figure 15.

PREVIOUS ARCHAEOLOGY

Previous archaeological investigations in Waiʻanae Moku have documented *heiau*, temporary and permanent habitation sites, human burials, and historic sites. Investigations first began over a century ago with the work of Thrum (1907) and continued with McAllister during his island-wide survey (1933). In the modern era, archaeological work has shifted to systematic identification of cultural resources and the development of a settlement model for the *moku*. Some of the most notable studies include the Bishop Museum's Mākaha Valley project conducted from 1968 to 1970, which documented pre-Contact agricultural areas, permanent habitations, *heiau*, and various other structures dating from AD 1400s to 1700s (Green 1969;1970;1980); investigations in Nānākuli by the State Historic Preservation Division (SHPD) from 1988 to 1992 (Cordy 2002a); investigations in Waiʻanae Valley beginning in 1997 by SHPD, Waiʻanae High School's Hawaiian Studies Program, and the University of Hawaiʻi-West Oʻahu (Cordy 2002b;2003); and intensive survey at the back of Lualualei Valley by AMEC (Dixon et al. 2003).

None of the previous archaeological investigations within 500 meters of the project area, which are listed in Table 1, have recorded historic properties (Figure 16). Most relevant to the current undertaking are three archaeological monitoring projects conducted either along or seaward of Farrington Highway.

Along the beach near the WWTP, archaeological monitoring was conducted at two locations for comfort station construction: one to the north and one to the south of the current project area (Thruman and Hammatt 2009). No cultural deposits were encountered. The soil stratigraphy was limited to landscaping and construction fills.

The second project involved archaeological monitoring for the Makaha Interceptor Sewer Rehabilitation/Replacement Project (Stine et al. 2012), which extended along the coast from Pōkaʻī Bay to the WWTP. No historic properties were recorded near the WWTP project area. A stratigraphic soil profile recorded 400 meters north of the current project area documented three layers of fill to a depth of 60 cmbs.

Nearest to the current project area was archaeological monitoring along Farrington Highway from Ala Poko Street to the south end of the WWTP, which was conducted for the Kahe-Permanente 46kV Reconductoring and Pole Replacements Project (Blahut and Hammatt 2017). There was potential for the presence of two historic properties: SIHP Site 50-80-04-09714, which is the OR&L railroad, and traditional Hawaiian cultural layers due the project's beach location; however, no historic properties were encountered. Near the current project area, two stratigraphic soil profiles were recorded. At 200 meters south of the current project area, Profile 1 documented a 30 cm thick layer of fill underlain by a 25 cm thick layer of loamy sand. The coral shelf was encountered at 60 cmbs. Along the west border of the current project area, Profile 2 documented a 7 cm thick A horizon underlain by a 13 cm thick layer of fill, followed by a 6 cm thick buried A horizon, which was underlain by 42 cm thick layer of sand to loamy sand. The coral shelf was encountered at 88 cmbs. No cultural materials were observed.

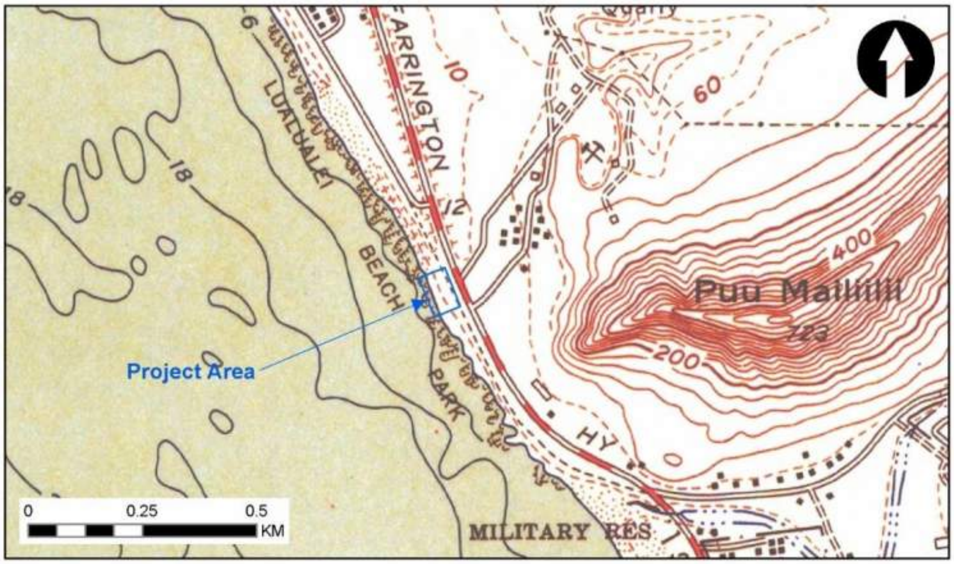

Figure 12. Portion of 1954 Topographical Map Showing Project Area Location (USGS 1954).

Figure 13. Portion of 1965 Aerial Photograph Showing Project Area Location (USDA 1962).

Figure 15. Portion of 1976 Aerial Photograph Showing Project Area Location (USGS 1976).

Figure 14. Portion of 1990 Aerial Photograph Showing Project Area Location (NOAA 1993).

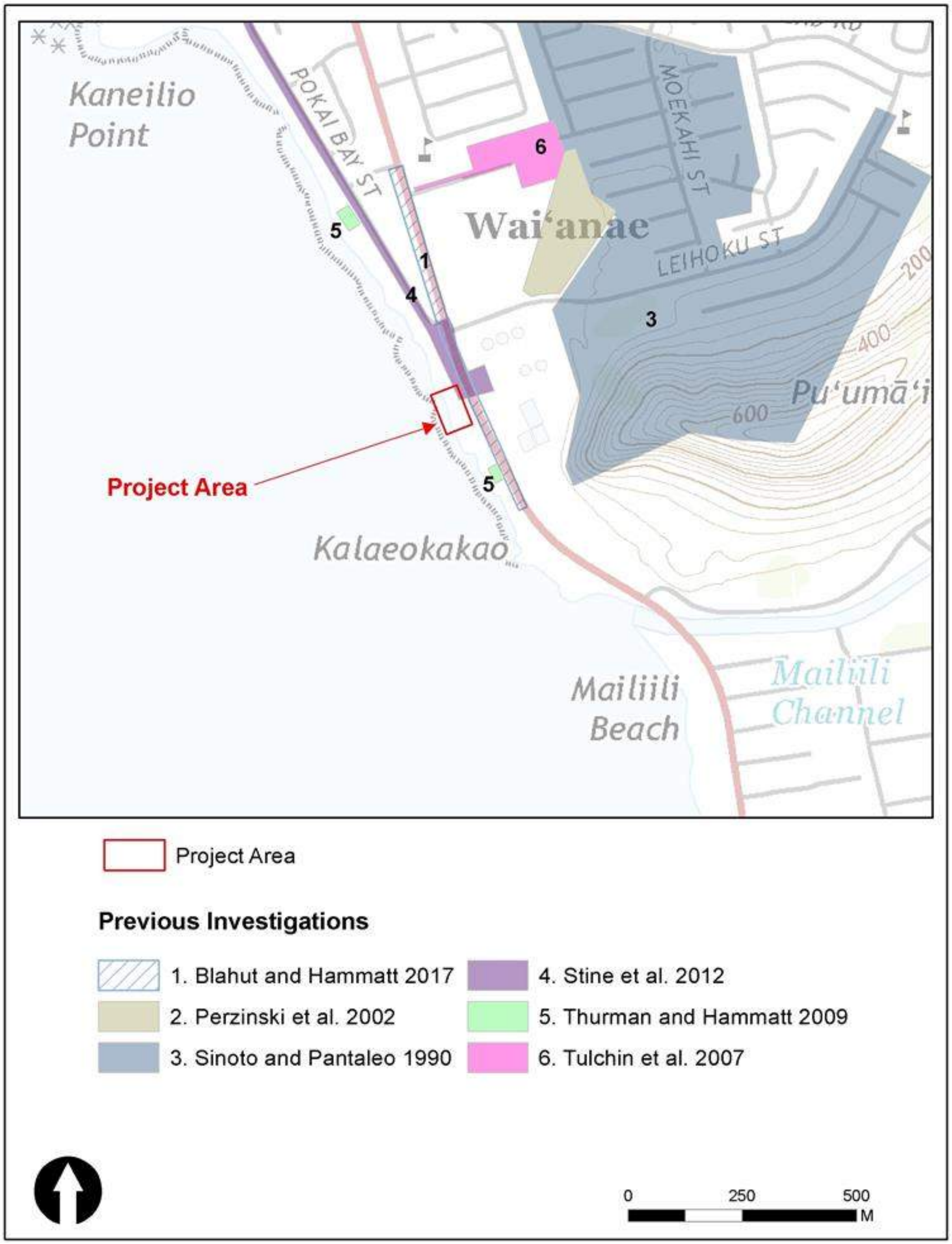

Figure 16. Locations of Previous Archaeological Investigations Near the Project Area.

Table 1. Previous Archaeological Studies in the Vicinity of the Project Area.

Reference	TMK(s) (1)	Nature of Study	Results
McAllister 1933	Island-wide	Archaeological Reconnaissance Survey	No sites recorded near the current project area
Sinoto and Pantaleo 1990	Pōkaʻī Bay Subdivision	Archaeological Reconnaissance Survey	No significant finds
Perzinski et al. 2002	8-6-001:029/ Waiʻanae Transit Center	Archaeological Assessment	No significant finds
Tulchin et al. 2007	8-7-023:060/ Waiʻanae Sustainable Communities Plan project	Archaeological Assessment	No significant finds
Thurman and Hammatt 2009	8-6-001:007/ Lualualei Beach Park	Archaeological Monitoring	No significant finds
Stine et al. 2014	8-5, 8-6/ Mākaha Interceptor Sewer Rehabilitation/Replacement Project	Archaeological Monitoring	No sites recorded near the current project area
Blahut and Hammatt 2017	8-6-001, 013/ Farrington Hwy	Archaeological Monitoring	No significant finds

*State Inventory of Historic Places

ANTICIPATED FINDS

In view of the prior archaeological findings and past land use, there is low potential for the presence of traditional Hawaiian subsurface cultural layers or features in the project area. There have been no historic properties, including human burials, identified near the project area (see Figure 16). However, the beach location and lack of development in the project area does suggest that traditional Hawaiian human burials may be encountered. Also, based on historical maps (see Figures 5–10), a portion of the OR&L railroad (SIHP Site 50-80-04-09714) may be extant in the project area.

FIELD INSPECTION

An archaeological field inspection was conducted by PCSI archaeologist Dennis Gosser, M.A., on 10 September 2020. The purpose of the field inspection was to ensure that no traditional Hawaiian pre-Contact or historical archaeological materials or features were present on the surface.

The portion WWTP Outfall project area consists of an approximately 100-meter-wide swath of beach that extends from Farrington Highway to the shoreline. On the opposite side of the highway is the WWTP. At the northeast corner is a parking lot for beach access. A campsite is present to the north, outside the project area. Surrounding the outfall sewer large is undeveloped beach scattered with large rocks or small boulders. Photographs of the project are shown in Figures 17–19. No traditional Hawaiian pre-Contact or historical archaeological materials were observed in the project area. Only four modern features were present, all of which consisted of stacked or intentionally arranged rocks, including one memorial. These four modern features are shown in Figures 20–24.

Figure 17. Overview Photograph of the Project Area, Facing North.

Figure 18. Overview Photograph of the Project Area, Facing South.

Figure 19. Overview Photograph of the Project Area, Facing Northwest

Figure 20. Modern Feature 1 With Memorial, Facing Northwest

Figure 21. Modern Feature 2, Facing West.

Figure 22. Modern Feature 2 With Rubbish, Facing Southeast.


Figure 23. Modern Feature 3, Facing North.


Figure 24. Modern Feature 4, Facing East.

CONSULTATION

In an effort to more completely understand the cultural and historical background within and around the project area and bring as much information to bear on the decision-making process for this project, PCSI sought community input.

METHODS

PCSI initially reached out to the SHPD (23 April 2021) in order to identify individuals and organizations that might be knowledgeable and interested in participating in the consultation. While SHPD did not provide any individual names, it did provide resources PCSI could consult, including previous Waianae-based environmental impact assessments and studies that included cultural consultation and the United States Department of Interior *Native Hawaiian Organization Notification List (NHONL)*. The NHONL is available at: https://www.doi.gov/sites/doi.gov/files/nhol-complete-list.pdf . The NHONL list is updated periodically (last updated in September 2020) and includes contact information (usually an individual) as well as each organization's geographic and topical focus. The following individuals and organizations were identified to attempt consultation (in addition, the introductory correspondence asked if the individual or group could forward the consultation invitation to other community groups or members that might be interested in participating):

- The Office of Hawaiian Affairs (OHA)
- The State Historic Preservation Division (SHPD)
- The Waiʻanae Hawaiian Civic Club
- The Association of Hawaiian Civic Clubs
- Hui Huliau, Inc.
- Institute for Native Pacific Education and Culture
- Mr. Thomas Kamealoha
- Koa Ike
- Marae Haʻa Koa
- Unsolicited individual

Three attempts were made to communicate with the above community groups and individuals. Emails were sent on 19 June 2021 and 19 July 2021. The second email was followed by a telephone call (20 August 2021) when telephone information was provided.

CONSTRAINTS

The primary constraints for the consultation process were those imposed due to the COVID-19 pandemic. PCSI's constraints followed mandates from our clients including the Federal Government, the State Government, local government agencies, and commercial partners. PCSI has also implemented internal mandates that ensure the broadest level of compliance. The primary result of the COVID-19 pandemic mandates is that restrictions have been placed on the types, duration, and sizes of gatherings. To mollify these restrictions, PCSI has attempted to include alternative means of interactive meetings including phone access, email, and various internet-based video meeting forums.

RESULTS

No responses were returned from the two rounds of email. The third round of attempted phone contact resulted in speaking with two individuals (Mr. Adrian Silva of Hui Huliau, Inc. and Mr. Thomas Kamealoha [cultural monitor]) and leaving four messages asking for a return phone call. Mr. Silva provided a different email address and asked that the information be sent to that address (which it was). Mr. Kamealoha indicated that he did not receive the emails. PCSI confirmed the address with Mr. Kamealoha (same as previously used), confirmed that any attachments were within the size and format limits to be received, and resent the email. Neither individual has responded. None of the individuals have responded where phone messages were left.

One unsolicited individual contacted PCSI subsequent to the second email. The individual respectfully declined to provide formal authorization or release (and will remain anonymous) but was willing to informally be interviewed by email to answer questions and discuss the project area specifically and Waiʻanae generally.

The individual is a 51 years old (2021) male who currently lives in Pearl City, but was born and raised in Waiʻanae until the age of 25 or 26. Asked if he was comfortable describing his ethnicity, he noted that his mother was part Hawaiian and part Portuguese and that his father was part Portuguese and part Irish. The individual frequently returns to Waiʻanae to visit friends and family in Waiʻanae as well as Nanakuli. The individual specified a family knowledge of local history but would not consider himself an expert.

Asked about cultural uses of the area around the project area, the individual noted that camping and day parties are popular to the south of the project area (City and County of Honolulu Lualualei Beach Park), as is (onshore) fishing. The individual noted an increase (PCSI assumed this meant an increase since childhood) in homelessness along the shoreline.

Asked about the modern built features to the north of the project area, the individual said he knew of them but that they change over time. The individual was aware that human burial (traditional) occurred along the Waiʻanae shoreline, but was not aware of any specific locations.

Asked about myths or legends as they might pertain to the project area, the individual was not aware of anything specific but did note a similar understanding of the hero Maui's role and presence in Waiʻanae. No additional information pertinent to the project area was discussed.

SUMMARY AND ASSESSMENT

The proposed Waianae Wastewater Treatment Plant (WWTP) Ocean Outfall project is within the TMK parcel (1) 8-6-001:007 in Lualualei, Waiʻanae Ahupuaʻa, Waiʻanae Moku on Oʻahu Island (see Figure 1). The project area measures 1.4-acre (.57-ha). The project proponent and land owner is State of Hawaiʻi. The project scope of work rehabilitation and improvements to the existing 36-inch ocean outfall sewer, which discharges treated effluent 6,180 feet offshore from the WWTP. A field inspection and an archaeological literature review that addresses historical, cultural, and archaeological background were conducted in order to evaluate any potential effect on historic properties in the project area, and to recommend mitigation of any adverse effect, if warranted.

Background research indicates that project area was not intensively used during the pre-Contact or early historic periods. Previous land use in the project area includes construction of the ocean outfall sewer in the mid-1960s and recreation and camping in the modern era. Based on previous archaeological investigations in the vicinity, there is low potential for traditional Hawaiian subsurface cultural deposits; however, the lack of development and the beach location does suggest the possibility of for encountering traditional Hawaiian human burials. Also, historical maps indicate that a portion of the OR&L railroad (SIHP Site 50-80-04-09714) may be present in the project area.

Community consultation resulted in the identification of modern uses such as camping, day gatherings, and fishing as well as the generalized possibility of human burials along the Waiʻanae coast. No cultural or traditional practices were identified within the project area.

RECOMMENDATIONS

Results of the field inspection and literature review conducted for the WWTP Ocean Outfall project indicate that there are no known historic properties within the project area. However, based on the project's beach environment, there is potential for traditional Hawaiian burials in subsurface sand deposits.

Additionally, buried remnants of the OR&L railroad (SIHP Site 50-80-04-09714) may be extant. Pursuant to HRS, Chapter 6E-8 and its implementing regulations at HAR §13-275-7(2), the project effect determination for the project area, based on the research presented herein, is "No Historic Properties Affected."

The project will not affect any significant architectural historic properties and at this time no significant archaeological historic properties have been identified within the project area. Because the proposed project has the potential to adversely impact subsurface historic properties that may be present, archaeological monitoring should be conducted for identification purposes with an SHPD-approved AMP.

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APPENDIX A: PROJECT SITE PLANS

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JOB NO. 25-65

WAIANAE OCEAN OUTFALL SEWER

WAIANAE, OAHU, HAWAII

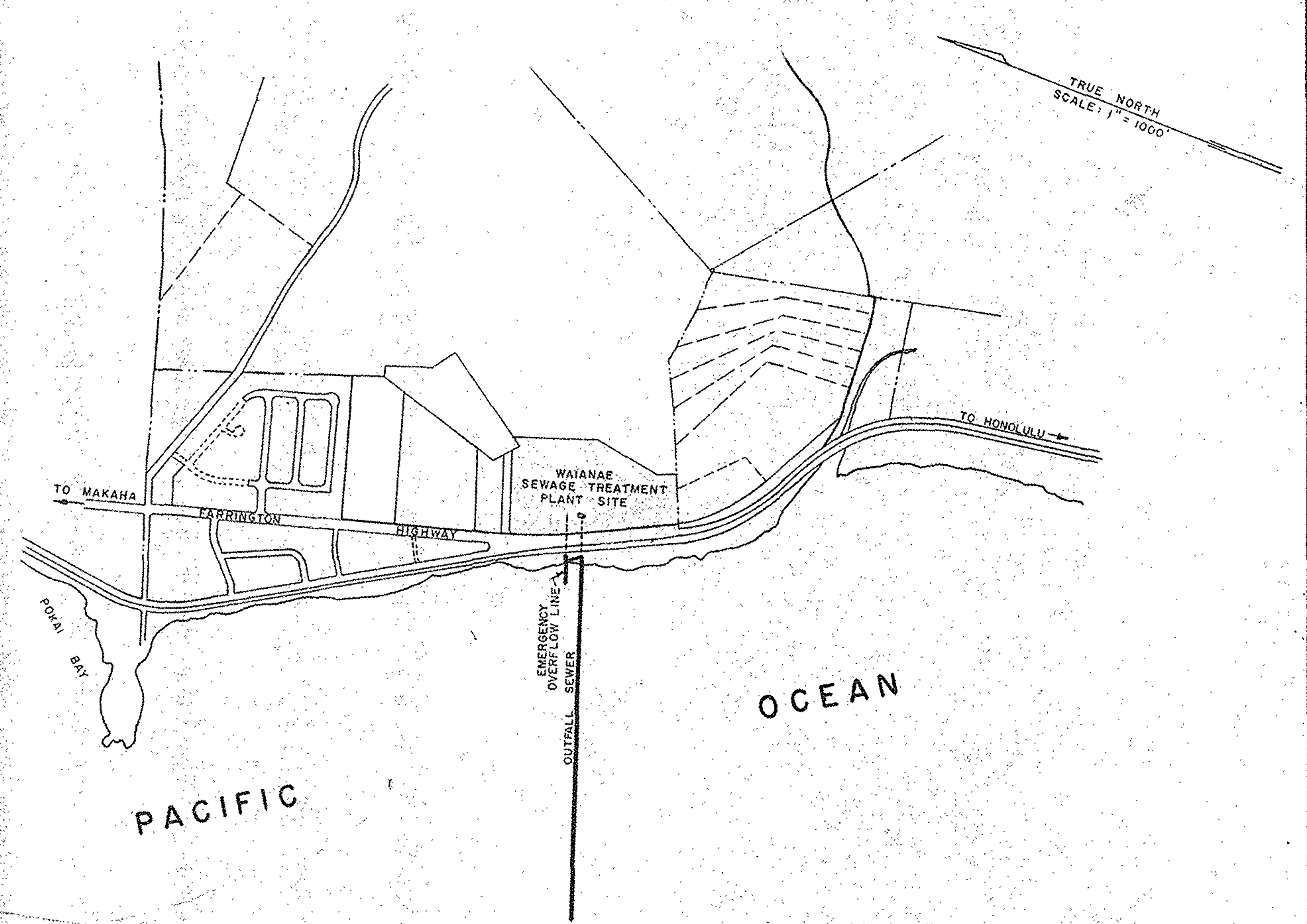
DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
DIVISION OF SEWERS

INSPECTOR'S COPY
Wye Book No.
Res. Engr. A. Distajo Jr.
Inspector A. Sakamoto
Date Final Inspection 11/14/67

SUNN, LOW, TOM & HARA, INC. — CONSULTING ENGINEERS
195 SOUTH KING STREET — HONOLULU, HAWAII

ALBERT O. Y. TOM — REGISTERED PROFESSIONAL ENGINEER No. 713 — HAWAII, U.S.A.

FRANKLIN Y. K. SUNN — REGISTERED PROFESSIONAL ENGINEER No. 531 — HAWAII, U.S.A.



LOCATION PLAN

1000' 500' 0' 1000' 2000'

SCALE: 1" = 1000'

TAX MAP KEY: 8-6-01

WN 26/18

INDEX TO DRAWINGS

APPROVED:

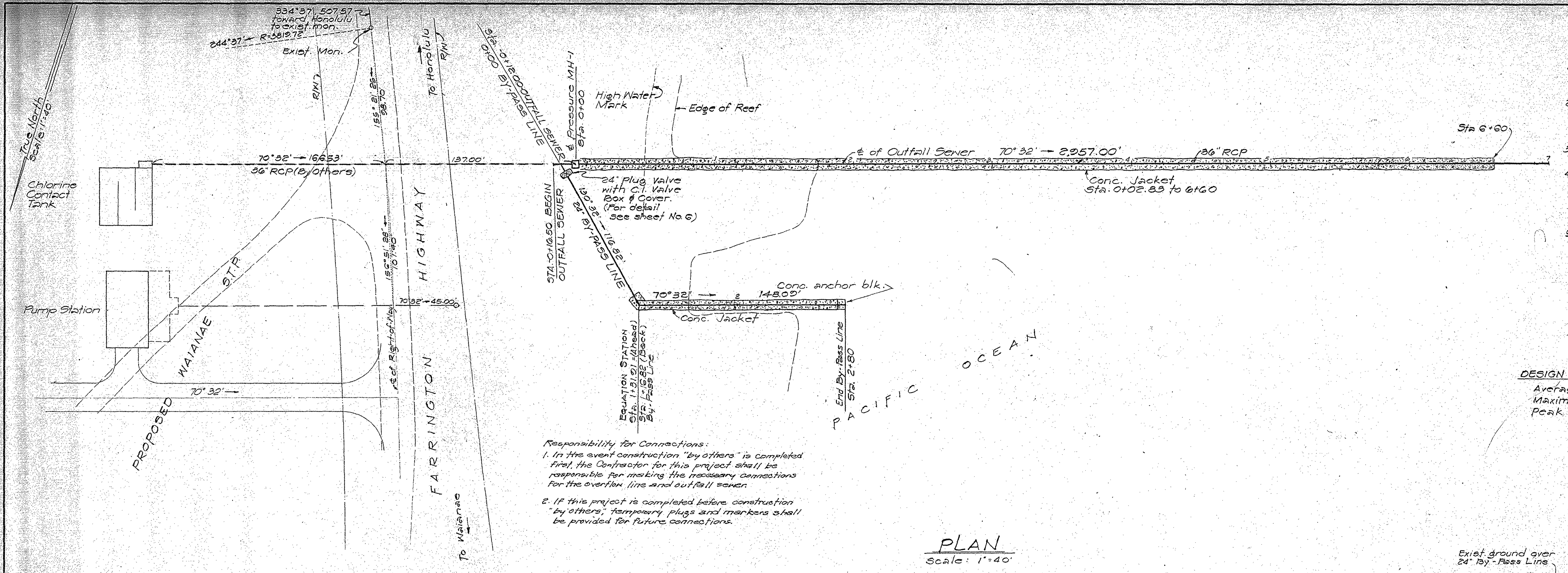
REGISTERED PROFESSIONAL ENGINEER No. 291-E, HAWAII DEPARTMENT OF PUBLIC WORKS CITY & COUNTY OF HONOLULU, HAWAII	2/21/66 DATE
REGISTERED PROFESSIONAL ENGINEER No. 492-E, HAWAII DIVISION OF SEWERS CITY & COUNTY OF HONOLULU, HAWAII	2/18/66 DATE
REGISTERED PROFESSIONAL ENGINEER No. 820-E, HAWAII ENVIRONMENTAL HEALTH DIVISION DEPARTMENT OF HEALTH	2/21/66 DATE

WAIANAE OCEAN OUTFALL

Rack 43L /6

SHEET 1 OF 6 SHEETS

FILE	POCKET	FOLDER	NO.
		3	57



GENERAL NOTES

202-2

1. Bench Mark and Reference Points at beginning of construction shall be furnished by the Engineer. Datum is mean sea level.
2. The elevations shown on the Profiles are P.I. (inv.) elevations. Maximum deflection per joint for all horizontal and vertical deflections shall be 0 degree 45 minutes (0°45'). Bends are acceptable.
3. 30" and 36" RCP and fittings test requirement shall be 50 ft. of hydrostatic head.
4. The Borings shown on the sheets are for design purposes only. The Borings and Soundings are believed to be reliable but the City and County of Honolulu does not guarantee the accuracy of same. Borings taken by Nat Whiton, Jan. 3, 1964.
5. Ocean bottom shown on profile at outfall ¢ is plotted schematically only. Contractor shall make his own verification of the profile. No extra payment shall be made to the contractor for any variations in the profile. Soundings were taken on February 17, 1965 along ¢.

DESIGN DATA

DESIGN FLOWS	INITIAL PHASE	ULTIMATE PHASE
Average	1.72 mgd	7.09 mgd
Maximum	3.68 mgd	15.10 mgd
Peak	4.69 mgd	19.28 mgd

REVISION	DATE	BRIEF	BY	APPR'D
1	7/12/66	Deleted 24" Overflow Line	amf	[illegible]

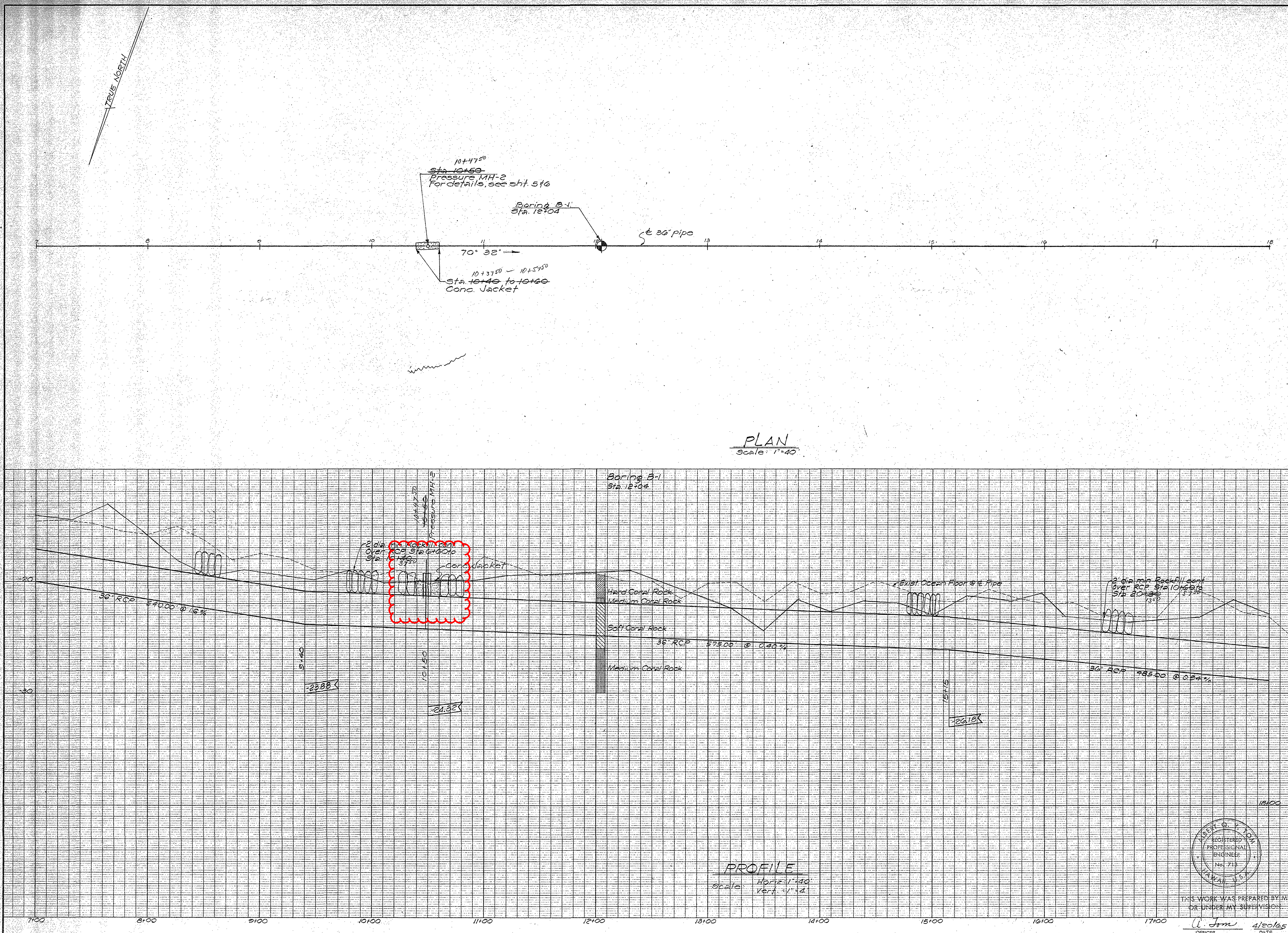
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.
A. Tom 4/20/65
OFFICER DATE

SUNN, LOW, TOM & HARA, INC.
CONSULTING ENGINEERS
195 S. KING ST. HONOLULU 13, HAWAII

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
DIVISION OF SEWERS
WAIANAE OCEAN OUTFALL SEWER
WAIANAE, OAHU, HAWAII
PLAN & PROFILE
OCEAN OUTFALL,
BY-PASS & OVERFLOW LINES

DRAWN BY C. Won ENGINEER G. Taguchi
APPROVED BY
[signature] 2/18/66
DIR., DIVISION OF SEWERS amf DATE
DATE
DATE
DATE

FILE	POCKET	FOLDER	NO.



THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION

A. Tom — OFFICER — 4/20/65 DATE

REVISION	DATE	BRIEF	BY	APPR'D

SUNN, LOW, TOM & HARA, INC.
CONSULTING ENGINEERS
195 S. KING ST. HONOLULU 13, HAWAII

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
DIVISION OF SEWERS

WAIANAE OCEAN OUTFALL SEWER
WAIANAE, OAHU, HAWAII

PLAN & PROFILE OCEAN OUTFALL SEWER

DRAWN BY C. Non ENGINEER B. Taguchi

DIR., DIVISION OF SEWERS 2/18/66 DATE

DATE DATE DATE

FILE	POCKET	FOLDER	NO.
11	11	3	59


202-4
TRUE NORTH
NOTE:
1-Stones shall be 12" to 24" in diameter and shall weigh at least 200#
2-Quarry Run & Rock Fill From: Sta. 20+50 to 22+60 Sta. 25+60 to 25+90
Stones with filler
36" R.C.P.
Quarry Run 6" To Fine
Sand
Crushed Coral Cradle
Approximate Coral Surface
QUARRY RUN & ROCK FILL DETAIL
NOZZLE LAYOUT-PLAN
NO SCALE
NOTE: Outfall sewer stationing at diffusers based on constant 10'-0" o.c. spacing. Corresponding adjustment will be necessary for diffuser spacing exceeding 10'-0".
Sta. 1+70.27
Sta. 0+26.32
Sta. 1+52.32
Sta. 1+68.27 to 1+69.27 Conc. Anchor Block
Sta. 1+70.10 30" RCP Plug with C.I. Cover. Provide 12" dia. opening with temporary plug @ bottom. For details see shts. 5 & 6
Sta. 1+70.27 End Ocean Outfall
8"-P
6"-P-OF
Sta. 20+13.50 to 20+33.50 Conc. Jacket
Sta. 20+23.50 Pressure MH-3
℄ 36" Pipe
70° 32'
Sta. 20+33.50 to 22+60 Quarry Run & Rock Fill For Detail - See Above
Sta. 25+60 to 25+90 Quarry Run & Rock Fill For Detail - See Above
Boring B-2 Sta. 21+04
Sta. 26+05.50 - 26+25.50 Conc. Jacket
Sta. 26+15.50 Pressure MH-4 For details, see sht. 5 & 6
36" RCP Plug With Concrete Reaction Block
Sta. 28+13.51 P.I. Special Wye Structure (For details - See This Sht.) 0+00 (Diffuser Line)
NOTE: Furnish One (1) 1" Thick Fiberglass Gate.
1½" Slot Opening For Fiberglass Gate
SECTION "A-A"
SCALE: 3/8" = 1'-0"
36" I.D.
18 - ¾" x 6" Stainless Steel Bolts ½" Thick Stainless Steel Cover Plate For Both Slots
Sta. 28+03.02 P.I. Special Wye
SCALE: 3/8" = 1'-0"
36"x36" SPECIAL WYE STRUCTURE
PLAN
Scale: 1" = 40'
36"x36" Special Wye
Plug
Concrete Reaction Block Poured In-Place
DETAIL OF 36" PLUG AND REACTION BLOCK
NOT TO SCALE
Conc. Jacket
2' Dia. min. rockfill continuous over RCP For details see sht. 5 Sta. 20+50 to 25+90
Exist. ocean floor @ ℄ pipe
36" RCP 485.00' @ 0.24%
36" RCP 800.00' @ 0.40%
Medium Coral Rock
Soft and Medium Coral Rock
2' dia. min. rockfill continuous over RCP Sta. 26+10 to Sta. 28+00
8 Diffusers @ 18'-0" o.c. min. (20'-0" o.c. max.) For Details see sht. 5
This Section Proposal Item 8
Excavate to Sta. 27+03.27 Cut at 2:1 to meet ocean floor
30" RCP 170.27' @ 0.00%
30" RCP plug with cast iron cover. Provide 12" dia. opening with temporary plug @ bottom. For details see sheets 5 & 6
End Outfall Sewer
PROFILE
Scale: Horiz. 1" = 40' Vert. 1" = 4'
18+00 19+00 20+00 21+00 22+00 23+00 24+00 25+00 26+00 27+00
-20 -30 -40
REVISION | DATE | BRIEF | BY | APPR'D
4 | 9-8-67 | Added Quarry Run & Rock Fill Det. - Sta. 20+50 & 26+00
3 | 8-31-67 | Revised Diffuser Slope & Ground Profile
2 | 7-31-67 | Changed 30" to 36" Pipe Realigned Diffuser Line
1 | 6-10-66 | Revised Diffuser & Plug notes.
SUNN, LOW, TOM & HARA, INC.
CONSULTING ENGINEERS
195 S. KING ST. HONOLULU 13, HAWAII
DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
DIVISION OF SEWERS
WAIANAE OCEAN OUTFALL SEWER
WAIANAE, OAHU, HAWAII
PLAN & PROFILE
OCEAN OUTFALL SEWER
DRAWN BY C. Non
ENGINEER B. Taguchi
APPROVED BY
DIR., DIVISION OF SEWERS
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION
OFFICER 4/20/65 DATE
SHEET 4 OF 6 SHEETS
FILE 11 POCKET 11 FOLDER 3 NO. 60

Appendix G

Pre-Assessment Comments and Responses

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POLICE DEPARTMENT

CITY AND COUNTY OF HONOLULU

801 SOUTH BERETANIA STREET · HONOLULU, HAWAII 96813
TELEPHONE: (808) 529-3111 · INTERNET: www.honolulupd.org

RICK BLANGIARDI
MAYOR

SUSAN BALLARD
CHIEF

JOHN D. McCARTHY
AARON TAKASAKI-YOUNG
DEPUTY CHIEFS

OUR REFERENCE EO-DK

March 31, 2021

SENT VIA EMAIL

Ms. Jennifer M. Scheffel
jscheffel@ssfm.com

Dear Ms. Scheffel:

This is in response to your letter dated March 23, 2021 requesting input on the Pre-Consultation, Environmental Assessment, for the proposed Waianae Wastewater Treatment Plant Outfall Improvements and Rehabilitation project to protect the pipe from progressive shoreline erosion.

Based on the information provided, the Honolulu Police Department (HPD) does not have any comments or concerns at this time. However, the HPD would like to be notified of any updates to the project to reassess its impact on police operations.

If there are any questions, please call Major Gail Beckley of District 8 (Kapolei, Waianae) at 723-8400.

Thank you for the opportunity to review this project.

Sincerely,

DARREN CHUN
Assistant Chief of Police
Support Services Bureau

Serving and Protecting With Aloha

SSFM International
Innovate | Adapt | Sustain

October 14, 2021

SSFM 2015_070.000

Mr. Darren Chun, Assistant Chief of Police
Support Services Bureau
Honolulu Police Department
801 South Beretania Street
Honolulu, Hawaii 96813

**SUBJECT: Waianae Wastewater Treatment Plant (WWTP)
Outfall Improvements and Rehabilitation
Waianae, Oahu, Hawaii
Tax Map Key (TMK): (1) 8-6-001:007
Response to Pre-Assessment Consultation Comments**

Dear Mr. Chun,

Thank you for your letter dated March 31, 2021 regarding the subject project. We note that the Honolulu Police Department does not have any comments or concerns at this time. We will notify the Department regarding availability of the Draft Environmental Assessment (Draft EA) upon its publication.

Your letter, along with this response letter, will be included in the forthcoming Draft EA. We appreciate your participation in the pre-assessment consultation process. Should you have additional comments or questions regarding this project, please contact me at (808) 356-1273 or via email at jscheffel@ssfm.com.

SSFM INTERNATIONAL, INC.

Jennifer M. Scheffel
Sr. Environmental Planner

DAVID Y. IGE
GOVERNOR OF HAWAII

ELIZABETH A. CHAR, M.D.
DIRECTOR OF HEALTH

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HI 96801-3378

In reply, please refer to:
File:

April 7, 2021

Ms. Jennifer Scheffel
SSFM International
jscheffel@ssfm.com

Dear Ms. Scheffel:

Thank you for your submittal requesting comments to the Pre-Assessment Consultation for Environmental Assessment for the Waianae Wastewater Treatment Plant (WWTP) Outfall Improvements and Rehabilitation located in Waianae, Oahu, Hawaii, Tax Map Key (TMK): (1) 8-6-001:007.

Project activities shall comply with the following Administrative Rules of the Department of Health:

- Chapter 11-46 Community Noise Control

Should you have any questions, please contact me at (808) 586-4700.

Sincerely,

Daryn A. Yamada
Acting Program Manager
Indoor and Radiological Health Branch

SSFM International
Innovate | Adapt | Sustain

October 14, 2021

SSFM 2015_070.000

Mr. Shawn Haruno, Acting Noise Supervisor
State of Hawaii
Department of Health
Indoor and Radiological Health Branch
P.O. Box 3378
Honolulu, Hawaii 96801-3378

SUBJECT: Waianae Wastewater Treatment Plant (WWTP)
Outfall Improvements and Rehabilitation
Waianae, Oahu, Hawaii
Tax Map Key (TMK): (1) 8-6-001:007
Response to Pre-Assessment Consultation Comments

Dear Mr. Haruno,

Thank you for the Indoor and Radiological Branch's letter dated April 7, 2021 from then Acting Program Manager Daryn Yamada regarding the subject project. Project activities will comply with HAR Chapter 11-46, Community Noise Control, as well as HAR Chapter 11-501, as applicable.

Your letter, along with this response letter, will be included in the forthcoming Draft EA. We appreciate your participation in the pre-assessment consultation process. Should you have additional comments or questions regarding this project, please contact me at (808) 356-1273 or via email at jscheffel@ssfm.com.

SSFM INTERNATIONAL, INC.

Jennifer M. Scheffel
Sr. Environmental Planner

HONOLULU FIRE DEPARTMENT
CITY AND COUNTY OF HONOLULU
636 South Street
Honolulu, Hawaii 96813-5007
Phone: 808-723-7139 Fax: 808-723-7111 Internet: www.honolulu.gov/hfd

RICK BLANGIARDI
MAYOR

April 8, 2021

Ms. Jennifer Scheffel
Senior Environmental Planner
SSFM International
501 Sumner Street, Suite 620
Honolulu, Hawaii 96817

Dear Ms. Scheffel:

Subject: Preassessment Consultation for Environmental Assessment
Waianae Wastewater Treatment Plant
Outfall Improvements and Rehabilitation
Waianae, Oahu, Hawaii
Tax Map Key: 8-6-001: 007

In response to your letter dated March 23, 2021, regarding the abovementioned subject, the Honolulu Fire Department reviewed the submitted information and determined that there will be no significant impact to fire department services.

Should you have questions, please contact Battalion Chief Reid Yoshida of our Fire Prevention Bureau at 723-7151 or ryoshida@honolulu.gov.

Sincerely,

JASON SAMALA
Assistant Chief

JS/TC:bh

SSFM International
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October 14, 2021 SSFM 2015_070.000

Mr. Jason Samala, Assistant Chief
Honolulu Fire Department
636 South Street
Honolulu, Hawaii 96813-5007

SUBJECT: Waianae Wastewater Treatment Plant (WWTP)
Outfall Improvements and Rehabilitation
Waianae, Oahu, Hawaii
Tax Map Key (TMK): (1) 8-6-001:007
Response to Pre-Assessment Consultation Comments

Dear Mr. Samala,

Thank you for your letter dated April 8, 2021 regarding the subject project. We note that the proposed project will have no significant impact to Honolulu Fire Department services.

Your letter, along with this response letter, will be included in the forthcoming Draft EA. We appreciate your participation in the pre-assessment consultation process. Should you have additional comments or questions regarding this project, please contact me at (808) 356-1273 or via email at jscheffel@ssfm.com.

SSFM INTERNATIONAL, INC.

Jennifer M. Scheffel
Sr. Environmental Planner

DEPARTMENT OF DESIGN AND CONSTRUCTION
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET, 11TH FLOOR
HONOLULU, HAWAII 96813
Phone: (808) 768-8480 • Fax: (808) 768-4567
Web site: www.honolulu.gov

RICK BLANGIARDI
MAYOR

ALEX KOZLOV, P.E.
DIRECTOR

HAKU MILLES, P.E.
DEPUTY DIRECTOR

SSFM INTERNATIONAL, INC.
RECEIVED -
APR 16 2021
JMS
FILE

FILE COPY

April 12, 2021

Ms. Jennifer M. Scheffel
Sr. Environmental Planner
SSFM INTERNATIONAL, INC.
501 Sumner Street, Suite 620
Honolulu, HI 96817

Subject: Waianae Wastewater Treatment Plant (WWTP)
Outfall Improvements and Rehabilitation
Waianae, Oahu, Hawaii
Tax Map Key (TMK): (1) 8-6-001:007
Pre-Assessment Consultation for Environmental Assessment

Dear Ms. Scheffel,

Thank you for the opportunity to review and comment. The Department of Design and Construction has no comments to offer at this time.

Should you have any further questions, please contact me at 768-8480.

Sincerely,

FOR Alex Kozlov, P.E.
Director

AK:krn (846741)

SSFM International
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October 14, 2021

SSFM 2015_070.000

Mr. Alex Kozlov, P.E., Director
City and County of Honolulu
Department of Design and Construction
650 South King Street, 11th floor
Honolulu, Hawaii 96813

SUBJECT: Waianae Wastewater Treatment Plant (WWTP)
Outfall Improvements and Rehabilitation
Waianae, Oahu, Hawaii
Tax Map Key (TMK): (1) 8-6-001:007
Response to Pre-Assessment Consultation Comments

Dear Mr. Kozlov,

Thank you for your letter dated April 12, 2021 regarding the subject project. We note that the Department of Design and Construction has no comments at this time. We will notify the department regarding availability of the Draft Environmental Assessment (Draft EA) upon its publication.

Your letter, along with this response letter, will be included in the forthcoming Draft EA. We appreciate your participation in the pre-assessment consultation process. Should you have additional comments or questions regarding this project, please contact me at (808) 356-1273 or via email at jscheffel@ssfm.com.

SSFM INTERNATIONAL, INC.

Jennifer M. Scheffel
Sr. Environmental Planner

DEPARTMENT OF PLANNING AND PERMITTING
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET, 7TH FLOOR • HONOLULU, HAWAII 96813
PHONE: (808) 768-8000 • FAX: (808) 768-6041
DEPT. WEB SITE: www.honoluludpp.org • CITY WEB SITE: www.honolulu.gov

RICK BLANGIARDI
MAYOR

DAWN[illegible]
DE[illegible]

EUGENE H. TAKAHASHI
DEPUTY DIRECTOR

April 22, 2021 2021/ELOG-575(ZS)

Ms. Jennifer Scheffel
SSFM International, Inc.
501 Summer Street, Suite 620
Honolulu, Hawaii 96817

Dear Ms. Scheffel:

SUBJECT: Pre-Environmental Assessment (EA) Consultation
Outfall Improvements and Rehabilitation
Waianae Wastewater Treatment Plant
86-100 Farrington Highway – Waianae
Tax Map Key 8-6-001: 007

This is in response to your letter, received on March 25, 2021, requesting comments for the forthcoming EA for the above mentioned Project. The proposed work involves constructing a new concrete encasement structure and capping three manhole covers on an existing wastewater outfall at the shoreline. Our comments are as follows:

A Special Management Area (SMA) Permit is not required for the Project, but a Shoreline Setback Variance may be required, as we determined in a memorandum to the Department of Environmental Services (ENV) dated August 10, 2017 (Correspondence File No. 2017/ELOG-1456, enclosed). Activities that fall under the definition of "development," as defined in the SMA regulations, are subject to the SMA permitting requirements. The installation, repair, and maintenance of underground utility lines, including sewer lines in existing corridors, is not "development." According to a memorandum from ENV dated July 25, 2017, all activities are anticipated to be located within the existing, pre-disturbed trench of the outfall pipe. Therefore, the Project, as proposed, does not require an SMA permit.

The outfall pipe was built in 1965, before the current shoreline setback (SSB) regulations were in place. Therefore, the existing structure is considered nonconforming, and may not be repaired or altered in any manner that increases its nonconformity. As stated in our 2017 letter, if repairs can be made without increasing the existing profile of the outfall pipe structure, and repair costs will not exceed

50 percent of the replacement cost of that portion of the structure within the SSB area, the Project will not require a shoreline setback variance (SSV). However, it appears that the repairs, as proposed, will increase the nonconformity of the structure. A SSV may only be granted using the public interest standard (Section 23-1.8(2), Revised Ordinances of Honolulu) if the proposal is the practicable alternative which best conforms to the purpose of the SSB rules. For this reason, a thorough alternatives analysis should be included in the draft EA to facilitate processing of the SSV. Options that would not affect beach processes should be considered, such as a fully underground replacement outfall or injection wells,

Finally, the Draft EA should analyze the Project in the context of the policies and guidelines of the Waianae Sustainable Communities Plan (WSCP). In particular, please describe how the proposal addresses the following: promoting the eventual hookup of residents with cesspools to the sewer system, the impact of capping and manhole removal on odors affecting surrounding uses, and protected views along the coast. Note that the WSCP policy on views states that Projects should be designed to not allow significant negative impacts on large open spaces. If the Project is large, the Draft EA should contain a detailed analysis of the potential impact on open space and scenic beauty. Inclusion of color simulations of the Project at its landing area would help in determining if visual impacts are significant.

Should you have any questions, please contact Zack Stoddard, of our staff, at (808) 768-8019, or zachary.stoddard@honolulu.gov.

Very truly yours,

Alex Beatty

for Dean Uchida
Director

Enclosure: Correspondence File No. 2017/ELOG-1456

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October 14, 2021 SSFM 2015_070.000

Mr. Dean Uchida, Director
City and County of Honolulu
Department of Planning and Permitting
650 South King Street, 7th floor
Honolulu, Hawaii 96813

SUBJECT: Waianae Wastewater Treatment Plant (WWTP)
Outfall Improvements and Rehabilitation
Waianae, Oahu, Hawaii
Tax Map Key (TMK): (1) 8-6-001:007
Response to Pre-Assessment Consultation Comments

Dear Mr. Uchida,

Thank you for your letter dated April 12, 2021 regarding the subject project (Letter No. 2021/ELOG-575(ZS)). We offer the following responses to your comments:

The August 10, 2017 determination stating a Special Management Area (SMA) Permit is not required was limited in scope to the emergency repairs. The proposed project consists of permanent repairs, including the installation of a concrete monolithic encasement over the existing outfall pipe. The monolithic concrete encasement would not be significantly different than the existing outfall pipe and is not expected to interfere with beach processes. Other alternatives to protect the pipe are discussed in Section 2.4 of the Draft EA. Replacement of the existing outfall was not considered in the range of alternatives. The City and County of Honolulu Department of Environmental Services will continue to consult with the Department of Planning and Permitting to determine the need for an SMA Permit and/or Shoreline Setback Variance.

Section 4.2.5 of the Draft Environmental Assessment (Draft EA) includes an analysis of the proposed project's consistency with the policies and guidelines of the Waianae Sustainable Communities Plan. Additional information regarding potential impacts to open spaces and views is provided in Section 3.8 of the Draft EA. The Proposed Action is not related to any plans associated with the eventual hookup of residents with cesspools to the sewer system. However, the repairs to the outfall would allow for the continued operation of the outfall with minimal maintenance, thereby keeping the Waianae WWTP operational for years to come. Capping of the manholes would not emit odors as the manholes are under 20 to 30 feet of water.

Your letter, along with this response letter, will be included in the forthcoming Draft EA. We appreciate your participation in the pre-assessment consultation process. Should you have additional comments or questions regarding this project, please contact me at (808) 356-1273 or via email at jscheffel@ssfm.com.

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October 14, 2021

SSFM INTERNATIONAL, INC.

Jennifer M. Scheffel

Jennifer M. Scheffel
Sr. Environmental Planner

DAVID Y. IGE
GOVERNOR OF HAWAII

SUZANNE D. CASE
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
LAND DIVISION

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

April 22, 2021

LD 0324

Jennifer M. Scheffel, Sr. Environmental Planner
SSFM International
501 Sumner Street, Suite 620
Honolulu, HI 96817

Via email: jscheffel@ssfm.com

Dear Ms. Scheffel:

SUBJECT: **Pre-Assessment Consultation for Environmental Assessment**
Waianae Wastewater Treatment Plant
Outfall Improvements and Rehabilitation
Waianae, Island of Oahu, Hawaii
TMK: (1) 8-6-001:007

Thank you for the opportunity to review and comment on the subject project. The Land Division of the Department of Land and Natural Resources (DLNR) distributed copies of your request to various DLNR divisions, as indicated on the attached, for their review and comment.

Attached are responses received from our (a) Engineering Division and (b) Office of Conservation and Coastal Lands. Should you have any questions, please feel free to contact Barbara Lee via email at barbara.j.lee@hawaii.gov. Thank you.

Sincerely,

Russell Tsuji

Russell Y. Tsuji
Land Administrator

Attachments

Cc: Central Files

DAVID Y. IGE
GOVERNOR OF HAWAII

SUZANNE D. CASE
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
LAND DIVISION

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

April 07, 2021

LD 0324

MEMORANDUM

FROM:

TO: **DLNR Agencies:**
X Div. of Aquatic Resources *(via email: Kendall.l.tucker@hawaii.gov)*
__ Div. of Boating & Ocean Recreation
X Engineering Division *(via email: DLNR.Engr@hawaii.gov)*
X Div. of Forestry & Wildlife *(via email: Rubyrosa.T.Terrago@hawaii.gov)*
__ Div. of State Parks
X Commission on Water Resource Management *(via email: DLNR.CWRM@hawaii.gov)*
X Office of Conservation & Coastal Lands *(via email: sharleen.k.kuba@hawaii.gov)*
X Land Division – Oahu District *(via email: DLNR.Land@hawaii.gov)*

TO:

FROM: Russell Y. Tsuji, Land Administrator *Russell Tsuji*
SUBJECT: **Pre-Assessment Consultation for Environmental Assessment, Waianae Wastewater Treatment Plant Outfall Improvements and Rehabilitation**
LOCATION: Waianae, Island of Oahu, Hawaii; TMK: (1) 8-6-001-007
APPLICANT: **SSFM International**

Transmitted for your review and comment is information on the above-referenced project. Please review the attached information and submit any comments by the internal deadline of **April 22, 2021** to the Land Division at DLNR.Land@hawaii.gov, and copied to barbara.j.lee@hawaii.gov.

If no response is received by the above due date, we will assume your agency has no comments at this time. If you have any questions, please contact Barbara Lee at barbara.j.lee@hawaii.gov. Thank you.

( ) We have no objections.
( ) We have no comments.
( ) We have no additional comments.
(✓) Comments are attached.

Signed: [signature]
Print Name: Carty S. Chang, Chief Engineer
Division: Engineering Division
Date: Apr 16, 2021

Attachments
Cc: Central Files

DEPARTMENT OF LAND AND NATURAL RESOURCES
ENGINEERING DIVISION

LD/Russell Y. Tsuji
Ref: Pre-Assessment Consultation for Environmental Assessment,
Waianae Wastewater Treatment Plant
Outfall Improvements and Rehabilitation
Location: Waianae, Island of Oahu
TMK(s): (1) 8-6-001-007
Applicant: SSFM International

COMMENTS

The rules and regulations of the National Flood Insurance Program (NFIP), Title 44 of the Code of Federal Regulations (44CFR), are in effect when development falls within a Special Flood Hazard Area (high-risk areas). State projects are required to comply with 44CFR regulations as stipulated in Section 60.12. Be advised that 44CFR reflects the minimum standards as set forth by the NFIP. Local community flood ordinances may stipulate higher standards that can be more restrictive and would take precedence over the minimum NFIP standards.

The owner of the project property and/or their representative is responsible to research the Flood Hazard Zone designation for the project. Flood Hazard Zones are designated on FEMA's Flood Insurance Rate Maps (FIRM), which can be viewed on our Flood Hazard Assessment Tool (FHAT) (http://gis.hawaiinfip.org/FHAT).

If there are questions regarding the local flood ordinances, please contact the applicable County NFIP coordinating agency below:

- Oahu: City and County of Honolulu, Department of Planning and Permitting (808) 768-8098.
- Hawaii Island: County of Hawaii, Department of Public Works (808) 961-8327.
- Maui/Molokai/Lanai County of Maui, Department of Planning (808) 270-7253.
- Kauai: County of Kauai, Department of Public Works (808) 241-4896.

Signed: [signature]
CARTY S. CHANG, CHIEF ENGINEER

Date: Apr 16, 2021

OA-21-118 SAL.

LD 0411

RECEIVED LAND DIVISION 2021 APR 16 AM 11:03 DEPT. OF LAND & NATURAL RESOURCES STATE OF HAWAII

RECEIVED OFFICE OF CONSERVATION AND COASTAL LANDS 2021 APR -8 A 11:31 DEPT. OF LAND & NATURAL RESOURCES STATE OF HAWAII

DAVID Y. IGE
GOVERNOR OF HAWAII

SUZANNE D. CASE
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
LAND DIVISION

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

April 07, 2021

LD 0324

MEMORANDUM

TO: **DLNR Agencies:**
X Div. of Aquatic Resources *(via email: Kendall.l.tucker@hawaii.gov)*
__Div. of Boating & Ocean Recreation
X Engineering Division *(via email: DLNR.Engr@hawaii.gov)*
X Div. of Forestry & Wildlife *(via email: Rubyrosa.T.Terrago@hawaii.gov)*
__Div. of State Parks
X Commission on Water Resource Management *(via email: DLNR.CWRM@hawaii.gov)*
X Office of Conservation & Coastal Lands *(via email: sharleen.k.kuba@hawaii.gov)*
X Land Division – Oahu District *(via email: DLNR.Land@hawaii.gov)*

FROM: Russell Y. Tsuji, Land Administrator *Russell Tsuji*
SUBJECT: **Pre-Assessment Consultation for Environmental Assessment, Waianae Wastewater Treatment Plant Outfall Improvements and Rehabilitation**
LOCATION: Waianae, Island of Oahu, Hawaii; TMK: (1) 8-6-001-007
APPLICANT: **SSFM International**

Transmitted for your review and comment is information on the above-referenced project. Please review the attached information and submit any comments by the internal deadline of **April 22, 2021** to the Land Division at DLNR.Land@hawaii.gov, and copied to barbara.j.lee@hawaii.gov.

If no response is received by the above due date, we will assume your agency has no comments at this time. If you have any questions, please contact Barbara Lee at barbara.j.lee@hawaii.gov. Thank you.

( ) We have no objections.
( ) We have no comments.
( ) We have no additional comments.
(X) Comments are attached.

X NO DETERMINATION ON PERMIT REQUIREMENTS YET. WILL WAIT TO REVIEW THE DRAFT EA.

Signed: [signature]
Print Name:
Division:
Date: 4.15.21

Attachments
Cc: Central Files

SSFM International
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LD 0324

March 23, 2021 SSFM 2015_070.000

Mr. Russell Tsuji, Administrator
State of Hawaii Department of Land and Natural Resources
Land Division
1151 Punchbowl St, Room 220
Honolulu, HI 96813

SUBJECT: **Waianae Wastewater Treatment Plant (WWTP)**
Outfall Improvements and Rehabilitation
Waianae, Oahu, Hawaii
Tax Map Key (TMK): (1) 8-6-001:007
Pre-Assessment Consultation for Environmental Assessment

Dear Mr. Tsuji,

The City and County of Honolulu Department of Environmental Services (ENV), Division of Wastewater Engineering and Construction, proposes to install a concrete encasement structure over the existing Waianae Wastewater Treatment Plant (WWTP) outfall to protect the pipe from progressive shoreline erosion from wave action compounded with ongoing sea level rise. In addition, three manholes along the pipe would be capped.

Project Background

The Waianae WWTP is located approximately 1.5 miles south of Waianae Small Boat Harbor on the western shoreline of the island of Oahu. The WWTP utilizes an ocean outfall structure for conveying treated effluent from the facility to offshore waters for disposal where it is released at a water depth of 105 feet by an array of diffusers for dilution and dispersal in the water column by natural oceanographic processes.

The Waianae WWTP's ocean outfall was initially constructed in 1965 with a 3,133-foot-long entrenched reinforced concrete pipe with a diameter of 36 inches and terminated with a 230-foot-long southward angled diffuser. Between 1982 and 1986 an extension was added to the original outfall. The extension section has a 42-inch diameter and is 3,051 feet long.

Sea Engineering, Inc. conducted an inspection of the outfall in 2018. The findings of the 2018 inspection were as follows:

1. Advancing shoreline erosion is threatening pipeline stability at its shoreline landing where emergency repairs were completed in 2017 to shore up an undermined section of pipe near the waterline.

2. Actively corroding cast iron manhole covers on the original 36-inch pipeline are at an elevated risk of failure due to loss of effective metal thickness of the cover from long-term galvanic corrosion.

Project Description

The purpose of the proposed project is to address the most critical findings from the 2018 outfall inspection, as described above. The 2018 inspection report recommended permanent repairs to safeguard pipeline stability within the eroded shoreline area and to permanently cap three manholes on the original 36-inch pipeline (i.e., cover and seal the manhole lids with a non-corrosive covering).

The proposed project includes the following:

1. Installation of a concrete encasement structure over the land-based portion of the existing outfall at the shoreline. The structure would be designed to not have blunt faces on the offshore side of the structure to minimize potential for cracking or failure. This could include arcing or rounding the face, and chamfering or rounding hard edges where possible.

2. Cap three of the cast iron manhole cover plates on the original 36-inch pipeline. To protect the caps from peak lift forces from wave action, the caps would be designed to not rely exclusively on mass for stability and would incorporate some form of mechanical connection to the cap of the existing manhole riser structure or other suitable alternative.

Request for Information

ENV, Wastewater Systems Division has contracted SSFM International, Inc., to prepare an Environmental Assessment (EA) for the proposed project in compliance with State environmental regulations under Hawaii Revised Statutes (HRS) Chapter 343 and Hawaii Administrative Rules (HAR) Title 11, Chapter 200.1. This letter is being provided to solicit any comments, concerns, or regulatory requirements that you may have regarding this project. We would greatly appreciate your cooperation in providing us with written comments within 30 days of the date of this letter. If you have any questions on this matter or the proposed project, please feel free to contact me at (808) 356-1273 or by email at jscheffel@ssfm.com.

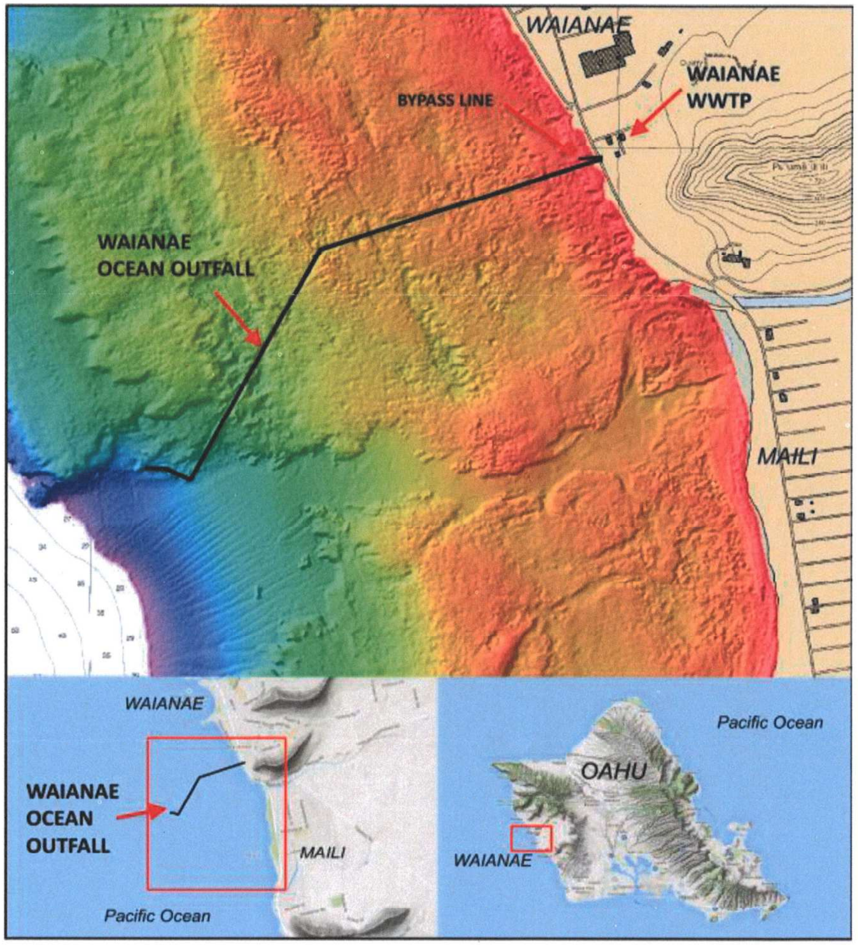
SSFM INTERNATIONAL, INC.

Jennifer M. Scheffel

Jennifer M. Scheffel
Sr. Environmental Planner
Email: jscheffel@ssfm.com

Attachment: Project Location Map

Project Location Map



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October 14, 2021

SSFM 2015_070.000

Mr. Russell Y. Tsuji, Administrator
Land Division
State of Hawaii
Department of Land and Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

SUBJECT: Waianae Wastewater Treatment Plant (WWTP)
Outfall Improvements and Rehabilitation
Waianae, Oahu, Hawaii
Tax Map Key (TMK): (1) 8-6-001:007
Response to Pre-Assessment Consultation Comments

Dear Mr. Tsuji,

Thank you for your letter dated April 22, 2021 regarding the subject project. We appreciate your distributing our pre-assessment consultation letter throughout the divisions of the Department of Land and Natural Resources (DLNR). We offer the following responses to the comments received from the Engineering Division and Office of Conservation and Coastal Lands (OCCL).

<u>Engineering Division</u>
Thank you for your comments regarding compliance with National Flood Insurance Program (NFIP), Title 44 of the Code of Federal Regulations (44CFR). An assessment of potential impacts to the project from being within a flood hazard area will be included in the Draft Environmental Assessment (Draft EA) and considered during the design engineering phase of the project.

<u>Office of Conservation and Coastal Lands</u>
The City and County of Honolulu Department of Environmental Services will continue to consult with OCCL to determine the need for a Conservation District Use Permit. We will notify OCCL regarding availability of the Draft Environmental Assessment (Draft EA) upon its publication.

Your letter, along with this response letter, will be included in the forthcoming Draft EA. We appreciate your participation in the pre-assessment consultation process. Should you have additional comments or questions regarding this project, please contact me at (808) 356-1273 or via email at jscheffel@ssfm.com.

October 14, 2021

SSFM INTERNATIONAL, INC.

Jennifer M. Scheffel
Sr. Environmental Planner

DEPARTMENT OF TRANSPORTATION SERVICES
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET, 3RD FLOOR
HONOLULU, HAWAII 96813
Phone: (808) 768-8305 • Fax: (808) 768-4730 • web: www.honolulu.gov

RICK BLANGIARDI
MAYOR

J. ROGER MORTON
DIRECTOR

JON Y. NOUCHI
DEPUTY DIRECTOR

TP4/21-846917

April 23, 2021

Mr. Lance Tokuda, Engineer
SSFM International, Inc. (SSFM)
501 Sumner Street, Suite 620
Honolulu, Hawaii 96817

Dear Mr. Tokuda:

SUBJECT: Waianae Wastewater Treatment Plant
Outfall Improvements and Rehabilitation
Waianae, Oahu, Hawaii
Tax Map Key (TMK): (1) 8-6-001:007
Pre-Assessment Consultation for Environmental Assessment

Thank you for the opportunity to provide written comments regarding the subject project. We have the following comments.

1. **Traffic Management Plan**. The Draft Environmental Assessment should include a Traffic Management Plan, which discusses traffic impacts the project may have on any surrounding City roadways, including short-term impacts during construction and long-term impacts after construction with corresponding measures to mitigate these impacts by applying Complete Streets principles.

2. **Neighborhood Impacts**. The area representatives, neighborhood board, as well as the area residents, businesses, emergency personnel (fire, ambulance, and police), Oahu Transit Services, Inc. (TheBus and TheHandi-Van), etc., should be kept apprised of the details and status throughout the project and the impacts that the project may have on the adjoining local street area network.

3. **Disability and Communication Access Board (DCAB)**. Project plans (vehicular and pedestrian circulation, sidewalks, parking and pedestrian

pathways, vehicular ingress/egress, etc.) should be reviewed and approved by DCAB to ensure full compliance with Americans with Disabilities Act requirements.

Thank you for the opportunity to review this matter. Should you have any questions, please contact Greg Tsugawa, of my staff, at 768-6683.

Very truly yours,

J. Roger Morton
Director

SSFM International
Innovate | Adapt | Sustain

October 14, 2021 SSFM 2015_070.000

Mr. J. Roger Morton, Director
City and County of Honolulu
Department of Transportation Services
650 South King Street, 3rd floor
Honolulu, Hawaii 96813

SUBJECT: Waianae Wastewater Treatment Plant (WWTP)
Outfall Improvements and Rehabilitation
Waianae, Oahu, Hawaii
Tax Map Key (TMK): (1) 8-6-001:007
Response to Pre-Assessment Consultation Comments

Dear Mr. Morton,

Thank you for your letter dated April 23, 2021 regarding the subject project (Letter No. TP4/21-846917). We offer the following responses to your comments:

1. Section 3.12 of the Draft Environmental Assessment (Draft EA) includes an analysis of potential traffic impacts from the Proposed Action. Impacts will be short-term and temporary during the construction period.
2. Area representatives, the Waianae Coast Neighborhood Board, the Honolulu Police Department, the Honolulu Fire Department, and other City and County of Honolulu departments were given the opportunity to provide comments during the pre-assessment consultation period. All will be notified regarding the availability of the Draft EA upon its publication.
3. Section 3.12 of the Draft Environmental Assessment (Draft EA) includes an analysis of potential traffic impacts during construction. Impacts will be short-term and temporary during the construction period.

Your letter, along with this response letter, will be included in the forthcoming Draft EA. We appreciate your participation in the pre-assessment consultation process. Should you have additional comments or questions regarding this project, please contact me at (808) 356-1273 or via email at jscheffel@ssfm.com.

SSFM INTERNATIONAL, INC.

Jennifer M. Scheffel

Jennifer M. Scheffel
Sr. Environmental Planner

DAVID Y. IGE
GOVERNOR

CURT T. OTAGURO
COMPTROLLER

AUDREY HIDANO
DEPUTY COMPTROLLER

STATE OF HAWAII
DEPARTMENT OF ACCOUNTING AND GENERAL SERVICES
P.O. BOX 119, HONOLULU, HAWAII 96810-0119

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APR - 1 2021

Ms. Jennifer Scheffel
SSFM International, Inc.
501 Sumner Street, Suite 620
Honolulu, Hawaii 96817

Dear Ms. Scheffel:

Subject: Pre-Assessment Consultation for Environmental Assessment for Waianae Wastewater Treatment Plant Outfall Improvements and Rehabilitation Waianae, Oahu, Hawaii TMK: (1) 8-6-001: 007

Thank you for the opportunity to comment on the subject project. We have no comments to offer at this time as the proposed project does not impact any of the Department of Accounting and General Services' projects or existing facilities.

If you have any questions, your staff may call Ms. Gayle Takasaki of the Planning Branch at 586-0584.

Sincerely,

CHRISTINE L. KINIMAKA
Public Works Administrator

GT:mo

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October 14, 2021

SSFM 2015_070.000

Ms. Christine L. Kinimaka, Administrator
Public Works Division
State of Hawaii
Department of Accounting and General Services
P.O. Box 119
Honolulu, Hawaii 96810-0119

SUBJECT: Waianae Wastewater Treatment Plant (WWTP)
Outfall Improvements and Rehabilitation
Waianae, Oahu, Hawaii
Tax Map Key (TMK): (1) 8-6-001:007
Response to Pre-Assessment Consultation Comments

Dear Ms. Kinimaka,

Thank you for your letter dated April 1, 2021 regarding the subject project. We note that the Department of Accounting and General Services does not have any comments at this time as the proposed project does not impact any of the Department of Accounting and General Services' department's projects or existing facilities. We will notify the department regarding availability of the Draft Environmental Assessment (Draft EA) upon its publication.

Your letter, along with this response letter, will be included in the forthcoming Draft EA. We appreciate your participation in the pre-assessment consultation process. Should you have additional comments or questions regarding this project, please contact me at (808) 356-1273 or via email at jscheffel@ssfm.com.

SSFM INTERNATIONAL, INC.

Jennifer M. Scheffel
Sr. Environmental Planner

DAVID Y. IGE
GOVERNOR
STATE OF HAWAII

JOSH GREEN
LT. GOVERNOR
STATE OF HAWAII

WILLIAM J. AILA, JR
CHAIRMAN
HAWAIIAN HOMES COMMISSION

TYLER I. GOMES
DEPUTY TO THE CHAIRMAN

STATE OF HAWAII
DEPARTMENT OF HAWAIIAN HOME LANDS

P. O. BOX 1879
HONOLULU, HAWAII 96805

In reply to: PO-21-081

April 5, 2021

Ms. Jennifer M. Scheffel
Sr. Environmental Planner
SSFM International, Inc.
501 Summer Street, Suite 620
Honolulu, Hawaii 96817
Email: jscheffel@ssfm.com

Aloha Ms. Scheffel:

Subject: Pre-Assessment Consultation for Draft Environmental Assessment, Wai'anae Wastewater Treatment Plant (WWTP) Outfall Improvements and Rehabilitation, Wai'anae, O'ahu, Hawai'i, TMK (1) 8-6-001:007

The Department of Hawaiian Home Lands (DHHL) acknowledges receiving the request for Pre-Assessment Consultation on the above-cited project and offers the following comments.

1. After reviewing the materials submitted, the proposed Wastewater Treatment Plant (WWTP) is located less than ½ mile from the nearest the Department of Hawaiian Home Lands' (DHHL) homestead community in the Lualualei Ahupua'a. As of February 2021, there are 1,946 native Hawaiian families leasing DHHL land for residential or agriculture uses along the Waianae Coast. Of those, 630 live within Lualualei and Wai'anae Ahupua'a. Construction activities may result in short-term noise, air quality and traffic impacts to beneficiaries living on the coast. The Draft EA should include mitigation measures to address traffic impact.

2. DHHL enthusiastically supports the upgrading of the WWTP. Many of DHHL's lessees and their 'ohana engage in activities along the shoreline. Nearshore water quality is of primary concern in maintaining the health of those ocean resources. Given accelerated sea level rise projections, upgrading the outfall is increasingly important for coastal environmental quality and the health and well-being of DHHL's beneficiaries as well as all of the Wai'anae Community residents.

3. As the environmental assessment documents are developed, it is important that DHHL's beneficiaries are informed of potential impacts, proposed mitigations, and evaluation of alternatives to the location and scope of the proposed project. DHHL and Hawaiian

Home Commission Act (HHCA) beneficiary groups formed along the Wai'anae Coast should be included in future consultation conducted regarding this project. We recommend contacting the following groups as part of your consultation process. They may have information regarding cultural and historic resources to share and may have an interest in obtaining more information regarding your project.

Wai'anae Kai Hawaiian Homestead Community
Wai'anae Valley Homestead Association
Ahupua'a o Nānākuli Hawaiian Homestead
Nānākuli Hawaiian Homestead Community Association
Princess Kahanu Estates

Mahalo for the opportunity to provide comments. If you have any questions, please contact Malia Cox at (808)620-9500 or via email at malia.m.cox@hawaii.gov.

Aloha,

William J. Aila Jr., Chairman
Hawaiian Homes Commission

C: Wai'anae Kai Hawaiian Homestead Community
Wai'anae Valley Homestead Association
Ahupua'a o Nānākuli Hawaiian Homestead
Nānākuli Hawaiian Homestead Community Association
Princess Kahanu Estates

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October 14, 2021 SSFM 2015_070.000

Mr. William J. Aila, Jr., Chairman
Hawaiian Homes Commission
State of Hawaii
Department of Hawaiian Home Lands
P.O. Box 1879
Honolulu, Hawaii 96805

SUBJECT: Waianae Wastewater Treatment Plant (WWTP)
Outfall Improvements and Rehabilitation
Waianae, Oahu, Hawaii
Tax Map Key (TMK): (1) 8-6-001:007
Response to Pre-Assessment Consultation Comments

Dear Mr. Aila,

Thank you for your letter dated April 5, 2021 (Letter No. PO-21-081) regarding the subject project. We offer the following responses to your comments:

1. The Draft Environmental Assessment (Draft EA) includes an analysis of potential air quality, noise, and traffic impacts during construction (Sections 3.10, 3.11, and 3.12, respectively.
2. Thank you for your support of the proposed project. As noted in the Draft EA, the Waianae Wastewater Treatment Plant (WWTP) is critical infrastructure for the island of Oahu. The Proposed Action is necessary to ensure that the shoreline section of the Waianae WWTP outfall pipe is not further undermined, which could cause damage that results in a release of effluent and takes the outfall pipe out of service. Overall, the Proposed Action would be beneficial to the community as it would reduce the risk of release of effluent in nearshore waters, ensure the continued operation of the outfall, and minimize maintenance costs to the City and County of Honolulu.
3. The recommended homestead associations have been added to the mailing list and will be notified of the availability of the Draft EA upon its publication.

Your letter, along with this response letter, will be included in the forthcoming Draft EA. We appreciate your participation in the pre-assessment consultation process. Should you have additional comments or questions regarding this project, please contact me at (808) 356-1273 or via email at jscheffel@ssfm.com.

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October 14, 2021

SSFM INTERNATIONAL, INC.

Jennifer M. Scheffel

Jennifer M. Scheffel
Sr. Environmental Planner

Jennifer Scheffel

From:	Speerstra, Linda CIV USARMY CEPOH (USA) <Linda.Speerstra@usace.army.mil>
Sent:	Monday, April 5, 2021 6:14 PM
To:	Jennifer Scheffel
Subject:	Waianae Wastewater Treatment Plant Outfall POH-2017-00175
Follow Up Flag:	Follow up
Flag Status:	Flagged

Email received from EXTERNAL sender. Confirm the content is safe prior to opening attachments or links.

Aloha Jennifer, thank you for reaching out to the Corps. I'm providing scoping information in regards to the early consultation request for the Waianae Wastewater Treatment Plant Outfall Improvements and Rehabilitation located in Waianaie, Oahu, Hawaii. The Corps has assigned this project number: POH-2017-00175. Please refer to this in future correspondence.

The Corps' regulatory authorities are based on two laws: Section 10 of the Rivers and Harbors Act (RHA) of 1899 (33 USC 403), which prohibits the obstruction or alteration of navigable waters of the U.S. without a permit from the Corps; and Section 404 of the Clean Water Act (CWA), which prohibits the discharge of dredged or fill material into waters of the U.S., including wetlands, without a Corps' permit.

Based on information provided it is unclear as to whether the work would occur below the mean high water mark (MHW) of the Pacific Ocean. If work is proposed below the MHW it would be subject to the Corps' jurisdiction as the Pacific Ocean is a waters of the United States. If the work would not occur in a waters of the U.S., no further action would be required.

The Corps' regulatory authorities are based on two laws: Section 10 of the Rivers and Harbors Act (RHA) of 1899 (33 USC 403), which prohibits the obstruction or alteration of navigable waters of the U.S. without a permit from the Corps; and Section 404 of the Clean Water Act (CWA), which prohibits the discharge of dredged or fill material into waters of the U.S., including wetlands, without a Corps' permit.

Waters of the U.S. include but are not limited to streams, rivers, lakes along with all marine waters subject to the ebb and flow of the tide. If the work to be conducted is located in a waters of the U.S., the proposal may fall within the thresholds of Nationwide Permit 3, Maintenance activities. A preconstruction notification can be found on our website at https://www.poh.usace.army.mil/Missions/Regulatory/.

The Corps is requesting that all requests be submitted electronically to our general inbox (CEPOH-RO@usace.army.mil) which is monitored daily. You can, of course, reach back out to me if you have any further questions. My contact information is below. Linda

Linda Speerstra
Chief, Regulatory Branch
U.S. Army Corps of Engineers
Honolulu District
808-835-4300

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October 14, 2021

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Ms. Linda Speerstra, Chief
Department of the Army
U.S. Army Corps of Engineers
Honolulu District
Regulatory Office, CEPOH-EC-R
Fort Shafter, Hawaii 96858-5440

SUBJECT: Waianae Wastewater Treatment Plant (WWTP)
Outfall Improvements and Rehabilitation
Waianae, Oahu, Hawaii
Tax Map Key (TMK): (1) 8-6-001:007
Response to Pre-Assessment Consultation Comments

Dear Ms. Speerstra,

Thank you for your email dated April 5, 2021 regarding the subject project (Project No. POH-2017-00175).

We acknowledge that a Section 404/10 permit may be required for the Proposed Action and will coordinate with and provide information to the Corps during the application process, as required.

Your letter, along with this response letter, will be included in the forthcoming Draft EA. We appreciate your participation in the pre-assessment consultation process. Should you have additional comments or questions regarding this project, please contact me at (808) 356-1273 or via email at jscheffel@ssfm.com.

SSFM INTERNATIONAL, INC.

Jennifer M. Scheffel
Sr. Environmental Planner

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